THE BUDDHIST ROBE

The path pointing to natural dyes and possible establishment of a natural dyeing industry in the apparel sector of Sri Lanka with special reference on the Buddhist robe

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Other books of the Authors

Scholarly Work

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- History of natural dyes in Sri Lanka - 2013 - S. Godage & Brothers.

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- Fashions of Royalty: The Kandyan Kingdom of Sri Lanka - 2018 - S. Godage & Brothers.
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- Fashion of Royalty: Kotte Kingdom of Sri Lanka - 2018 - S. Godage & Brothers.
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Dedication

To

All our teachers who laid the foundation for education

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THE BUDDHIST ROBE

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PREFACE

It gives us pleasure to release this writing as a complete intensive study on the greatly unexplored area of the Buddhist Robe for the benefit of the researchers and for the University undergraduates verifying and identifying how natural dyeing plays a pivotal role in colouration in ancient context which signified much with its eco-friendly nature, what is commonly discussed and falls into sustainable practices.

The Buddhist Robe: the path pointing to natural dyes and possible establishment of a natural dyeing industry in the apparel sector of Sri Lanka with special reference on the Buddhist robe is a scholarly work is the first of a series intended primarily as a invaluable reference source book for undergraduates of our Universities. This is a totally a practical guide in applying how the related natural colour substances apply to real life situations like offering Kaṭhina Cīvara Pūjā by colouring natural dye stuffs, since Professor Samudrika devoted more than 15 years exploring, experimenting and specializing in natural dye stuffs creating a path way for many followers by taking the initiative to invoke the imperative provisions of natural dyeing for the benefit of the textile sector meeting the expectations of the sustainable practices which recover through the proper application of natural dye stuffs which are available to us. The page by page coverage of the Sri Lankan Buddhist robe dye history with sumptuous imagery and experts' accessible guide to the natural dye tradition of the country. This will serve as a great reference for not only for undergraduates who involve in the appreciation of natural dye traditions of Sri Lanka but also for academics who teach the subject and researchers who are involved in the respective fields. Combining contextual facts impact with cultural significance, the traditional robe dye adorns all types of surfaces from discarded cloth to refined cotton cloth.

This scholarly work reflects this ubiquity by presenting a biography of dye forms in a different way – painted, literal and laboratory status of dye particles. Chapter one contains the uniqueness of Sri Lankan dye stuffs spread throughout history where natural dyes are plucked from history brought to the fore with essential details isolated and framed. This permits a detailed research of how natural dye systems become of a part of Buddhist traditional practice and culture of the country. Further this work discovers intriguing cultural elements and connections, which are based on original references too. This is an overview and an in-depth research of the robes worn by the Buddhist monks with its cultural context in relation to the

great chronicle of Mahāvaggapāli, Vinaya-piṭaka of the Pali Canon in its 8th chapter: 'Cīvarakkhandakaya' describes the robe of Buddhist priests and its traditional practices. The second chapter is dedicated to establish a historical representation of the Buddhist robe emerging in the socio-cultural context in terms of developing its visual and figurative aspects discussed with an array of visuals depicted in Sri Lankan temple paintings. The third chapter highlight the art of traditional dyes in Sri Lanka with its colour substances, methods, materials and some significant dye recipes based on well proven literary facts. The fourth chapter considers the scientific clarification of the methodology of robe dyeing and its characteristics under set laboratory condition.

In an ocean of knowledge, this being a pot of water collected thus is expected to quench the thirst of many who are desperate for knowledge in this area of natural dyeing specified in the Buddhist robe dyeing in Sri Lanka and we simply dedicate this book to all our teachers who laid the strong foundation for our education.

This book is the result of a collective effort. The present scholarly work grew out of the early seeds which had origins in our research activities, teaching coloration to BSc Engineering and Bachelor of Design undergraduates, an appreciation of the art tradition of Sri Lanka to BSc Engineering undergraduates of the University of Moratuwa.

March 2019

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We must take this opportunity to extend our gratitude to all our teachers who laid the foundation for our primary and secondary education at Anula Vidyala, Nugegoda (Samudrika), Siri Piyarathana College, Padukka, Mahamaya Girl's College, Kandy (Gayathri), Maliyadeva Girl's College, Kurunegala and St./ Joseph's Convent, Kegalle, (Virajini).

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We would like to take this opportunity to thank Rev. Professor. Medagampitiye Wijithadhamma Thero, Head, Department of Pali and Buddhist Studies, Faculty of Social Sciences and Humanities, University of Sri Jayewardenepura, who spent precious time with providing significant comments which increased the validity of our research.

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FOREWORD

Natural dye is a subject which has been scholarly addressed widely by National and International scholars in research arena. It is very much appreciated that producing a book pertaining to the subject area of natural dye is a fulfillment of a timely needed activity. Because it is said to have been a well-known fact that the making of colours by using earthy materials and substances taking from natural vegetation developed gradually from the beginning of the human settlement of civilization in the world. In such a situation in Sri Lankan tradition provides ample evidences of practices of colouring the Buddhist robe by the use of natural dye stuffs since ancient times. Senior academics of the Department of Textile and Clothing Technology at the Moratuwa University, Professor U. G. Samudrika Wijayapala, Dr. Gayathri Madubani Ranathunga and Dr. Priyanka Virajini Medagedara Karunaratne made a serious attempt to study natural dyeing of the Buddhist robe in a precise way have produced a scholarly work proven skillfully covering a myriad aspect of natural dye with clarity.

I have no doubt that this book will greatly be appreciated and made use of by undergraduates who learn about natural dyes, and interested parties in this subject area including scholars and researchers on par with dissemination of knowledge and pure academic pursuits. I wish them all success in their future endeavors.

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March 2019

INTRODUCTION

The Oxford dictionary (1884) defines dye as “a natural or synthetic substance used to add a colour to or change the colour of something”.Encyclopedia Britannica describes it as “Dye, substance used to impart colour to textiles, paper, leather, and other materials such that the colouring is not readily altered by washing, heat, light, or other factors to which the material is likely to be exposed. Dyeing and printing are processes employed in the conversion of raw textile fibres into finished goods that add much to the appearance of textile fabrics”.

Dyeing is the process or work of coloring fabrics with dyes. The history of dyeing goes back to the Neolithic period. Since ancient times, colouring of textiles was directed by using the colours extracted from natural sources such as plants and animals, until the synthetic dyes were developed and commercialized in the mid-19th Century. Synthetic dyes uphold the market almost entirely because of their higher level of fastening properties, availability of spectrum of colours and cost effectiveness. However, synthetic dyes are petrochemical based, and their toxic nature as well as it requires more resource in the process of dyeing which has created unsustainable environmental impacts. This threatening environment impact has been driven along with the dyeing process associated with substantial amount of water, usage of chemicals, and energy, the last creates carbon footprint and chemical harmful to nature, discarding of waste water to natural water streams after the dyeing process causes water and environmental pollution. It has been recognized that the presence of dye particles and also heavy metals in the wastewater such as copper, lead, nickel makes the effluent are highly toxic. Therefore, the textile dyeing process is recognized as one of the most environmentally unfriendly industrial processes in the world.

Due to the toxic nature and the negative environmental impacts of synthetic dyes, there is a real demand coming through for the use of natural dyes recently. Synthetic dyes captured the market with their significant and attractive factors such as wide colour range, brightness and cost effectiveness. The use of natural dyes has been practiced by the textile industry to some extent worldwide. It has now been recognized that natural dyes could provide both social and environmental benefits because natural dyes are not environmentally hazardous. Besides, the use of eco-friendly natural dyes has become significantly important today due to rising environmental awareness around the world, and especially in the textile industry, in order to minimize the adverse environmental impact created in the textile dyeing

process. However, there are some deficiencies natural dyes which slow them from being commercially viable. Usually natural dyes provide a limited and dull range of colours. Moreover, that long extraction processes, moderate colour fastness to wash and light, non-availability in bulk quantities and less reparability contribute to the limited use of natural dyes in the textile industry.

For successful commercialization and use of natural dyes, it is vital to develop standardized dyeing techniques, improved colour fastness properties, obtain new shades of colours and investigate an economical process for extraction and application of natural dyes. Therefore, a need has arisen to look back and examine the traditional natural dyeing and mordanting techniques to learn from ancient practices and rejuvenate them to suit the modern world, while maintaining the eco aspects of the product and process. This study is necessary to define the situations of the past and its meaning in the light of the present issues. The traditional practices can provide a perspective for decision making about present problems.

Therefore, this text book aimed to investigate traditional dyeing techniques which have been practiced by the Buddhist monks in Sri Lanka since ancient time. This collection of writings will provide suggestions which have been practiced from generation to generation to enable maximizing the sustainability of the textile dyeing process.

CONTENTS

CHAPTER 1

Doctrine and discipline of the robe History and the present today

Introduction

A robe is a loose fitting outer garment which signifies the honorary stature of the wearer. According to historical evidences the Buddhist monks practiced wearing the tradition of robes going back to 25 Centuries. Buddhist history reveals that the first five monks were permitted to wear robes that were constructed of discarded fabrics patched together from shrouds as practiced by many mendicant holy men in India at the time. The monks would scavenge cloth from rubbish heaps and cremation grounds. The robe was known as *Cīvara* in the Pali language and still being commonly used by the Sri Lankan Buddhist monks who adhere to the philosophy of Buddhism. These are recorded in the *Vinaya-piṭaka* of the Pali Canon or *Tripitaka*. The great chronicle of *Mahāvaggapāli* in its 8th Chapter- *'Cīvarakkhandhakaya'* is devoted to describe the robe of Buddhist priests and its traditional practices (Max Muller, 1982). The traditional Buddhist robe represents simplicity. '*Mahāvaggapāli*' explains that the robe is expected to be used to its maximum utilization. (Mahāvaggapāli, part II, 1957, (Sinhala Translation), Ven. Pandita Ambalangoda Dhammakusala Thero, 713). '*Sasanavatharaṇaya*' is another written text that too explained the tradition of wearing, preparing and practice of the Buddhist robe. Max Muller (1982, 199), explains in his translation of *Mahāvaggapāli*, that *kivara* mean both 'a robe' and cloth for making robes'. Wikipedia encyclopedia clarified the term 'robe' by considering the colour of it. The word Kāṣāya (in Sanskrit), kasāva (in Pali) kas*ā*vata කසාවත (in Sinhalese) are the robes of fully ordained Buddhist monks and nuns, named after a brown or saffron dye. In Sanskrit and Pali, these robes are also given the more general term *cīvara,* which references the robes without regard to color.

The primary needs of a Buddhist monk

According to the Buddhist teachings the monk should have four basic needs known as "*Sivpasa"* as follows;

1. Cloth (*Cīvaraya)*

   Paṃsukūla cīvaraṃ nissāya pabbajjā

This clarification shows that the robe or the *cīvara* must be made by "*Paṃsukūla*" which is the shroud to wrap the dead before cremation and that must be found from cremation grounds. This discarded clothing was recommended as the best robe material which shows they had no value to others. The robe represented detachment, symbolized modesty, humility, simplicity and non-elaboration. The robes, shelter, food and medicine were intended to represent the "Middle Path" and symbolize the practice of simplicity in life.

2. Food (*Piṇḍapāta*)

   Piṇḍapāta bhojanaṃ nissāya pabbajjā

3. Shelter (*Senāsana*)

   Rukkhamūla senānsanaṃ nissāya pabbajjā

4. Medicine (*Gilānapratya*)

   Pūthimutta - bhesajjaṃ nissāya pabbajjā

The personal belongings of the Buddhist monk

The *'Aṭṭhaparikkhāra'* or an *"aṭa pirikāra"* is known as "eight monastic requisites" (*pirikāra*) which is accepted to be used by the Buddhist monk.

1. One sheet robe (*Tanipoṭa sivra*)
2. Double sheet robe (*Depaṭa sivra*)
3. Lower robe (*Andanaya*)
4. Belt (*Banda Paṭiya*)
5. Alms bowl (*Pātraya*)
6. Vixen blade or Shaving knife (*Delipihiya*)
7. Needle and thread (*Idikaṭu-nūl*)
8. Cloth filter (*Perahankaḍaya*)

The triple and five-fold robes

The robes worn by Buddhist monks and nuns of Sri Lanka today are thought to be unchanged from the original robes of 25 Centuries ago. The traditional outfit (Robe) is consisted of three parts:

1. *Uttarāsaṅga* or the one sigle robe (*tanipaṭa sivra*)

This is the most prominent robe and it covers the upper body. This comes over the *antaravāsaka*. It is sometimes also called the *kashaya* robe. It is a large rectangle, about 6 by 9 feet. It can be wrapped to cover both shoulders, but most often it is wrapped to cover the left shoulder but leave the right shoulder and arm bare.

2. *Antaravāsaka* or the double robe (*depaṭa sivra*)

The *antaravāsaka* is a waist cloth worn under the *uttārasaṅga*. It is an inner robe covering the lower body. It is the undergarment that flows underneath the other layers of clothing. It is wrapped around the waist like a sarong, covering the body from waist to knees. When needed, its height could be adjusted so it did not hang as low as the ankles.

3. *Andanaya or* the lower robe

When the Buddhist monk is staying at the temple they are wearing the lower robe, *"andanaya"* and the one sheet robe *"tanipaṭa sivra"*. When he is going outside the temple he wears the double sheet robe (*depaṭa sivra)*, *"antaravāsaka*" and it is also used as a seat by him.

The "*saṅghāṭi"* is an extra robe that can be wrapped around the upper body for warmth. When not in use, it is sometimes folded and draped over a shoulder. It comes over the upper robe (uttarāsaṅga), and the undergarment (antarvāsa).

According to the Buddhist Scriptures and the Commentaries, in the early monastic days, the monks would go out on their alms-round dressed only in their waistcloth which was neatly worn, and carrying their upper robe and bowl in their hands. When the monks were in the vicinity of houses, they would put on their upper robe before going to collect alms.

The original nuns' robe consisted of the same three parts as the monks' robe, with two additional pieces, making it a "five-fold" robe. Nuns wear a bodice (*samkacchika*) under the *uttarāsaṅga*, and they carry a bathing cloth (*udakasaṭika*).

4. *Saṃkacchika* or the bodice

5. *Udakasaṭika* or bathing cloth

Varieties of robes

1. *Paṃsukūla cīvaraya* (a robe prepared from a shroud) ,
2. *Kaṭhina cīvaraya* (a robe given to the priests who abide by precepts during the rainy season)

According to the cultural practice of Buddhism an offering of a *Kaṭhina cīvaraya* to a Buddhist monk it is said to have been considered as a great meritorious act rendered by Buddhists.

Other varieties of robes

In addition to that various cloths are recommended in the chronicle of '*Mahāvaggapāli' (Mahāvaggapāli,* part II,1957, (with Sinhala Translation), Ven. Pandita Ambalangoda Dhammakusala Thero, 669,669,721,723,725*)*

1. *Gṛhapati Cīvaraya*
2. *Poravana Saluva* (blanket)
3. *Diya Saluva*
4. *Hindana etiriya*
5. A piece of cloth to wipe the mouth

As the wandering community of disciples grew, the Buddha found that some rules about necessary. These are recorded in the *Vinaya-pitaka* of the Pali Canon or *Tripitaka.* There are four percepts/disciplines recommended for dressing and covering up the robe. The four percepts/disciplines described as below,

1. The lower robe should be worn to a one level (*Pariṇḍalākāra*). It should be a one level with no parts higher than others. Navel point and knees should be covered by the lower robe. From knees to calf there should be 8 inches covered by the robe.
2. When one sheet robe is worn its two lower ends should be at one level. This robe should be placed 4 inches above from the lover robe.
3. When going out from the temple it is recommended to cover the body with the double sheet robe properly. Then only the head, hands until writs and legs until the calfs are uncovered.
4. Shoulders and hands should be covered

A description of Mahāvaggapāli : Varieties of robes, methodology of dyeing and the patterns of the robe

Mahāvaggapāli records six varieties of robes of six varieties of textiles such as linen, cotton, silk, wool, coarse cloth and of hempen cloth (Max Muller, 1982). At that time the Buddhist monks accepted lay robes and they would seek cloths in the cremation grounds to acquire *paṃsukūla* robes (shrouds). The Buddha

recommended that any part of the cloth that was unusable was trimmed away, and the cloth be washed. Then the robe was dyed by being with un-boiled dye subsequently the cloth became ill-smelling. Then the Lord Buddha advises monks to use boiled dyes, which can be made by using little dye –pots. The robe dye is allowed to be obtained from six kinds of substances: roots and tubers, plants, bark, leaves, flowers and fruits The method of dyeing is explained as 'let a drop of dye fall into water, or on to your nail (in order to try if the dye is duly boiled) and also to use a (large) trough for dyeing (cloth) in (Max Muller, 1982. 205). At that time robes had become stiff because of too much dye. In order to have smooth robes the Lord Buddha advises to beating it with the by hands.

The pattern inspired by paddy field in Magadha

According to the *Vinaya-pitaka*, *Mahāvaggapāli* (Max Muller, 1982. 206-207) the Lord Buddha advises his chief attendant Ananda to make the robe by being inspired by the pattern of rice fields in the village of Magadha. Venerable Ananda observed the Magadha fields and sewed strips of cloth representing a paddy field into a pattern separated by narrower strips to represent paths between the fields. Ananda did this, and the pattern has been repeated on monks' robes in most schools of Buddhism ever since. The paddy fields can be roughly rectangular and separated by strips of dry ground for paths. The paddy field pattern in the Theravada robe shown in the figure 5 is in five columns, but sometimes there are seven or nine columns. *Kaṭhina* ceremony or 'robe giving' ceremony takes pride of place since such a robe can only be offered once a year only at the ceremony after vas (rainy season). The Buddha brought in a rule that a monk who had observed vas and completed the period could possess another robe in addition to the prescribed set of three (Max Muller, 1982. 233). Ananda Coomaraswamy (1956. 236) stated in Medieval Sinhalese Art, that current practice of offering *Kaṭhina* robes of Sri Lanka started by mid 20th Century. A meritorious act is held to be the presentation to the Sangha, at the close of vas or Buddhist lent, of *Kaṭhina* robes, i.e., priests' robes, spun, woven and made up in a single day. Coomaraswamy (1956. 236) cites Rupavaliya (trns. 48) that "even Kings frequently performed this ceremony, employing hundreds of persons in all such work as picking the cotton, after it is extracted from the fruit, weighing, converting it into balls, spinning, weaving, washing, cutting into pieces, stitching, dyeing". Poojavaliya mentions that eighty *Kaṭhina* robes had been made overnight completing all the workmanship including stretch from plucking cotton up to the finishing point. (Poojavaliya, 1999. 795). Thus on a certain occasion, King Parakrama Bahu II (1236-70), offered no less than eighty robes to the priesthood, in memory of the eighty chief disciples of the Buddha (Mahāvaṃsa, Ch. LXXXV). It mentioned some accepted colours of the robes too. It is further stated that "now at that time the *Chabbaggiya Bhikkhus* wore robes that are blue, light yellow, crimson, brown, black and brownish yellow or dark yellow colour. Robes that are all of a

blue colour are not to be worn. Who so ever wears them be guilty of a *dukkaṭa* (Max Muller, 1982. 247)

The present situation: Robes as symbols of power

Today the society has rapidly changed with the effect of neo-liberal individualist and consumerist society. People are more attracted to this modern consumer obsessed society; their attitudes may have influenced the behaviour of Buddhist monks too. Buddhist accepted way of living means that commitment to simplicity and detachment becomes problematic and questionable because the expectations of people grow high. According to this school of thought the monks wear clothes not to satisfy themselves, but for the reason to protect and cover the body. It is understood that the robe became a symbol of power; subsequently many monks became attached to many material possessions despite Buddha's teaching against it. Nowadays, the robe symbolizes wealth, power and strength. The colours of the robe vary by country, region, sect, position and occasion; they have become symbols to control human culture.

Robe dyeing of today: Case studies

The purpose of this chapter was to record the traditional robe dyeing processes and techniques that are still being practiced in Sri Lanka. There are five groups of people in the Western Province, Central Province and Southern Province that currently do robe dyeing annually during the *vas* period who were selected and their inherited practice recorded. Semi –structured interviews were selected as the method for data collection because that helps to investigate the situation in detail and obtain rich descriptions from the participants regarding the dyeing process and techniques. Interviews were conducted to obtain information regarding the source and type of natural dyes being used, dye process (recipe), mordant (fixing agent), colour fastness and durability of the final product. Follow up telephone interviews were conducted to clarify the process and techniques. Moreover, field observations were carried out to understand the dyeing process. Furthermore, colour and wash fastness properties were also investigated in detail for each of the colours.

According to the interview results a range of natural dye colour and natural mordant (fixing agents) were discovered. According to the respondents, the final colour of the material is depending on the dye recipe as well as the mordant. Usually plants extracts are used in raw form, or dried form, or powder form. From all three forms, colour intensity was found to be high. The most general method is plant extracts are chopped into small pieces, dried them in sunlight and grind them to obtain a dye power. Plant extracts are not only used as dyes, but also as a mordant (fixing agent) in the dyeing process. Either plant extracts or non-toxic mordants such as Alum are always being used in the dyeing process. Clay pots are used as the dye bath in which dyes and mordant are mixed with required amount of water and

boiled with the yarns using fire wood. The colour fastness to the fabric is checked time to time by visual observation and the fabric is kept in the dye bath until the cloth to absorb the expected colour evenly. Once taken out of the dye bath, the dyed cloth is dried in sun shed. Moreover, to achieve better colour fastness, chopped bombu leaves *(Symplocos cochinchinensis synonym: Symplocos stawellii)* are put into the cold water during washing.

A recipe from Western province

Dye substances

- Jak tree (heartwood) dust is used to obtain pure yellow colour which is for Siam ordination priests.
- Jak fruit (*waraka*) roots *(Artocarpus heterophyllus)*
- Mahogani roots/ bark/peals *(Sweietenia macrophylla)*
- Bombu leaves *(Symplocos cochinchinensis)*
- Dried areca nuts (*Karunka*) *(Areca catechu)*
- Dried *sepalika* flowers (*Nyctanthesarbor –tristis)*

The process

Each dye substance is wrought tightly as a pouch with cotton cloth separately then boils in 3 hours. The tanning is strained and then added to dye powders available in the market in order to achieve the required colour (such as yellow / marron/brown). Wetted cloth is dipped into the dye bath. A trough carved out of a wood (*Pandu oruva*) figure 1 shows a traditional utensil which is used for dyeing robe for ages is still used for dyeing. The cloth is spined in the wood trough in order to absorb the dye evenly. Then the cloth is dried in sun shade. The dye fades away in washing. Dyeing is done twice a month.

A recipe from Southern province

Preparation of yarn

80/2 gages grey yarns are soaked into liquidized cow dung and let aside for one day (24hrs) and washed in cool water. Washing is done until the aroma of the dung fades away.

Dye substances

- Rath handun powder **(***Pterocarpus santalinus)*
- Sudu handun powder *(Santalum album)*

- Mahogani roots/ bark/peals (*Swietenia)*
- Raw Jak fruit (*waraka*) roots *(Artocarpus heterophyllus)*
- Dried *sepalika* flowers (*Nyctanthe sarbor – tristis)*
- Turmeric powder *(Courcuma longa)*
- Raw veniwel geta pieces *(Coscinium fenestratum)*
- Aralu powder (*Terminalia chebula)*
- Welmadatiya powder *(Rubia cordifolia)*
- Banana stem (ambul) - *'sour'* plantaion *(Musa acuminata)*

Procedure

Grind ingredients altogether then keep one day for retting. The next step is to boil the sour mixture with alum for three hours then add yarns. Yarns are dipped in the sour mixture over night. Then the yarns are washed with cool water. Chopped Bombu leaves are added to washing water of the robe then the robe is woven.

Figure 1: Wooden trough[1]

1 Sri Senevirathnarama Uposhatha Rajamahaviharaya, Dodanthale, Mawanella.

Figure 3: Getting ready to cut the robe[2]

Figure 2: Dyeing the *'kaṭhina'* robe[3]

2 http://serendib.btoptions.lk/article.php?issue=48&id=1237#page
3 http://asbvihara.org.au/

Figure 4: Outer appearance of the finished robe[4]

Figure 5: The robe inspired by Magadha paddy field-orange colour[5]

4 http://exploresrilanka.lk/2011/08/sivura-the-story-of-the-saffron-robe/
5 https://www.buddhistdoor.net/features/the-making-of-a-monastics-robes

Figure 6: Dark maroon colour robe[6]

Varieties of colored Buddhist robes

Figure 7: Robe of light yellow[7]

Figure 8: Robes of crimson

6 https://henduwa.com/2016/03/26/the-meritorious-event-of-coloring-the-katina-robe/
7 https://www.masterfile.com/search/en/saffron+robe

Figure 9: Robes of dark orange

Figure 10: Robes of saffron and orange

Figure 11 :Shades of brown yellow robes[8]

Figure 12: The burgundy robes of Myanmar[9]

8 http://justfunfacts.com/interesting-facts-about-saffron/
9 http://israeliabroad.com/2017/01/09/a-morning-with-the-monks-of-myanmar/

Figure 13: Robe of brownish yellow

Figure 14: Robe of black and yellow ochre[10]

10 https://www.alamy.com/stock-photo-buddhist-monk-with-shaved-head-wearing-black-and-yellow-robe-standing-171459726.html

Figure 15: Robes of brownish yellow, orange, and saffron[11]

It is evident that different meanings were given to the robe from time to time, but practiced within the Buddhist philosophy. The colour 'Yellow' is bound to the Buddhism and has been practiced from time immemorial. It was considered a sacred colour and unacceptable to be worn by people other than spiritual personalities. The Buddhist monks have no substitute colour and yellow colour signified high position. Furthermore, yellow became the colour of renunciation. When the Franciscans visited Kandy during the days of King Vikramabahu (1542-1551) the sight of Buddhist monks were prominent to them because of the colour of their robes. It was expressed as, "Royal activities embellished the town with places of Buddhist worship and soon yellow-robed members of the Buddhist clergy were among the most prominent townsfolk" (Silva, 1967. 2). The importance that was given to the colour yellow by the society is reflected in the above statement, 'abandoning the yellow robe' to denote disrobing. There were deviant colours of Buddhist robe but they were hues of yellow. This unique colour remains as a sacred colour to date. Colour combinations are considered culturally bound with certain ideologies and traditions (Geboy 1996). It is important to remember that religion is an important part of culture, and that in every religion colours have their associations. In Sri Lanka the yellow coloured robe is a prime marker of Buddhist identity, so it is not surprising that normative texts, such as vinayas, contain a wealth of guidelines relating to its colouration (Heirman, 2014). It was identified that yellow colour was also the colour of discipline in life, physically or morally and spiritually, for it is the colour enjoined upon the Buddhist monks.

11 http://exploresrilanka.lk/2011/08/sivura-the-story-of-the-saffron-robe/

CHAPTER 2

The Buddhist robe in Sri Lankan art and sculpture

The tradition of the dress practice of Buddhist monks unchanged from its original form from the beginning of the Anuradhapura era of 3rd Century to the Kandyan Kingdom, (15th Century 1815) until end of the 18th Century. The outer appearance of the robe of a Buddhist monk is depicted in the same form in literary descriptions, wall paintings and sculptures from the early days to the eighteenth Century. Significant examples were supported by Samadhi seated Buddha image at Anuradhapura, Awkana standing Buddha image at Awukana, Anuradhapura and Buddha images at Polonnaruwa '*Gal Vihāraya'* (12th Century) and an array of visual representations at mural paintings at many Buddhist temples spread throughout the country show vivid hues of coloured robes.

The robe represents the Buddhist priest in Sri Lanka. Buddhism with its own ascetic customs was introduced to Sri Lanka from India in the 3rd Century Scholars of the era arrived at the conclusion that it was the Gandhara artists who created the first Buddha image. The well known author Ananda Coomaraswamy in his book titled "Theory of the Buddha Image" had stated that it was the Mathura (India) artists who created the first Buddha image. It was pointed out earlier that the Buddha image was introduced to Sri Lanka during the reign of King Dutugemunu, (161-137) and that it developed gradually to be carved on stone from the time of King Goṭhabhāya (249-62). Moreover, one notices that the early Buddha images were carved in the Samdhi Murda (Mediation posture). In early images the robe was worn to cover only one shoulder draping down to an unusual length. The robe had folds and is flimsy. The robe clings to the form of the body (Wijesekere, 1990. 20 -27). Touches of red colour could be seen in the arm pit of the Samadhi Buddha image, Mahavihara, may be the robe had been coloured in red.

The robe is depicted with reddish or yellow ochre in ancient visual representations. However, the material and colour has been subjected to change in order to show divisional differentiations later on. The robe, one of the major components of the Buddhist order which does not stand for fashion or style has remained as a documentary item of the order ever since. Hence, unlike on other

dress habits, foreign influences on the evolution of the Buddhist robe had been subtle until the 18th Century since it was introduced.

By the 18th Century the pious '*Theravāda'* Buddhism was almost stagnant. Therefore under the patronage of Kandyan Kings the higher-ordination had to be brought several times from Burma and Siam during the period between the 15th and the 18th Century Siam and Burma were pioneers to establish respectively '*Siam ordination'* and '*Amarapura ordination'* in Sri Lanka.

This period can be recognized as a transitional period of the evolution of the Buddhist priests' robe where a variety of changing and developing processes are evident. The main influences came from Siam from where higher- ordination was brought three times to re-establish the *'Upasampadā'* during the 17th and 18th Centuries. During King Narendrasimha's (1707-1739) reign the first embassy was sent to Siam. Jayathilaka, (1934. 39) suggests that this event seems to have taken place in the year 2231 which corresponds to year 1689 of the Christian era. The pattern of dressing, amount of utensils which belong to a monk was changed according to Siamese cultural and religious rituals.

King Vimala Dharma Suriya I (1591-1604) and Vimala Dharma Suriya II (1687-1707) sent mission to *Arakan* (Burma) to obtain *Bhikkus* for restoration of the higher-ordination (*Upasampadā)* (Geiger, 1953.100). Two embassies sent to Arkan by King Vimaladharmasuriya II (1687-1707 AD) for the purpose of bringing over competent monks to Ceylon to revive the 'Upasampadā' for Buddhist monks. (Mudiyanse, 1971-1974.26). In the meantime in 1803 Ven. Gnanavimalathissa of Ambaghapitiya brought higher-ordination from Burma and established the *Amarapura ordination* (Hettiaratchi, 1970. 721). Amarapura Nikaya, was established on the refusal of the Siyam Nikaya to grant Upasampada to non-Govigamas castes. Salagama Bhikkus in 1802 sent a mission to Burma to obtain valid higher ordination. In the first decade of the 19th Century, five delegations from the Salagama, Karava and Durava castes traveled to Burma for this purpose (Silva, 2005. 268 / 320).

These two ordinations were in charge of the Sri Lankan Buddhist tradition since then. Alms bowl and the table, Brocade robes were gifted by the Siam King during the Kandyan Kingdom. These are currently displayed at the museum of the Malvatu Vihāraya, Kandy.

Pictorial Narration: Evolution of the Colour of the Buddhist priest's robe.

The Buddhist robe is depicted in the temple paintings and sculptures of Sri Lanka. Ancient viharas of Sri Lanka are cave temples of the infinite Buddha. Over the course of several Centuries it has provided shelter to millions of pilgrims who have come in search of peace and salvation from the bonds of *samsara*. Thousands of images of Buddhas in sculptures and paintings in the cave temple have been created by skilled Sinhalese artists and craftsmen of centuries gone by (Senevirthne,1983).

The first colour depiction of the priest's robe is evident in the paintings of the religious site of Gonagolla of the 5th Century **(see figure 16)** (Bandaranayake 1986). Patches of pigment show a part of the face and draped torso of a Bodhisattva figure in a light red coloured robe which is delineated with red outlines, holding a lotus stalk with a female figure in *añjali mudra* in an attitude of worship. Bandaranayake (1986) suggests the female as 'An *apsara* with her head bent in supplication (action of a prayer) to a Bodhisatva. Appearing today almost a line drawing, in faded red, with touches of yellow ochre, orange. The foreground of the Bodhisatva shows orange colour bands.

Figure16: Paintings of Gonagolla of 5th Century

The next colour depiction of the priest's robe is evident in the paintings at the relic chamber of Mahiyangana Dagaba which belonged to the 8th Century (**see figure 17**). Patches of pigment show a retinue of priests; the figure of the foreground is prominent. The priest wears an orange coloured robe which depicts with raised hands in *añjali mudra* in an attitude of worship.

Figure 17: Buddhist priest in an orange robe, paintings of Mahiyangana Dagaba 8th Century

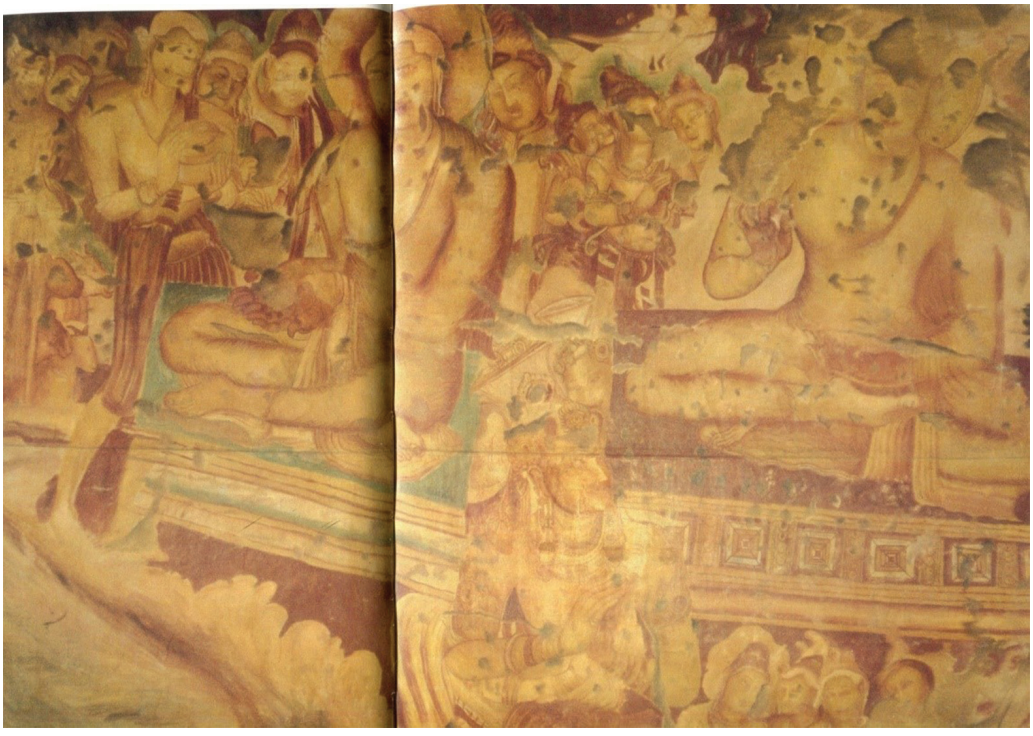


Figure 18: Buddha with yellow coloured robe: Hindagala temple painting
8th Century
Mahakanda, Peradeniya, Kandy.

The history of Hindagala Viharaya is dated back to the Anuradhapura period (377 BC–1017). Although no historical references are available, two rock inscriptions belonging to the 6th and 7th Centuries and a fragment of rock painting belonging to the same period indicate the early establishment of the temple (Coomaraswamy, 1927.163). Hindagala is a cave shrine. Inside the cave, a recumbent and seated Buddha images are visible. The seated Buddha image is believed to be built by Queen Henakanda Biso Bandara during the Gampola period (1341–1408) (De Silva & Chandrasekara, 2009.72). On the surface of the hood of the rock cave, just below the drip ledge, is a fragment of a mural depicting a scene from the life story of Buddha. This fragment of the painting shows "Visit of Buddha to Indasala Guha", two seated Buddhas in the midst of devotees are the center of the attraction (**see figure 18**). The painting in those at Hindagala cave shrine where narrative cycles are visible. It is the complex series of events in the narrative are reduced to only two scenes in the picture. There is a complex juxtaposition of panels, levels, and figures. The whole painting is yellow complexion. The foreground, represented by the lowest section of the painting, is occupied by the dramatic figure of Indra, whose turning head and torso mark and at the same time conceal the separation between one incident and the other. The robe of the Buddha is yellow coloured. A glimpse of red touches marked the shadow of the robe.

Figure 19: The Buddha in Tivanka image house of Polonnaruwa of the 11th Century

A mobile pose of the Buddha is seen only in Thivanka image house of Polonnaruwa of the 11th Century (**see figure 19**). A large scale painting of the inner shrine shows the Buddha descending from Tāvtiṃsa heaven to '*Sankassa'* on a golden ladder. They are carefully painted, with firm linear control, a clear statement of plastic quality and tonal modeling. A fine network of painterly detail combined with great poise. The narrative action or iconic grouping is usually centralized. (organized around a central figure) (Bandaranayake, 1986). The robe is of a reddish orange colour.

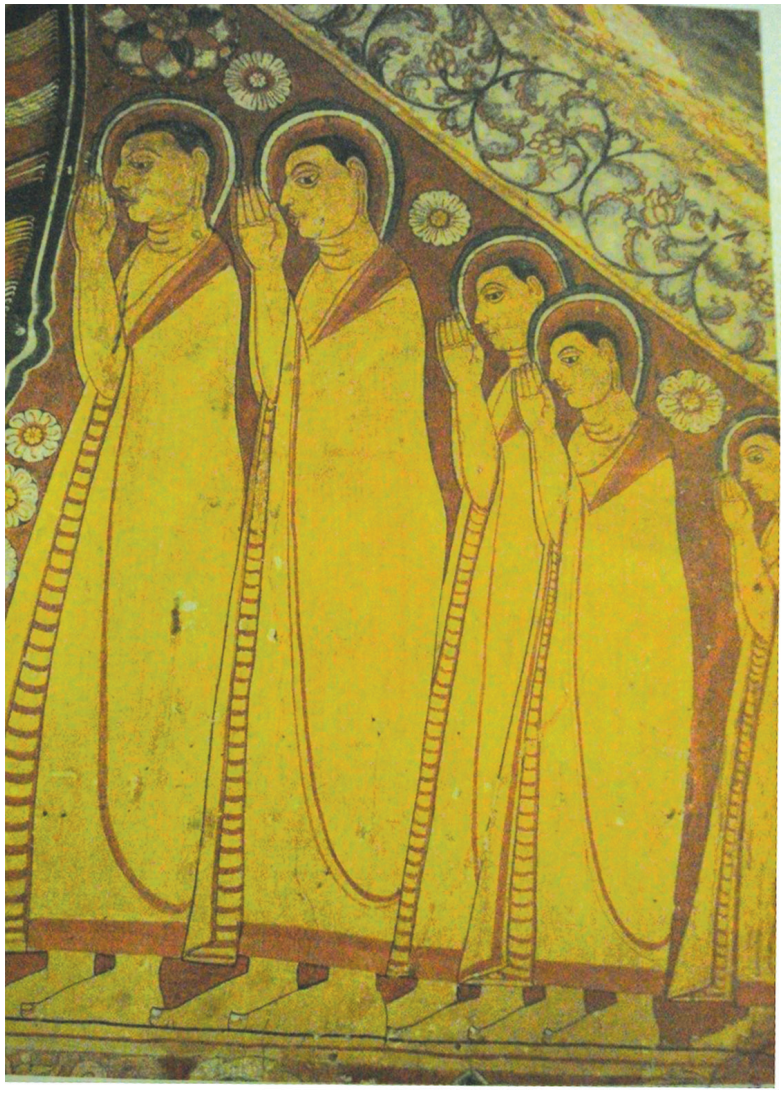


Figure 20: Sangha-The order of Buddhist monks: Hindagala temple, Hindagala, Mahakanda, Peradeniya, Kandy. 8th Century

A retinue of monks in yellow coloured robe is painted in Hindagala temple, Hindagala, Mahakanda, Peradeniya, Kandy (**see figure 20**). The style of the painting resembles the Kandyan school. The radiant circle over heads signify they depict *arhants*. The figures are well executed and brilliantly painted, brightest colours are illuminated with a number of figures in the same manner. All wore yellow coloured robes outlined by crimson lake red. The hem of the robe is marked by a wide red band which seems to be draped over the body and cascading over the nave.

Paintings of the Kandyan period are also found in several Buddhist viharas in Kandy and its suburbs, such as Degaldoruwa, Gangaramaya, Medawala, Sooriyagoda, Gadaladeniya, Lankathilaka, Hindagala and Ridi vihara in the Kurunegala District and Dodanthale in the Kegalle District.

Figure 21: Standing Buddha in red coloured robe in Dambulle cave temple; Dambulla

Dambulla possesses many Buddha images of sculptures and paintings. The colossal standing image wore a bright red coloured robe (**see figure 21**). The delineation of the folds of the drapery is shown as ridges. Senevirathne (1983) claims that some statues have a wooden framework plastered with mud and lime. Some of the colossal statues have a cotton robe over the plaster, on which the paint was applied. Most of the statues are painted with golden yellow, and a few statues also have a red coloured border on the robe. Frescoes radiate spirituality and serenity while in an apparent state of veneration.

Figure 22: Row of Buddhist monks with yellow coloured robes Gadaladeniya temple paintings.

Gadaladeni Vihara was built by Ganeshvaracari, the Architect from South India on a request made by King Bhuvanekabahu IV (1341-51). At the beginning, it was known as Dharmakirti Vihāraya. Gadaladeni Vihāraya shows the South Indian Vijayanagar tradition. A few ancient inscriptions are evident.

A large panel shows a painting of the Buddha and his disciples (**see figure 22**). The painting style does not show competency relatively to the best Kandyan school of art. The background colour is white and each monk represents with a circle of radiant ray over the head.

The robe is loose fitting, a heavy opaque garment of yellow ochre colour. The most common representation of the robe of the Kandyan painting style is the robe shown in concave ridges which is not evident in these robes. The body colours of the monks are in one colour, the robes are in another. Most of the Buddha figures and monks' body colour and the robe colour are same in other examples. This painting shows that traditional practice is always yellowish robe.

Figure 23: Ridi Vihāraya, Ridigama. 18th Century

The delicately modeled figure shows iconic forms setting standard Kandyan school style (**see figure 23**). The standing Buddha figure shows with right hand raised in abhayamudra. The Buddha is standing on a lotus pedestal. Eyes of the Buddha are elongated and half shut. The ear lobes are also elongated.

The robe is designed in traditional style, keeping the right shoulder and the right arm bare. The robe is shown in concave ridges and flaming siraspatha fitted with a central gem. The schematic lines on the robe of the Gampola period folds had, by this time, developed into the stiff and rigid lines (concave ridges) characteristic of the Buddha image of the Kandyan period. The figure shows an attempt to make the visual opaque formalized heavy drapery to appear close fitting. The border of the part of the robe that overhangs the shoulder and the bust of the image comprises, like those seen in the previous period, a sort of rigid band that reaches its lap (Wijesekera, 1990.140).

Kandyan artists had a limited palette of basic colours, red and yellow is prominent, and an abundance of line. Linework was widely used in decorating the sculpture. A standing Buddha sculpture clad in a yellow coloured robe. The robe is chrome yellow which is different from the colour of the robe which is seen in the Ridi Vihāraya. The colour of the robe and body colour are the same. A bright red band is shown at the hem and the left shoulder.

Figure 24: Enthroned Buddha clad in yellow coloured robe Lankathilaka temple paintings. 18th Century

Figure 25: Seated Buddha statute: clad in ivory coloured robe Sellawali temple, Gohagoda, Kandy.

The Buddha image belonged to the post King Kirthi Sri Rajasimhe (1747-82) period (**see figure25**). The Buddha robe is the same as the body colour, ivory. The robe shows neat pleats such texture on the surface. The robe is out lined by crimson lake red, a red band flows over the left shoulder and the hem of the robe is attached to a wide red band. From the point of view of painting it is considered the best representation of the Kandyan dress (Somathilake, 2003. 28).

Figure 26: Standing Buddha clad in red coloured robe: Sellawali temple, Gohagoda, Kandy.

The robe of the Buddha statue is bright red in colour (**see figure 26**). The background color is ivory, a neat rhythmic pattern of red has created a textural effect to the cloth. A red band of similar colour is thrown over the left shoulder and the hem is attached to a thick red band.

Figure 27: Standing Buddha clad in a yellow coloured robe: Sooriyagoda temple, Danthure, Pilimathalawa.

The robe is bright yellow (**see figure 27**). The body of the figure is in the same colour. The yellow robe is delineated by fine red rays of lines which give the effect of the texture of the cloth.

Figure 28: Rows of Buddhas in yellow coloured robes. Gangarama Rajamaha vihara, Lewella, Kandy.

18th Century

There are a large number of panels on the wall with paintings of the Buddhas (**see figure 28**). All Buddhas wore yellow ochre coloured robes. This method of covering walls with paintings of the Buddha in square panels seems to have become popular in and around Kandy at some stage during King Kirthi Sri Rajasimhe's (1747-82) reign (Somathilake, 2003.30).

Figure 29: Gangarama Rajamahavihara, Lewella, Kandy. 18th Century

Figure 30: Buddha at Gadaladeniya temple, Handessa, Gadaladeniya.

The standing Buddha is in a gold coloured body (**see figure30**). The robe is significantly different from the body colour which is in turmeric Yellow.

Figure 31: Buddha at the Gadaladeniya temple, Handessa.

The whole statue is applied with Gold colour including the robe (**see figure 31**). The hem of the robe is dull ash colour and may be the artist wanted to highlight the difference. The texture of the robe is depicted with neat rhythmic lines which is unique in all Kandyan paintings and sculptures. During the Anuradhapura era in the 3rd Century robes clung to the body with hardly visible details.

Figure 32: Venerable Valivita Saranankara Thero - Malwathu Vihāraya, Kandy

With the renewal of Buddhism a new form of Buddhist robe was introduced which is well depicted in the image of Venerable Valivita Saranankara Thero of the Malwathu Temple, Kandy (**see figure 32**). During the 18th Century pure Buddhism was almost diminished. Those who entered the Buddhist order continued without observing prescribed rites. They were known as *ganninanse*. Just after about eight decades since the restoration of the Order under the patronage of King Wimaladharmasuriya II (1687-1707) the community of *Sangha* again sank into deplorable depths of corruption. Even the admission to the order of *Sāmaṇera* was done in terms of *Vinaya* as no monk of Higher Ordination was available. They were known as *Ganinnanses* to differentiate them from the laymen. They lived a lax life engaged in secular vocations and maintaining families. (Senanayake, 2003. 6). They wore white or saffron coloured cloth rather than robes (Silva and Beumer, 1988. 113). They maintained moustaches and beards and even hair (**see figures 33 & 34)**.These *ganninanses'* presented a new image of the Buddhist priest in Sri

Figure 33: G*aninnanse* of Kandyan era[1]

Figure 34: A chief priest during King Rajasimha II (1635-1687) [2]

Figure 35: Buddhist priest during the Kandyan era. (Davy 1821)

1 Museum of Malwathu Vihāraya, Kandy

2 Knox R, 1966, *Historical Relation of Ceylon*, Tissara Prakasakayo, Dutugemunu street, Dehiwala, Colombo, p.141.

With the revival of Buddism brought by Siam, the simple way of practice of robe was modified with Siamese foreign influences. A luxurious value was given to the robe and all utensils as they were made of expensive foreign materials. Various materials, colours, different methodologies of wearing and different utensils came to be practiced during Kandyan reign. The robe was worn wrapping it around the waist and tightening it to the waist with a band. Different kinds of belts were used by both '*Nikāya's*. When the Buddha's robe is described, the belt is known as '*paṭi dhātu*' which is depicted as a thin belt in wall paintings and sculptures. This belt was used to tighten the lower garment to the waist. The early artists paid more attention to the aesthetic value in preparing the Buddha's outfit in detail. It is well evident from the image of *Avkana* and paintings of Mahiyangana (**see figure 17**) showing careful detailing of the texture of the robe that emphasizes the beauty of the body contours.

Fan (*Vaṭāpata*) has been used to get air circulation from early days. However, later it became as a symbol of dignity and appointment. When a venerable priest is appointed to a chief priest it is symbolizes by offering the '*Vaṭāpatha'*. Although it was a simple accessory to a priest in the early days and during the Kandyan reign it became a very luxurious and exclusive item that belonged to a high-priest. It became as an ornament which is clearly evident among *Siam Nikāya* priests. The *Vaṭāpatha* which was awarded to Ven. Sangha-Raja Saranankara thero (1698-1778) by King Kirthi Sri Rajasingha (1747-82) was made of brocade fabric and with a handle of ivory studded with precious stones (**see figure 37 & 38**). Moreover, according to early records many elaborate and luxurious accessories were gifted to Sanga Raja by the Siam King such as fans, brocade robes (**see figure 36**) and bags (**see figure 39**) and alms bowls. It was recorded that the offerings made to the Sanga Raja were as follows (Pieris, 2003.142).

220 pieces of red and yellow silk	Styli
30 red fans	Toothpicks (metal)
30 strings of prayer beads	Nailpicks (metal)
30 packets of needles	Looking- glasses
Arecanut cutter	Cloves, nutmegs, cinnamon
Chunam boxes	Wax candles
Scissors	2 alms bowls
Razors	1 web of cloth

Therefore as a result of receiving foreign gifts, Kandyan priests must have preferred exclusive textiles and accessories. It was recorded that the Siam King sent many items to the Tooth Relic (Pieris, 2003. 144).

I gold pagoda(varagan)	2 cloth water strainers
53 rupees	1 betel bag
50 current ridis	60 wax candles
1 ticclalridi	8bundles incense sticks
2 coloured cloths	1 long sandal wood
11 rolls of fine cloths worth 30 ridis	9 alms bowis
3 cloths,named Kavaniya, Samukkalama and Sarasaya	Needles
2 Lansolu cloths	Flowers
1 Silk tuppatiya	Lamps

Figure 36: A robe of brocade material of Venerable Velivita Saranankara Thero[3]

Figure 37: The Vaṭāpata(fan) awarded to the Sangha-raja as insignia of office by King Kirthi Sri Rajasingha.[4]

3 Museum of Malwathu Vihāraya, Kandy

4 Sir Jayathilaka (1934), Sarananakara the last Sangha-Raja of Ceylon,Visidunu Prakashakayo (pvt) Ltd, No 471, Lake rd, Boralasgamuwa, p.45.

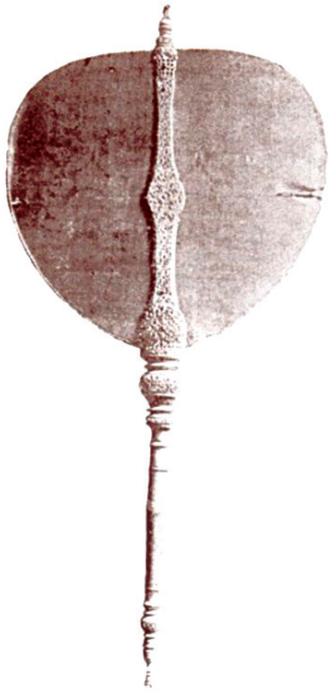


Figure 38: Original Vatapotha of Sangha-raja[5]

Figure 39: Brocade bag awarded to the Sangha-raja by King Kirthi Sri Rajasingha on behalf of the King of Siam[6]

5 Museum of Malwatta Raja MahaVihāra Kandy

6 Sir Jayathilaka D.B (1934), Sarananakara the last Sangha-Raja of Ceylon,Visidunuprakashakayo (pvt) Ltd, No 471, Lake rd, Boralasgamuwa, p.51.

Henry Olcott and Buddhists (Colombo, 1883)[7]

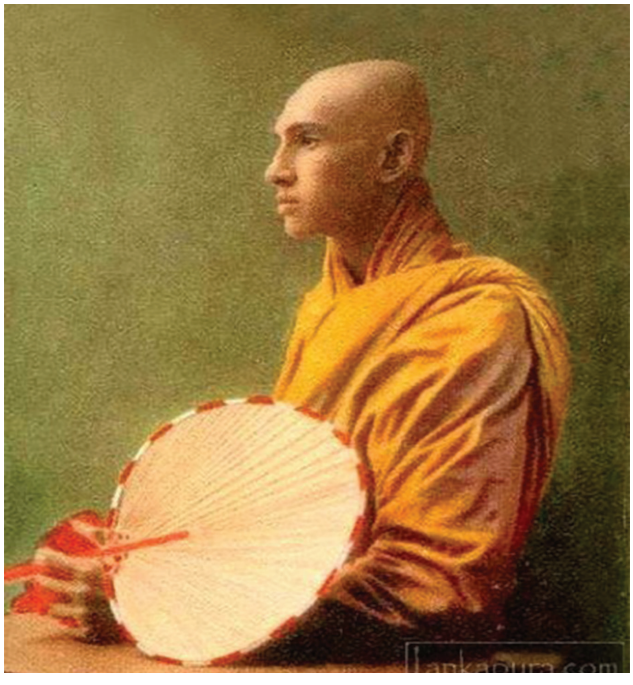
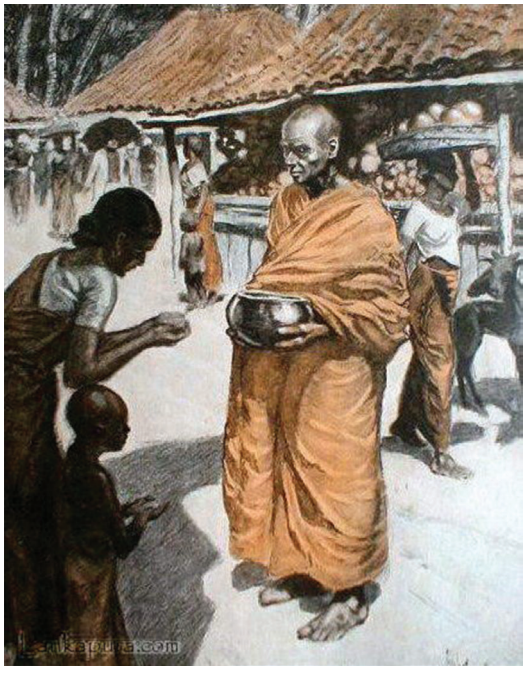


Figure 40: Buddhist priest in Sri Lanka late 1800[8]

7 https://en.wikipedia.org/wiki/Henry_Steel_Olcott
8 http://lankapura.com/2010/11/buddhist-priest-in-sri-lanka-late-1800s/

Figure 41: Buddhist Monks in 1880[9]



42: Buddhist Priest with the Begging Bowl, at Market Place in Ceylon Date: 1911[10]

9 https://www.pinterest.co.uk/pin/509399407822663934/Ceylon (Sri Lanka) Priests - c1880's

10 (http://lankapura.com/2008/07/buddhist-priest-begging-bowl/)

Figure 43: Mahāthera of Aurādhapura Mahāvihāraya. (early 20th Century) Three copies of the Visudhimagga being Presented to the Kelaniya Rajamahaviharaya, paintings by Solias Mendis. (1932-1946)

Figure 44: Mahanayaka Thero with 16th Diyawadana Nilame (1964-1975) of the temple of Tooth Relic, Kandy[11].

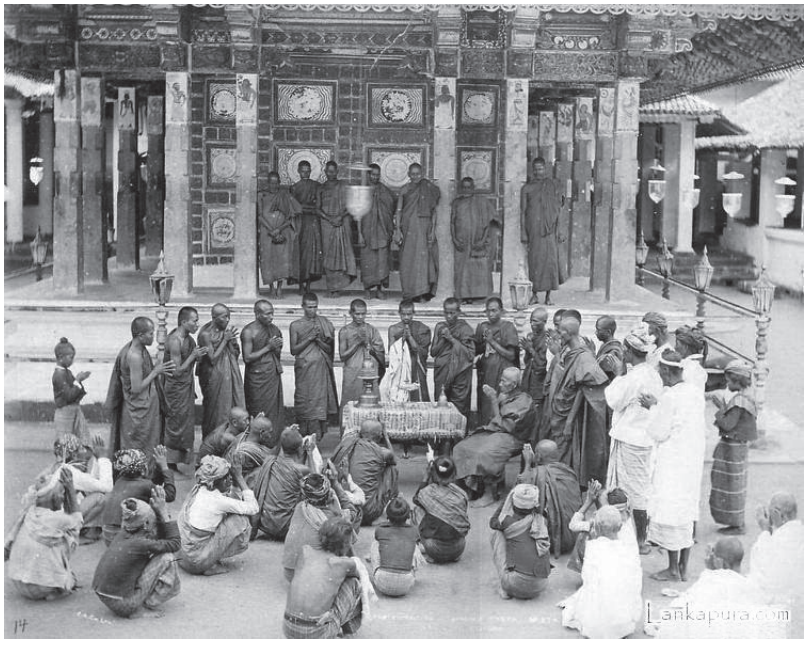


Figure 45: Buddhist monks of Sri Lanka[12]

11 https://en.wikipedia.org/wiki/Kandy_Esala_Perahera#/media/File:Diyawadana_Nilame_H.B_Udurawana_%26_Most_Venerable_Sirimalwatte_Ananda_Mahanayake_Thero.jpg

12 http://lankapura.com/2008/07/kandy-temple-monks-prayer-ceylon/

Figure 46: Buddha clad in orange colour robe- Gangaramtemple, Colombo today.

These historical visuals reveal that there are a number of ways the monks wear their robes (depending usually on their sect and country). The most universal one is that which is worn for the alms-round when the robe is covering both the shoulders. The two top corners are held together and the edges rolled tightly together. The roll is then pushed over the left shoulder, down the back, under the armpit and is pressed down with the left arm. The roll is parted in front through which protrudes the right arm. Within the monastery or residence and when having an audience with a more senior monk, a simpler style is adopted (as a gesture of respect and to facilitate work). The right side of the robe is pushed under the armpit and over the robe on the left leaving the right shoulder bare. The Buddhist monastic robe is so versatile that it can be used, besides as a blanket, a seat-spread, a groundsheet, a head-cover, and a windbreak too. It is easy to clean and repair. It is perhaps the oldest style of dress still in fashion after 2,500 years. By studying the Buddhist robe in a systematic way it is realized that the robes serve not just as a kind of uniform to remind the wearer that he or she is a member of a larger universal community, but is itself an object of reflection to be worn "properly considering them: only to ward off cold, to ward off heat, to ward off the touch of insects, wind, sun and reptiles; only for keeping myself decent" . Above all, they remind the wearer that he or she has committed him or herself to high spiritual ideals — to master the *Dharma*, liberate oneself and show others the way. The robes are meant to symbolize simplicity and detachment from materialism.

CHAPTER 3

Dyeing: ancient dye recipes
Colour Substances, Methods, Materials and Techniques

The art of dyeing of cloth is an ancient technique practiced by native artisans. Coomaraswamy (1913) states that 'Sri Lanka work is essentially cotton. ' Blue, white or red coloured works are applied to a blue or white background. King Wimala Dharma Suriya I (1591-1604) developed cotton farming during his reign (Abayasinghe, Dewaraja, Somarathne 1977, 48). Cotton was grown in the land of Vanni (Arasaratnam, 1958. 172). Discussing domestic dyeing in Sri Lanka Coomarawaswamy (1956) claims that "no yarn is now dyeied locally, except occationally with an aniline green. It seems, however, natural to suppose that the red and blue dyeing, with madder and indigo, used to be done by weavers themselves,but evidence to that effect is very scanty. Now a days, the red and blue yarn are available in Batticaloa as they are imported from India. The blue colour substance has been difficult to obtain earlier, then later black colour has been substituted,but the appearence has not achieved the expected level. It is seem that a better blue colour yarn is obtainable in Jaffna, and supposed to be supplied in some quantity of this to the Talagune weavers".

Ananda Comaraswamy (1907, 108 -113) in his study of dyeing in Ceylon explores two plants *Chaya (Oldenlandia umbellate)* and *Patangi (Coesalpinia sappan)* which were extensively used for dyeing in Ceylon in the following items, the old Kandyan flags and dewala hangings used to be so done, almost certainly by Tamil workmen. Painted clothes are popular in Jaffna for the Sinhala consumer.

1. *Chaya (Oldenlandia umbellate)*

Chaya[1] root can be seen only in the Northern province specially in the Mannar District (**see figures 47 & 48**). Coomaraswamy (1907) commented that the colour is a dull pinkish purple and very durable. During the British occupation in Sri Lanka the Jaffna cloth which was often dyed with Chaya and sappan was

1 In India it is called chay root or choy root, from its Tamil name, chaaya ver.

much esteemed and was exported in considerable quantities to the coast. Chaya root affords a fine dye and was used in Ceylon and India for dyeing cloth. The root grew wild in the Districts of Mannar, Jaffna patam and Vanniya and was monopolised by the Government (Silva, 1942.488). The cotton used for the coarser varieties was produced in Ceylon itself, for it grew well in various parts of the Island. The Dutch had established a plantation in Mannar which was in the North kept up until 1803 (Silva, 1942.523).W.C Gibson, a merchant of Galle, asked for a grant of 157 acres of land in Tangalla, on which to plant Indigo (Silva, 1942.325).

Family: Rubiaceae **Order:** Oldenlandia **Species:** O. umbellata

Figure 47: ***Chaya (Oldenlandia umbellate)***

Fiure 48: ***Chaya (Oldenlandia umbellate): (Whitney, 1911)***

Recipe 1 –

Ananda Comaraswamy (1907, 108 -113) (The full description of the dyeing process is given by S. Kartiresu in the Ceylon National Review, No 2,1906.)

Chaya root dyeing

The *Chaya* root is generally used in combination with other dyes, these are applied in the required places after the parts which remain white have been protected by bees wax, and then comes the dyeing proper with *Chaya* root. In an earthen vessel, some 4 or 5 gallons of water are gently heated and about a quart of *Chaya* root powder is put in and boiled gently, the heat must not to rise over 110^0 F. Now the cloth is allowed to boil for about two or three hours by keeping the same heat. It is taken out, dried in the shade, washed in cold water, and dried again. A second vessel is also made ready in a similar way, but in this case the water heat should be increased to about 145^0 F. A third vessel is also so made ready and the process repeated, the heat must be reached to 180^0 or 190^0 F. Then the heat melts the wax on the cloth.

Shades of *Chaya* root colour

- Dark reddish colour

If *alum*[2] (see figure 49) mixed with the *Chaya* root, a dark reddish colour will be achieved. The same colour can be obtained by soaking in the cloth of water with gallnut powder and leave it dry and again soak with water with alum.

- Black

The dyes used in combination with *Chaya* root to produce black or red lines are called *karam*. About 2 ounces of alum and 1 lb of iron filing or rust are put into a vessel containing about a quart of water and are left to lie for two or three days until the water gets dark. If the colour is not dark enough it is needed to add more iron to it. Furthermore, if iron is put into the water of a young coconut, in the proportion of about a pound to a quart may be used,and forms an indelible black if used on a cloth previously soaked in gallnut water; while for the colour red a 10 per cent. Solution of alum may be used on a cloth previously soaked in gallnut water. The parts to be so coloured are painted with the *karam* previously to the general dyeing with *Chaya* root, the parts to be white remaining protected by bees wax throughout.

- Red

Red *karam* is prepared without iron, and the cloth should be soaked in a mixture of gallnut powder and water.

2 Alum /ˈælum/ is both a specific chemical compound and a class of chemical compounds. The specific compound is the hydrated potassium aluminium sulfate (potassium alum) with the formula $KAl(SO4)_2.12H_2O$. Historically, alum was used extensively in the wool industry from Classical antiquity, during the Middle Ages, and well into 19th century as a mordant or dye fixative in the process of turning wool into dyed bolts of cloth. https://en.wikipedia.org/wiki/Alum

Figure 49 : Alum $KAl(SO4)_2.12H_2O$

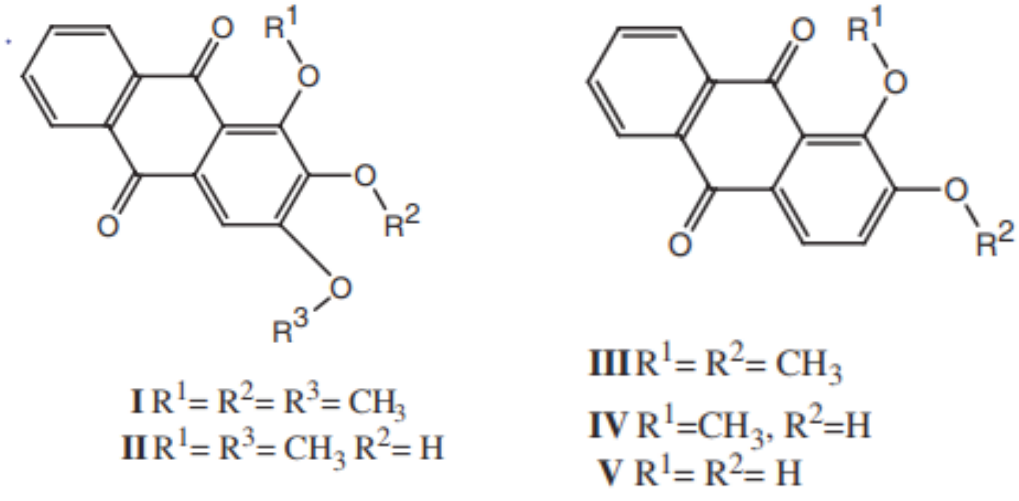


Figure 50: Phenolic components of chay root[3]

3 Siva Ramamoorthy a, Gaurav Mudgal a, D. Rajesh a, F. Nawaz Khan b, V. Vijayakumar b & C. Rajasekaran, 2010.

Patangi (Coesalpinia sappan)

Patangi is the most important of other Ceylon dyes. It is used for colouring palm and grass leaves for mat weaving, a fine red; it is also applied to rattan for baskets, to ola leaves for various purposes, and to the niyanda fibre used for making whips, brooms and mats. (Comaraswamy, 1907.108 -113).

family: Caesalpiniaceae **Order:** Caesalpinieae

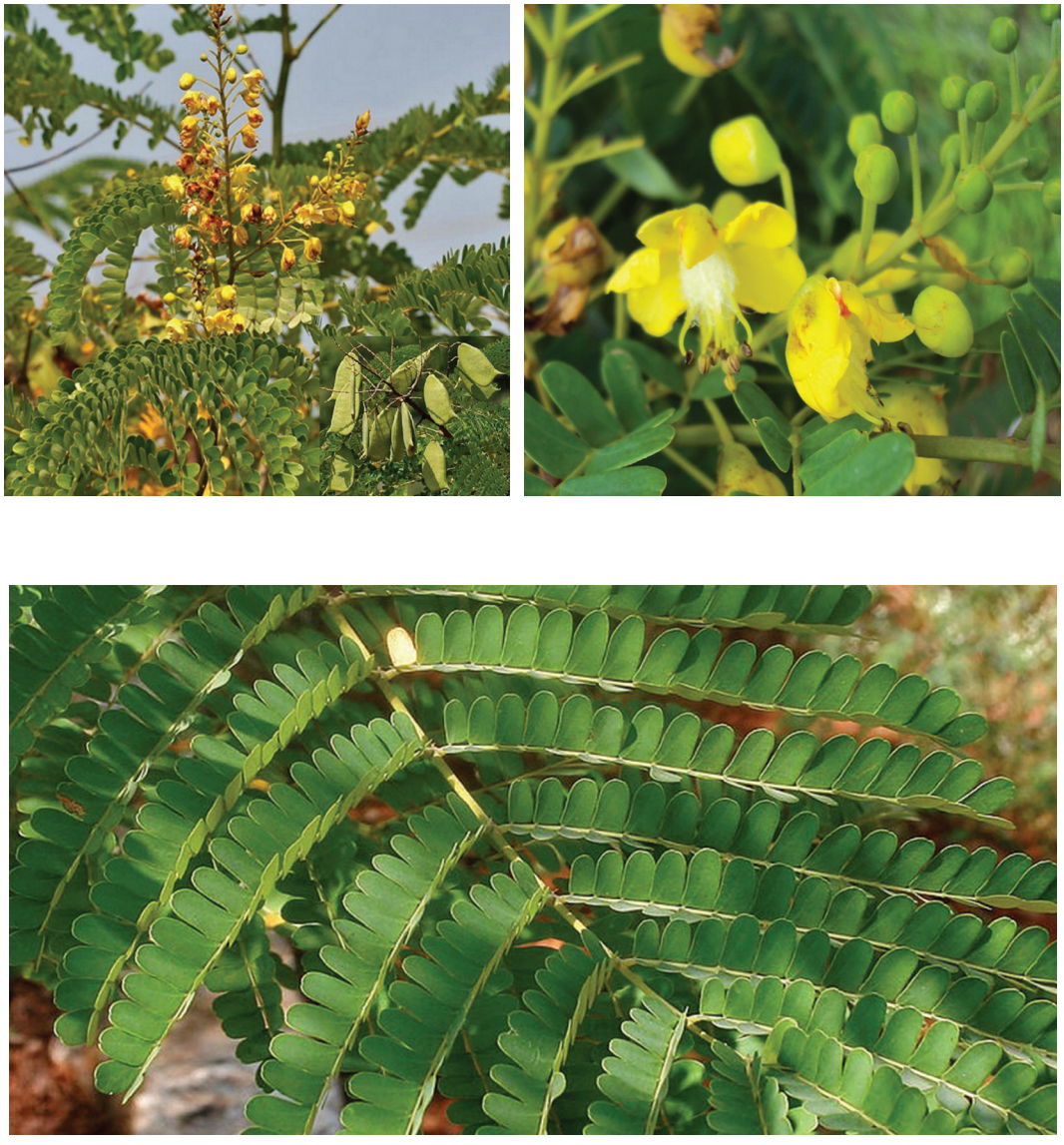
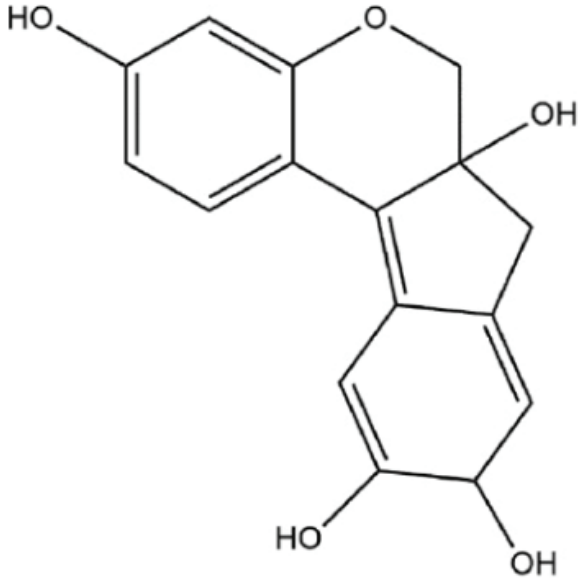


Figure 51: Patangi *(Caesalpinia sappan)*



Figyre 52:The chemical structure of Caesalpinia sappan[4]

Recipe 2

Ananda Comaraswamy (1907, 108 -113)

Patangi (*Coesalpinia sappan*)

Preparation of patangi

Method 1

On the first day two handfuls of korakaha leaves (*Memecylon umbellatum*) are pounded in a mortar, squeezed out in water by hand, and the resulting liquid, resembling pea soup, strained;two handfuls of patangi chips are added and the whole left to stand.

On the second day the solution has become red. The patangi chips are removed, pounded, and replaced, and the whole boiled with the indi leaves (*Phoenix dactylifera*) which is to be dyed, tied up in little sheaves.

The pot is allowed to cool and left till the next day.

4 Chartarrayawadee, W., Too, C. O., Ross, S., Ross, G. M., Jumpatong, K., Noimou, A., & Settha, A. (2017).

On the third day leaves of Bombu (*Symplocos spicata*), Hin-Bowitiya (*Osbeckia octandra*) and Korakaha (*Memecylon umbellatum/ memecylon angustifolium*), pieces of Kebella bark (*Aporosa lindleyana*) and a handful of chips of a yellow wood called Ahu (*Morinda citrifolia*) together with a small bundle of roots of Ratmulgas (*Knoxia platycarpa*) are pounded and added to the solution in which the indi leaves remain; the whole is boiled and then allowed to cool and stand till the next day, when the leaves are removed and dried, after which they are ready for use. Worthington (1959) explores that Bombu (*Symplocos spicata*) origins in Ceylon,India,China,Malaya and Japan. Korakaha (*Memecylon umbellatum/ Memecylon angustifolium*) has origins in Ceylon and South India. Kebella (*Aporosa lindleyana*) has origins in Ceylon and India. Ahu (*Morinda citrifolia*) has also origins in India and Malaya.

Preparation of patangi Method 2

The method 2 is popular in the Welimada area (hill contry). To a pound of galleha (another grass used for mats) take two pounds Korakaha or Weli-Kaha (*Memecylon caitellatum*), half a pound of Kiribat-mul (root of Knoxia platycarpa) two pounds patangi powder, four cents weight of green 'saffron' half cent weight of lime, and four pots of pure water.

Boil for three days, with a strong fire in the evening and slowing the fire during the night. The pot must not be removed from the hearth during the three days, after which the dyed grass can be removed and dried in the shade.

Shades of Patangi

- The red is made with Patangi with addition of Korakaha leaves and gingelly oil and alum.
- The yellow is obtained from the yellow wood of the Weniwel creeper (*Coscinium fenestratum*) and Kaha fruits (*Bixa orellana*).
- The black colour is produced with the help of gallnuts - Aralu (*Terminalia chebula*) and Bulu (*Terminalia beleria*) and rice field mud. The customary method of dyeing grasses or palm leaves black is to bury them in rice field mud, after soaking in an extract of galluts (*Aralu or Bulu*).The lower oxide of iron in the mud combines with tannin to form tannin of iron, or ink.

Figure: 53 Patangi *(Coesalpinia sappan)*[5]

Figure 54: wood pieces of patangi[6]

5 http://plantillustrations.org/illustration.php?id_illustration=121504&SID=0&mobile=0&code_category_taxon=9&size=1

6 http://wijayalintassamudra.blogspot.com/2014/12/receiving-raw-material.html

Dyeing properties of *Patangi (Coesalpinia sappan)* are varied. By manipulating the Ph of the dye bath by the addition of wood ash water or vinegar the dyer' produce everything from deep eggplant to lavender and maroon to a blood red colour. The mordanted dye with alum displays good fastener towards washing. Furthermore, the dye is reported to have anti-inflammatory activity. The pigment finds use in manufacture of facials which are resistant to light heat and water and are non-irritating. The wood was formally used in calico printing of cotton, wool and silk. (Badami, Moorkath, Suresh, 2004.76)

Figure: 55: Korakaha leaves
(Memecylon umbellatum)

Figure 56: Bombu leaves
(Symplocos spicata)

Figure 57: Hin- Bowitiya
(Osbeckia octandra)

Figure 58 : Kebella bark
(Aporosa lindleyana)

Figure 59: Ahu
(Morinda citrifolia)

Figure 60 : Weniwel
(Coscinium fenestratum)

Figure 61: Aralu
(Terminalia chebula)

Figure 62: Bulu
(Terminalia beleria)[7]

Wood of the Jak (*Artocarpus integrifolia*)

The yellow dye of priests' robes is obtained from the wood of the jak (**see figure 63**), in an extract of which the cloth to be dyed is soaked; the extract is sometimes boiled also with Bombu leaves (*Symplocos spicata*). The yellow dye is not permanent, but is easily renewed, and the colour improves with repeated applications (Comaraswamy, 1907.108 -113).

7 Figures55/56/57/58/59/60/61/62:http://nopr.niscair.res.in/bitstream/123456789/9400/1/NPR%203(2)%2075-82.pdf .

Figure 63: Jak (*Artocarpus integrifolia*) :
Jak tree trunk showing texture and coloration

Figure 64 : Leaves of jak tree[8] (*Artocarpus integrifolia*)

8 http://www.asia-medicinalplants.info/artocarpus-heterophyllus-lam/

Many plants have been practiced in dyeing in ancient Sri Lanka. The living tradition of Sri Lanka is well evident how exotic colours are produced by using numerous of floral and fauna. Madder (*Rubia tinctiorum*), Indigo plant (*Indigofera),* Kaha (*Bixa orellana*) or Turmeric and Arecanut (*Areca catechu linn*) are some of the dye substances which are mentioned in dyeing during ancient times of Sri Lanka.

Figure 65 : A sketch f Jak fruit tree (Bailey L. H. ,1917)

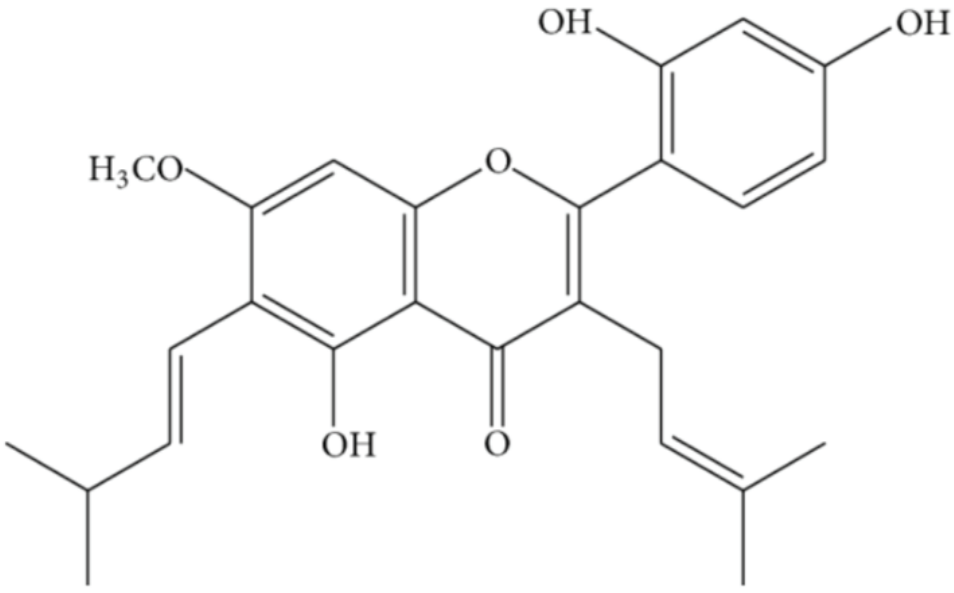


Figure 66: Chemical structure of Artocarpin[9]

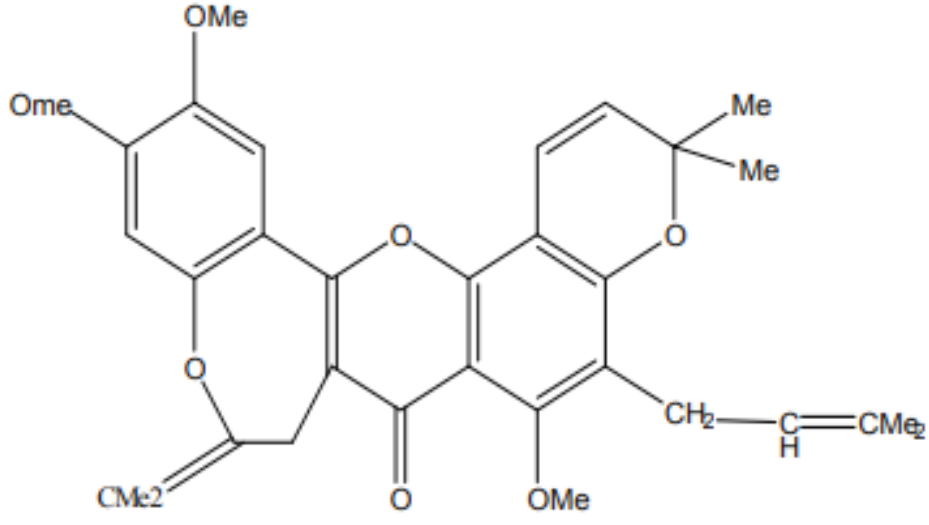


Figure 67: Chemical structure of Isocycloheterophyllin[10]

9 Hu, S. C. S., Lin,et al, 2014
10 Vankar, P. S., Shanker, R., & Wijayapala, S. (2011).

Madder *(Rubia Tinctorum)*

Madder[11] roots were used for dyeing during the Dutch occupation in Sri Lanka. The root was found in Ceylon. According to the traditional stories it was rarely been used for dye purposes in the country. The root is widely used in India for dyeing. The genus name Rubia derives from the Latin ruber meaning "red"[12].

Family: Rubiaceae **Order:** Rubieae

Figure 68: Madder *(Rubia tinctorum)*[13]

11 ***Rubia tinctorum***, the **common madder** or **dyer's madder**, is a herbaceous perennial plant species belonging to the bedstraw and coffee family Rubiaceae. It has been used since ancient times as a vegetable red dye for leather, wool, cotton and silk. For dye production, the roots are harvested in the first year. The outer brown layer gives the common variety of the dye, the lower yellow layer the refined variety. The dye is fixed to the cloth with help of a mordant, most commonly alum. Madder can be fermented for dyeing as well (*Fleurs de garance*). In France, the remains were used to produce a spirit as well. https://en.wikipedia.org/wiki/Rubia_tinctorum (Indian term: Manjistha)

12 (https://en.wikipedia.org/wiki/Rubia), (Madder: Encyclopædia Britannica, Volume 17, 1911)

13 https://en.wikipedia.org/wiki/Rubia

Figure 69: Madder *(Rubia tinctorum)*[14]

Figure 70: Madder (Rubia tinctorum)[15]

14 https://www.etsy.com/listing/646803719/madder-rubia- tinctorium-1oz-natural-dye

15 Darstellung und Beschreibung sämtlicher in der Pharmacopoea Borusica aufgeführten offizinellen Gewächse by Otto Carl Berg & Carl Friedrich Schmidt.

Leipzig, Arthur Felix, [1858-1863], 1. edition, volume 4, plate 30b. Hand-coloured lithograph (sheet 215 x 278 mm). Text enclosed. http://www.meemelink.com/prints_pages/22006.Rubia.htm

Figure 71: Dried Madder (*Rubia tinctorum*)[16]

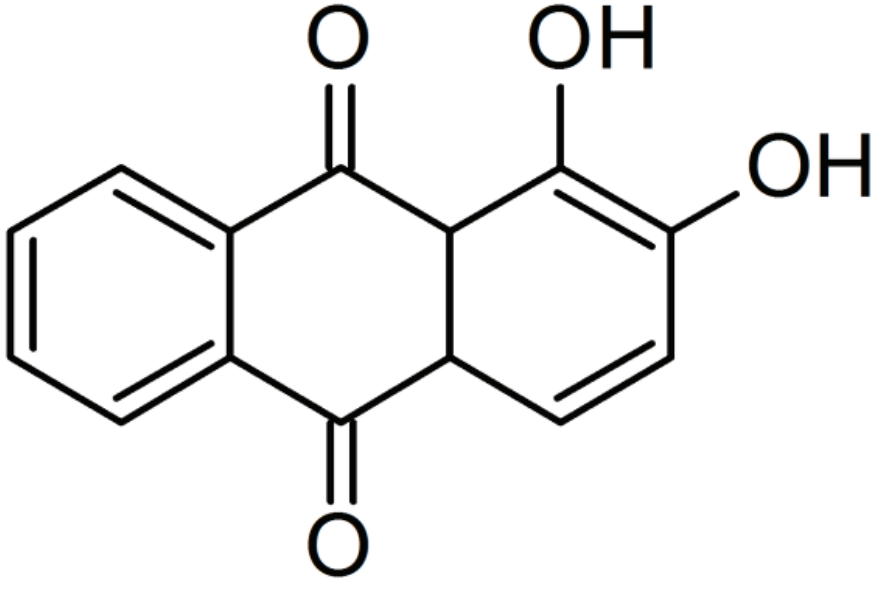


Figure 72: Chemical structure of Madder (*Rubia tinctorum*)[17]

16 https://www.amazon.in/Manjistha-Root-Majeeth-Indian-madder/dp/B079DF1BM3

17 Agnhage, T., Perwuelz, A., & Behary, N. (2017). Towards sustainable Rubia tinctorum L. dyeing of woven fabric: How life cycle assessment can contribute. Journal of cleaner production, 141, 1221-1230.

Figure 73: Naturally dyed skeins made with madder root

Figure 74: Naturally dyed yarns made with madder root[18]

18 https://kanakavalli.com/blogs/kanakavalli-journal/varna-sutra-raktha-the-colour-of-passion

Figure 75 : Hues of red : Naturally dyed yarns made with madder root[19]

Indigo plant (*Indigofera)*

Indigo[20] colour has been given a special value in dyeing. A wild indigo plant is seen in Northern Ceylon. It offered a bright pale blue dye, locally, but slightly used. The blue was also made use of as a pigment.

From the time of the Indus valley civilisation in the third millennium, Indigo and madder-red dyed cotton had been created on the Indian[21] sub-continent for

19 https://debmcclintock.me/2015/06/11/madder-exhaust-pigment-precipatation/

20 ***Indigofera*** is a large genus of over 750 species of flowering plants belonging to the family Fabaceae. They are widely distributed throughout the tropical and subtropical regions of the world. Several species, especially *Indigofera tinctoria* and *Indigofera suffruticosa*, are used to produce the dye indigo. Scraps of Indigo-dyed fabric likely dyed with plants from the genus Indigofera discovered at Huaca Prieta predate Egyptian indigo-dyed fabrics by more than 1,500 years. Colonial planters in the Caribbean grew indigo and transplanted its cultivation when they settled in the colony of South Carolina and North Carolina where people of the Tuscarora confederacy adopted the dying process for head wraps and clothing. Exports of the crop did not expand until the mid-to late 18th Century. https://en.wikipedia.org/wiki/Indigofera

21 http://josephcarinicarpets.com/blog/indigo-textiles

One of the first accounts about Indigo dying came from Marco Polo, the famous Venetian who explored Asia. He documented the dying process during his trip to India in 1298.

foreign customers. Fragments of Indian Indigo cotton batik dating from as early as the 6th Century has been discovered in a chain of sites along the ancient Silk road. Large numbers of Indian cotton fragments- decorated with mordanted dyes and batik stamp resist have been found at the old Islamic port of 'Fustat' on the Nile delta in Egypt and in coastal sites along the Red Sea, evidence of a vigorous trade to the Middle East spanning at least 500 years from the beginning of the second millennium of the present era (Maxwell, 2003. 112).

Ancient Cotton textiles decorated by dye are still in excellent condition. The reason was the technique that had been used. Since the dominant dye used, whether with block printed or hand drawn mordants, was the colour fast 'Turkey red' *chay* or madder, the designs still appear with surprising boldness despite their considerable age. In this decorative process, the application of chemically different liquid mordants to the surface of the cloth either with a series of carved wooden blocks or a slim pen like instrument resulted in design elements of different colours when combined with the same dye substance. In particular, iron oxide mordants created black dyes and potassium oxide led to bright red colour. Other substances and combinations resulted in browns and purples (Maxwell, 2003. 112).

The process of extracting blue colour from green leaves of indigo plant is a difficult and time consuming act. First the indigo pigment gets detached from glucose as the leaves are soaked in water and fermented. The leaves are taken out, leaving indigo in the water, which when exposed to air gives out a blue colour. This blue colour of indigo remains hidden until the leaf of indigo plant is fermented. After the water is whisked properly, the blue colour settles down forming watery clay. This sludge is then heated or sun dried to be made into cakes. Archaeological evidences show that the oldest natural colour ever known by mankind was Indigo.

Indigo plant *(Indigofera)*

Indigo dye

Figure 76: Indigo plant[22]

22 http://gaatha.com/the-story-of-indigo-2/

Figure 77: Indigo plant[23]

Figure 78: Grinding indigo solid colour bars[24]

23 https://gaiaconceptions.com/2016/12/15/20161215plant-medicine-indigo-indigofera-tinctoria/
24 http://josephcarinicarpets.com/blog/indigo-textiles

Figure 79: Dipping into dye bath[25]

Figure 80: Indigo dyed cloth from ancient Egypt : Metropolitan Museum; USA

25 http://josephcarinicarpets.com/blog/indigo-textiles

Figure 81: Stepping extraction of Indigo[26]

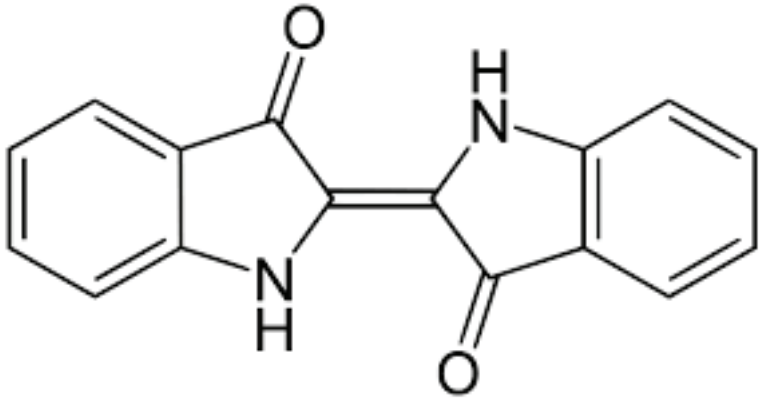


Figure 82: Common structure of some of the simpler indigoid dyes[27]

26 http://tdsblog.com/dye-off-natural-vs-synthetic/indigo-stepping-extraction/
27 http://www.asiantextilestudies.com/indigo.html

Rata Kaha /Anaththa or (*Bixa orellana*) or Turmeric (*Curcuma longa*)

A yellow dye is produced from the young fruits of Rata Kaha / anaththa *(Bixa orellana)* or from turmeric (*Curcuma longa*) which is pounded in a mortar, extracted with water, and boiled for an hour let to be dyed. Across Indonesia it is yellow, often a fugitive dye from turmeric related tubers. (Maxwell, 2003.74).

Figure 83: Fruits of the rata kaha *(Bixa orellana)*

Figure 84: Turmeric *(Curcuma longa)*

Arecanut *(Areca catechu linn)*

Abayasinghe (1969) claim that arecanut had been used for dyeing of cloth which is the largest industry in India. It was one of the most exported good from Sri Lanka during the Portuguese era (1597-1658). It is said that arecanut had been an essential ingredient in dyeing cloth during those days (Abayasinghe, 1969. 84). The Dutch had a trade transporting arecanut to Coromondal and selling it (Arasaratnam, 1958.158).

Figure 85: Arecanut (A*reca catechu linn*)

Important chemical classes of natural dyes

Chemical class	Natural dye sources	substrate	Colour produced
Anthraquinonoids	Madder *Rubia tinctorium*	Wool & silk	Pink, red, crimson orange, brown & maroon
Dihydropyrans	*Sappan*	Wool, silk & cotton	Crimson, black, purple

Natural yellow dyes

Class of dyes	Common name	Botanical name
Flavanoid dyes	Jak	*Artocarpus integrifolia*
Diaroyl methane	Turmeric	*Curcuma longa*

Natural red dyes

Natural source Plant source	Common name	Botanical name
	Madder	*Rubia tinctorum*

Natural brown dyes

Class of dyes	Common name	Botanical name
Anthraquinones	Chaya root	*Oldenlandia umbellata*
	Madder	*Rubia tinctorum*

CHAPTER 4

The science of dyeing

Dyes derived from natural materials such as plant leaves, roots, bark, insect secretions, and minerals were the only dyes available to mankind for the coloring of textiles until the discovery of the first synthetic dye in 1856 (Nimal et. al. 2015). In Sri Lanka dyeing Buddhist robe by using natural dye stuffs has a long history that goes back more than a thousand years. The richness of the availability of natural plant extractions of Sri Lanka provides myriads of avenues for promoting an indigenous colour code. The country's natural vegetation covers about one-third of the total land area, a resource that is both plentiful and a potential market for agriculture, textiles and product development. Sri Lanka is committed to economic development that is sustainable and economically friendly. In this context, the use of natural dyes is consistent with this policy. It offers the growth of more plant life, non-toxic chemical means of coloring and could ensure products that are completely unique to Sri Lanka.

Robe dyeing

The procedure of traditional robe dyeing was recorded after conducting an in-depth observation. The selected temple was known as Gallangolla which is situated in Kandy, in the Central Province of Sri Lanka.

The traditional procedure of dyeing a Buddhist robe is as follows:

The robe must be prepared by stitched pieces together according to the prescribed way as inspired by the paddy fields of Magadha.

Ingredients

Chopped jak (*Artocarpus integrifolia*) bark
Bombu (*Symplocos spicata*)
Salt (*Sodium chloride*)
A wooden dye bath (trough: *Pandu oruwa*)

Method

(a) The dye solution is prepared by boiling the chopped jak *(Artocarpus integrifolia)* bark with water until the required colour, dark yellow appears.

(b) The extracted solution is strained and used for dyeing.

(c) Prior to dyeing, the robe is soaked in the Bombu (*Bambusa vulgaris*) solution which is prepared by boiling 1.0 kg of Bombu (*Bambusa vulgaris*) chips in 8 liter of water for 2 hrs to remove impurities, then squeezed and left in the shade for a few minutes to dry.

(d) Then the robe is soaked in the solution of jak *(Artocarpus integrifolia)* extract for two hours until the required shade appears.

(e) The dyed robe is washed in clean water and dried under sunlight.

Figure 86: Dyeing the robe

Figure 87: Squeezing of dyed robe

The laboratory verification process of the traditional method of dyeing

1. 2 kg of matured bark chips of jak were dried in the laboratory oven under 37 ºC
2. Then dried chips were powered by using an industrial grinding machine and sieved to get finely powdered particles (355 µm).
3. 1 kg of the powder was added to 4 liters of water and boiled while stirring for one hour.
4. This was followed by the addition of another 4 liters of water to the same container to get maximum extraction from dye the particles (MLR - Material to Liquor Ratio used was 1:8). Then extracted dye solution was filtered by using a vacuum filtration unit.
5. The 5g of fabric pre- treated with extract of Bombu (*Symplocosspicata*) bark was dyed in a bath containing 30 g/l Sodium chloride salt and 250 ml of the extracted dye solution at 80 ºC for 30 minutes.
6. Prepared dye solution was put into the *"Pandu Oruwa"* (wooden trough).
7. The robe soaked in to the dye solution and kept for a few days 2-3 days and ensuring the uniform absorptive of the dye.
8. The robe was then washed, rinsed and the excess water squeezed out and the robe dried.

Selection of dye yielding bio-materials for natural dye extraction

A comprehensive literature survey was carried out to investigate the natural dye producing plants in the world and those which are indigenous to Sri Lanka. The initial selection of plants from the overall list of bio materials was carried out. After a comprehensive literature survey, about 90 natural dye giving plants were identified. (Taylor, 1986; Mell, 1929; Munidasa, 1988; Tilakasiri, 1994). (**See page 108**)

The literature survey revealed more than 50 different plant parts which could be used as raw materials for dyestuff extraction; a selection was performed with regard to the following requirements:

1. Production of the plant material in sufficient amounts with modern industrial methods including simple extraction methods to obtain the dyestuffs.

2. Formation of suitable classes of dyes which is, in their applicability, comparable to the classes of synthetic dyes in use at the present.

Plant raw materials which go as waste but still containing dye materials in relatively large quantity were selected. Some new natural dyeing methods were selected which are ecologically friendly and developed with less health hazards from a selected plant materials to investigate their suitability as textile dye.

Dyeing tests and quality criteria

The applicability of plant dyes for industrial purposes makes high demands on the quality of the product, especially with respect to transportability and shelf life of the dyestuff as well as to the standardization of high quality dyestuff and the reproducibility of the dyeing results.

In order to establish a resource efficient and economically viable product line, mainly residual material from the food and wood working industry were used as resources. The dye stuff product was assessed according to the following criteria:

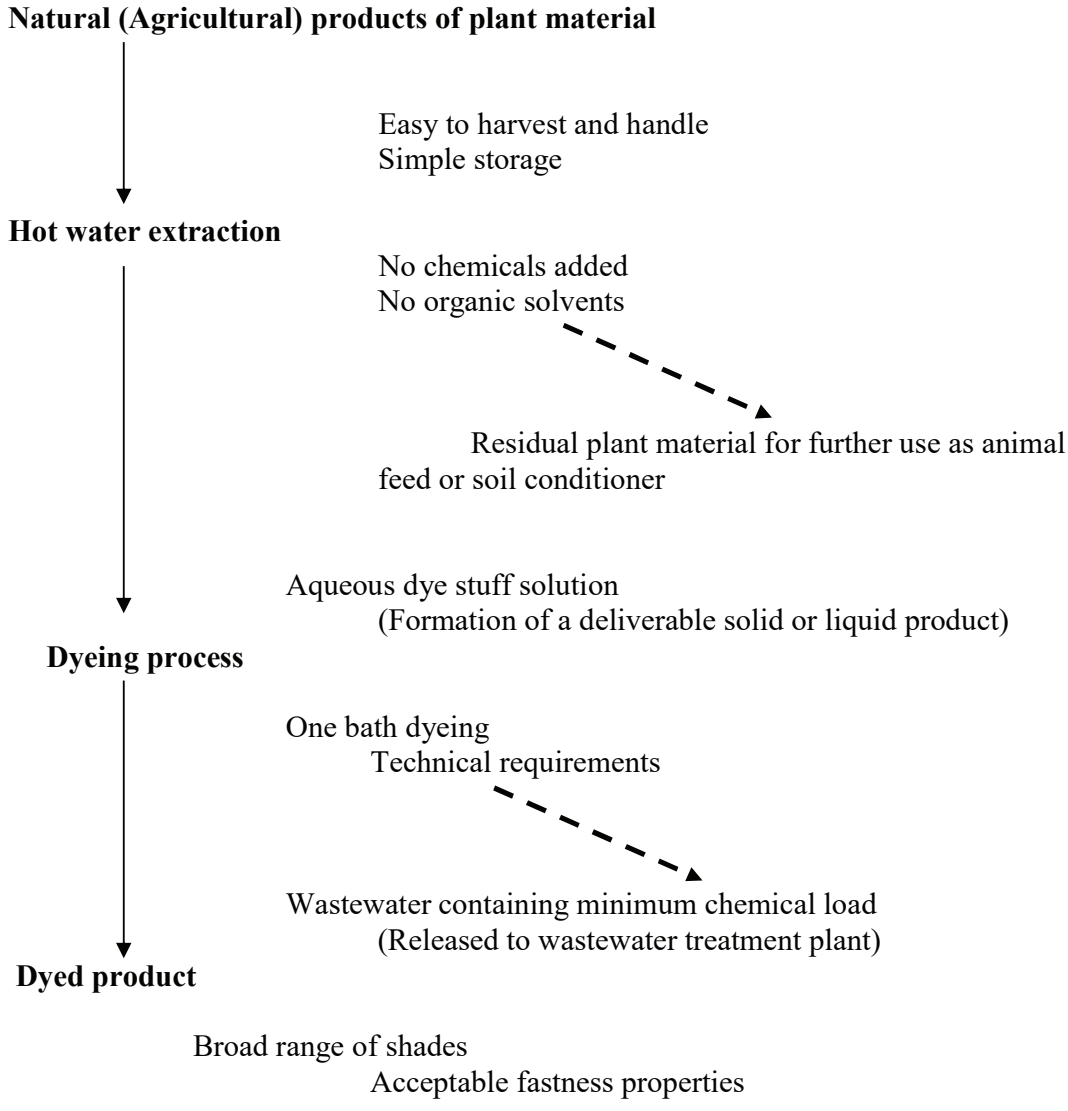
1. Availability of raw material at the lowest costs possible,
2. Possibility of making ready –to –use dye solutions,
3. Transportability and shelf life, in order to guarantee supra regional supply,
4. Manageability at operational level,
5. Material is ready to compost without further treatment and can be used for other purposes.
6. Use of watery plant extracts is possible, use of solvent and chemicals is not intended,
7. Good fastness of the dyed product,
8. Applicability to the dyeing of protein fiber (wool), cellulose fiber (linen, cotton).
9. Dye stuff which does not need mordant is preferred, if mordant is necessary, copper and aluminium mordant or bio mordant is to be used.

Sri Lanka is at an advantageous position since the country holds a rich reservoir of natural raw materials. Different parts (leaves, bark, seed, flowers, roots and woods etc.,) of a considerable number of plants have been reported to yield dyes, however a large number of them is hitherto unexplored. The number of possible plant sources was reduced by rigorous selection considering the main aspects given in the table below.

The main requirements for basic set of natural dyes

Agricultural demands	Requirements defined by a technical dye house
Reasonable requirements for production and harvesting of the plant materials	Simple and rapid dyeing process, no intermediate drying steps
Easy handling and storage of the raw materials	One-bath dyeing
High dyestuff content	Broad range of shades formed by a basic set of brilliant dyes, including dark shades (black)
Easy extraction with water	Applicability in dyeing machines in use today
	Easy correction of deviations in color depth and shade
	Acceptable fastness properties
	Observance of existing waste water limits, eg., heavy metals
	No use of mordants based upon Cu, Sn, or Cr salts
	Bio-degradability of dyes in waste water treatments
	Consumption of chemicals and energy comparable or lower than the current state of the art systems based upon synthetic dyestuffs

Extraction of the dye stuff and the steps of dyeing



Criteria of selecting appropriate materials to be dyed

A fabric character plays a pivotal role in the absorption of dye of a textile. Therefore fabric characterization needs to conducted in a physical testing laboratory.

1. Macroscopic features

Molecular Structure, Length, Cross section were determined by using laboratory microscope (Make: AJAY OPTK, Model: CM/L – 9010250, India).

2. Physical properties

Tenacity (g/den), stretch and elasticity were measured by using Universal Testing Machine (Make: Instron, Model : 4465, USA)

Moisture Regain - The fabric samples were conditioned in the standard atmosphere of 65% Relative Humidity and $27 \pm 2\ ^0C$ for four hours until the oven dry weight was obtained. Moisture regain was calculated using the following equation.

$$MR = \frac{IW - ODW}{ODW} \qquad \text{----------} \qquad (3\text{-}1)$$

Where, MR - Moisture regained
IW - Initial weight
ODW - Oven dry weight

Specific gravity of fabrics and yarns was calculated by using a hydrometer.

Pre- treatment: preparation of cloth for dyeing

Cotton Fabrics

Grey cloth, as it comes from the loom stage, is unattractive and contains natural as well as added impurities, which hinders the successful operations of dyeing by reducing the absorption capacity of the fabric, that's why it is necessary to make the fabric water absorbent, by making the fabric free from any natural as well as added impurities in order to achieve a successful dyeing process.

Methods of pre- treatments

1. De-sizing
2. Scouring
3. Bleaching
4. Mercerization

- **De-sizing**

  Gray cotton cloth was impregnated in 5 % Genencore GC 2X desizing agent with 10 % alkaline (NaOH) solution at 80 ºC for one hour with material to liquor ratio of 1: 50. De-sizing was done at pH 6.5 - 8.0 for 1 hr.

- **Scouring**

  Scouring was done to remove natural and added oil and waxes present in the de-sized fabric. The de-sized fabric was treated with 4 % Sodium Hydroxide and 0.5 % detergent solution at 95 ºC for 1 hour with material to liquor ratio of 1: 50.

- **Bleaching**

  The scoured fabric was treated with 35 % Hydrogen peroxide solution at 90 ºC for 1 hr keeping the material to liquor ratio at 1:50 to remove natural colouring matter.

- **Mercerization**

  De-sized, scoured, bleached fabric was subjected to be mercerization at a low temperature under tension. 20 % NaOH, 52 Sec. under tension at 20 ºC.

  5 g samples of each prepared fabric pieces were dyed individually with 47 selected extracts of bio-materials.

Silk fabrics

The *Munga silk* of 45 g/m^2 fabric was scoured with solution containing 0.5 g/l sodium carbonate and 2.0 g/l non-ionic detergent (*Labolene*) solution at 40 - 45 ºC for 30 min, keeping the material to liquor ratio at 1: 50. The scoured material was thoroughly washed with tap water and dried at room temperature. The dried scoured material was then soaked in clean water for 30 min prior to dyeing or mordanting. Degumming was carried out by treating 5.0 g sample of silk with saturated hot soap solution at pH 10-12 for 45 min to remove natural gum present in silk.

Wool yarns

The cleaned wool yarn of 60.0 g sample was scoured with solution containing 2 g/l non-ionic detergent (*Labolene*) solution at 30-35 ºC for 30 min, keeping the material to liquor ratio at 1:50. The scoured material was thoroughly washed with tap water and dried at room temperature. The scoured material was soaked in clean water for 30 min prior to dyeing or mordanting.

Silk and wool were directly pre-mordanted with metal salts; no tannic acid treatment is required for these fibers.

Methods of extraction of colour yielding parts from the bio-materials

The following sequence of processes was followed to obtain colour yielding parts from the bio- materials.

- Drying
- Grinding
- Sieving
- Extraction
- Filtration

Drying

Most of the plant materials were dried in a laboratory oven (Make: SDL Atlas, Model : DP61,UK) at 37ºC until all the moisture evaporated from the bio-material and a constant weight was obtained (Oven dry weight).

Grinding

Dried materials were powdered to fine particles to obtain maximum extraction of colouring material from the bio-materials. This was carried out in an industrial type grinding machine at 6000 rpm. (Make: Hauser, Model: S45-400, UK).

Sieving

Ground raw materials were subjected to sieve analyzer (Make: Cilas , Model: 1190 , UK) to obtain fine sand of uniform particle size (355 μm) of the raw materials.

Laboratory equipment for colour extraction

Figure 88: Combined Laboratory Oven & Incubator
G209A/B
Dual purpose for both perspiration and oven-dry tests with high accuracy.

Figure 89: Hardinge, Hauser S45-400 Jig Grinder

Figure 90: electromechanical sieve shaker Cilas, Model: 1190, UK

Methods of extraction of colorants

The dye yielding components of the bio materials were extracted by the following three methodologies:

- Aqueous extraction
- Solvent extraction
- Sonicator extraction

Aqueous extraction

Raw materials (2.0 kg) were subjected to grinding and sieving. Ground and sieved raw materials (1.0 kg) were soaked overnight. The MLR (Material to Liquor Ratio) of extraction bath was 1:8. For 1.0 kg of raw material initially 4 liters of distilled water was added and plant parts were boiled. After about 1 hr another 4 liters of water was added to the same extraction to ensure maximum extraction of dye yielding parts from the raw material. Extraction was carried out until the volume of bath reduced to 1 liters for 2 hrs. After that it was left to cool down. This can be considered as concentrated natural dye and was used for dyeing of fabric samples. **Figure 91** shows the extracted dye solution of R. cordifolia (Welmadata).

Experimentations of liquor volumes

Wt. of raw material (kg)	Liquor volume (ml)	Final liquor volume (Concentrated) (ml)
1	4000 + 4000	1000

Figure 91: Aqueous extraction of *R. cordifolia* (Walmadata)

This aqueous extraction procedure was repeated for all the selected 47 natural dye yeilding bio-materials. (**see page 106 / 107 - Chart B**)

1. Solvent extraction

Sometimes colourants, present in natural sources, did not get extracted into the aqueous medium. In such a case, a soxhlet was used to extract the natural colorant in the organic solvents. Mainly, the solvent used was Methanol.

Figure 92: Solvent extraction unit

Coloring matters were extracted by using the solvent extraction method. The Bio-materials were cut into pieces, dried and were refluxed in a soxhlet with methanol till it discharged the colour. The extraction process was carried out for 4-6 hrs. This method was used for extraction of colouring matter from the finally selected ten samples. (**see page 106 - chart A**)

2. Sonicator extraction

Figure 93: Sonicator

The extraction of colouring matter from bio-materials was carried out by using the sonicator. 100g of finely ground raw material was added to the sonicator bath. The sonicator used was of 20kHz frequency and 150W, (Make: Julabo, Model :30, India). When the bath is irradiated with high energy, ultrasonic cavitation occurs which releases considerable amount of energy due to collapsing of the bubbles. This increases with the surface tension at the bubble interface and decreases with the vapor pressure of the liquid. Since the aqueous extraction bath has water, which has comparatively high surface tension, it is a very effective medium for extraction of the maximum amount of coloring component.

3. Filtration

Figure 94: Vacuum filtration units

The insoluble residue was separated by sedimentation and filtration through a stainless steel filter fabric (0.3 mm mesh). The extracted dye samples were cooled and were subjected to filtration to get rid of fine solid particles to prevent deposition on the fabrics. The filtration was carried out by using a vacuum filtration unit (Make: Millipore, Model: HAWP04700, Thaiwan). The resulting extract was used for the dyeing of fabrics.

4. Mordanting

Three basic methods of mordanting are in vogue on yarns / fabrics. The use of different mordants changes the colour of a dyestuff and enhances the colour stability.

Dyeing would depend upon the type of mordanting used. There are three methods of mordant as follows:

(a) Pre-mordanting

The cotton fabric was treated with 4 % (owf) solution of tannic acid prepared in water. The fabric was dipped in tannic acid solution for at least 4-5 hours and covered to avoid patchy stains on the fabric which was squeezed and dried.

In this method the yarn/fabric was mordanted in the first stage and then dyed in the second stage. An aqueous solution was prepared by dissolving the required amount of suitable mordant in water. The yarn/fabric was immersed and boiled for 30 to 45 min in the mordanted solution. The yarn/fabric was dyed in the prepared dye bath.

(b) Simultaneous mordanting

In this method the mordant and the dye were applied simultaneously in the same bath. The yarn/fabric was dipped in the extracted dye liquor and boiled for 15 min. The required amount of mordant was added to the extracted dye solution and stirred well and boiled for 30 to 45 min. Then the fabric was washed, rinsed and dried.

(c) Post-mordanting

In this method the fabric was first dyed and then mordanted. The dye solution was prepared. The yarn/fabric was dyed in the dye solution. The aqueous solution was prepared by adding the required amount of suitable mordant. The dyed material in the mordanting liquor was boiled for 30 to 45 min.

Types of mordant

Two types of mordant were used to enhance the performance properties of dyed materials.

1. Synthetic mordant

Synthetic mordants are chemical substances which fulfill the above purposes. Some common synthetic mordants were selected to use with plant colorant extracts (eg. Ferrous sulphate, Potassium dichromate etc,).

2. Natural mordant

These are natural substances which give the above mentioned properties. The common natural mordants used were Aralu (*Terminalia chebula*) and Sepalika (*Nyctanthes arbor-tristis*).

Different dyeing conditions

During the dye stuff selection, a one bath dyeing process with the addition of the mordant into the dye bath was investigated to serve as the general dyeing procedure instead of a two bath dyeing step with separated mordanting. The selection of a one bath dyeing procedure was made with regard to the demands of the textile dyers, who would reject a two bath dyeing process with the arguments of handling, time consumption, and risks of lower reproducibility. The possibility for a variation in colour depth and shade with the use of dyestuff mixtures and mixed mordants was found.

Initially extracted colourants were used to dye mercerized cotton fabric at 40 ºC, 60 ºC, and 80 ºC. From the above temperatures the best performing temperature was selected. Then the salt concentrations were varied. (i.e. 10.0 g/l, 20.0 g/l, 30.0 g/l). From these salt concentrations the best possible salt concentration was selected based on the better dye uptake and fastness properties.

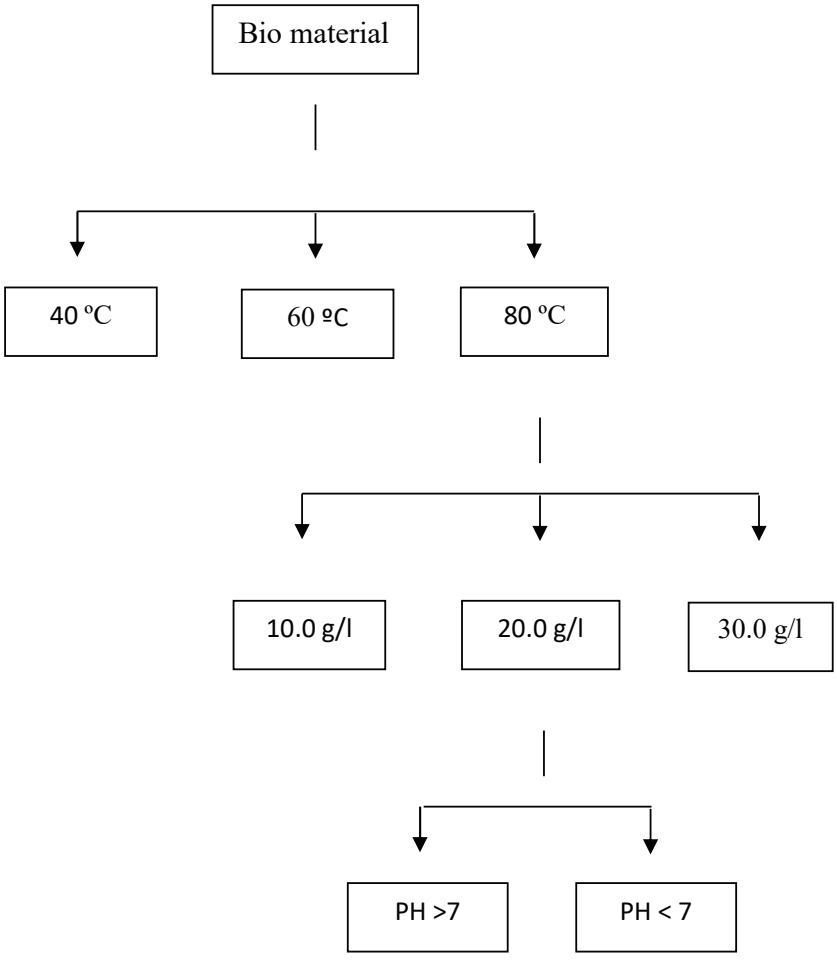
With the optimization of the above parameters, pH of the individual dye baths was varied. i.e. pH <7, pH =7, pH >7. pH of these dye baths were measured by using a pH metre (Make : Hanna: Model : H1 8314, Portugal). pH of the aqueous dye baths were determined by directly inserting the pH meter into the dye bath while for methanolic extracted dye baths, the methanol was evaporated and extracted dye was dissolved in water. pH was measured in this aqueous solution.

By using the above optimum conditions, samples were generated for all (47) selected bio - materials. (**See page 106 and 107 - chart B**)

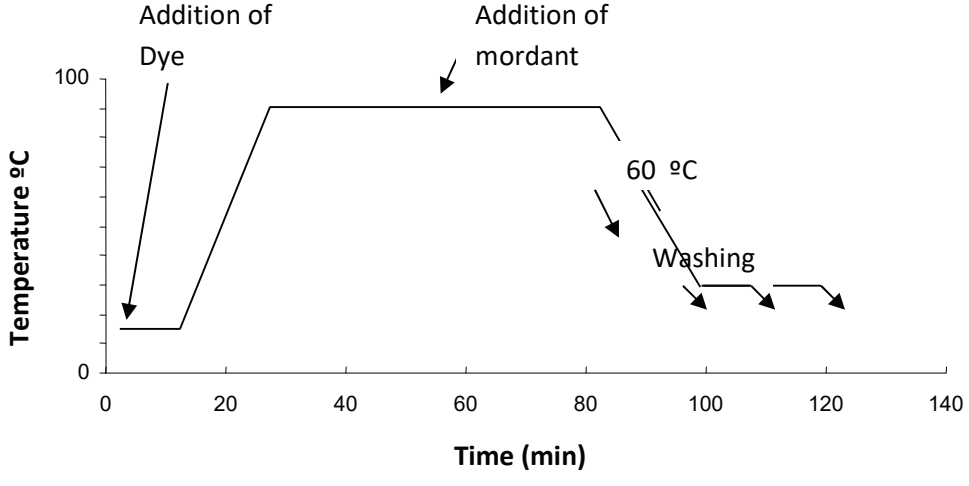
Levels of temperature, salt concentrations and pH conditions followed are illustrated in the figure below.

Selection of optimum conditions for dyeing

Levels of temperature, level of salt concentrations and pH conditions



Temperature time diagram for dyeing process



The dyeing was performed on cellulosic material by the exhaustion method using a MLR of 1:20 (For 1.0 g of fabrics/yarn 20 ml of liquor) with cellulosic material.

Bleached wool yarn (10.0 g) was used as a protein fiber substrate with M.L.R. 1:20 at50 ºC for one hour. The dyeing trials were performed in a sample dyeing machine according to the temperature dyeing diagram given in **page 98**.

Techniques used for dyeing

Two techniques of dyeing were used to compare the shades of dyed fabrics or yarns.

1. Conventional Dyeing
2. Sonicator Dyeing.

Conventional dyeing

Conventional dyeing of substrates was carried out at 95 ºC for one hour in the sample dyeing machine (Make: Colour Pet 12, Model: 12 LMP, Japan) in the laboratories of the Department of Textile and Clothing Technology, University of Moratuwa, Sri Lanka.

Figure 95: Conventional dyeing in sample dyeing machine

Sonicator dyeing

Sonicator dyeing was carried out in the facility for Ecological and Analytical (FEAT) laboratories in the Indian Institute of Technology, Kanpur, India. The same equipment (Make SR05: Model: Julabo, India) used for extraction was used for dyeing.

In sonicator dyeing 250 ml of extracted dye was added at the beginning to the dye bath. In all the dyeing processes, tap water was used. In sonicator dyeing, extracted dye was taken into sonicator bath and the treated fabric was dipped in for one hour at 40 ºC. Dyed fabric was dipped in 4 % sodium chloride solution for one hour and then fabric was washed with tap water and dried.

Methods of evaluating performance properties

There are four types of standard methods used in evaluating the performance properties of fabrics. Four types of evaluation of fastness properties were carried by using a wash wheel, Microscal, Crock meter and Perspirometer respectively. The standardized methods of fastness testing are given in the table below.

Standard reference numbers for fastness testing

Test Parameter	Standard Reference Number
Colour fastness to Washing	ISO 105 C01 05
Colour fastness to Light	ISO 105 B02
Colour fastness to Rubbing	ISO 105 X12
Colour fastness to Perspiration	ISO 105 E04

1. Colour fastness to washing

For colour fastness to washing, ISO105 C 01 05**,** wash fastness ratings from 1 (fading) to 5 (excellent fastness) were used (See page 101).

2. Colour fastness to rubbing

This test method assesses the resistance of the colour of textile materials to rubbing off in the dry state or in the presence of moisture or solvent. Such rubbing of colour may result in fading or streaking, and/or staining of other materials.

Colour fastness to rubbing, ISO 105 X 12, rub fastness ratings from 1 (fading) to 5 (excellent fastness) were used, similar to standard wash fastness ratings.

Wash fastness (WF) and Rub Fastness (RF) ratings

Rating No.	Description
1	severe fading
2	Poor fastness
3	Medium fastness
4	good fastness
5	Excellent fastness

3. Colour fastness to light

Colour fastness to light, ISO -105 – B 02**,** a Microscale to measure resistance to fading using a laboratory apparatus (Microscal–James H. Heal, UK) was used under the following conditions: light-exposure system featuring an air-cooled Xenon arc discharge lamp simulating outdoor global radiation; irradiation on sample level λ 300–400 and 400–700 nm; test chamber temperature: 25 °C; and relative humidity 65 %. A light fastness rating from 1 (severely fading) to 8 (excellent fastness) was made by comparing the resistance to fading of each sample to that of eight different blue tones.

Ratings of light fastness (LF)

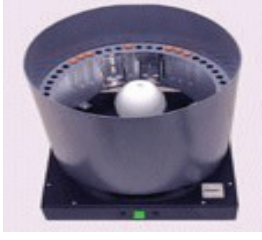
Rating No.	Description
1	Severe fading
2	Fading
3	Medium fastness
4	Quite good fastness
5	Good fastness
6	Very good fastness
7	Exceptional fastness
8	Excellent fastness

4. Colour fastness to perspiration

This assessment specifies a method for determining the resistance of the colour of textiles of all kinds and in all forms to the action of human perspiration. The fastness of colour when subjected to perspiration is a constant problem for manufacturers of clothing. To evaluate this phenomena colour fastness to perspiration, ISO 105 E04 was used. Perspiration fastness ratings from 1 (fading) to 5 (excellent fastness) were used, similar to wash fastness ratings and rub fastness ratings given in the Table below.

Equipment used for performance analysis

Evaluation of fastness properties were done by measuring washing, light, rubbing and perspiration fastness values using the following equipment given in the Table below.

Test parameter	Equipment	Pictorial view	Manuf.	Make Model Year of Manf.
Colour fastness to Washing	Wash wheel		James H. Heal, UK	Thermolab,UK (2001)
Colour fastness to Rubbing	Crockmeter		James H. Heal, UK	Ravindra Eng.,India (2003)
Colour fastness to Light	Microscal		James H. Heal, UK	Microscal,UK (2000)
Colour fastness to Perspiration	Perspirometer		James H. Heal, Uk	Sashmira ,UK (1989)
Trace elements a Heavy metals	Atomic Absorption Unit		Perkin Elmer	Perkin Elmer, USA (2004)

Measurements and analysis

Colour measurements

The relative colour strength of dyed fabrics expressed as *K*/*S* was measured by the light reflectance technique using the Kubelka–Munk equation (3.2). The mathematical basis for all colour matching software is the Kubelka–Munk series of equations. These equations state that for opaque samples such as textile materials, the ratio of total light absorbed and scattered by a mixture of dyes is equal to the sum of the ratios of light absorbed and scattered by the dyes measured separately. The reflectance of dyed fabrics was measured on a premier color scan.

$$\frac{K}{S} = \frac{(1-R)^2}{2R} \qquad \text{----------} \qquad (3\text{-}2)$$

Where R - Decimal fraction of the reflectance of dyed fabric.

K - Absorption of characteristic of light

S - Scattering characteristic of light

An evaluation of parameters related to the colour matching system

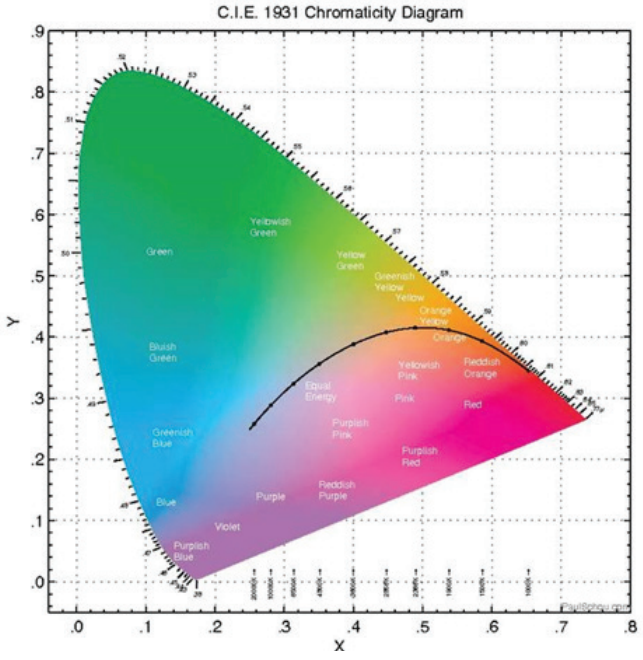
The reflectance of dyed fabrics was measured on a premier color scan.

C.I.E. is short for "Commission Internationale de l'Eclairage", which in English is the "International Commission on Illumination". The CIE system is used for colour specification. Essentially it is in the form of a sphere. There are three axes; L* and C* and h°.

L* represents lightness value, the higher the lightness value represented the lower the colour yield. a* and b* represent the tone of the colour, positive values of a* and b* represent redder and yellower tones while a negative value shows greener and bluer tones. C* represents chroma or purity of colour. h represent the hue (shade) of colour.

The CIE lab values were also recorded for all dyed samples along with controlled sample.

The CIE lab values of the dyeing were measured with a tristimulus colour imeter (Minolta Chroma-Meter CR 210, sample diameter 10 mm). The colours are given in CIE lab coordinates, L corresponding to the brightness (100 =white, 0 =black), a to the red–green coordinate (positive sign =red, negative sign =green) and b to the yellow–blue coordinate (positive sign =yellow, negative sign =blue).



CIE lab colour coordinate system

Measurement of dye exhaustion

The extracted dye can be identified by the characterization through various techniques. The following section describes the equipment used and methods of identification in detail.

Ultraviolet and visible spectrophotometer

The UV spectrum for any dye extract gives the typical λ_{max} value of the colourant which is specific. The extracted dye was diluted and dissolved in a suitable solvent system (water) and scanned through a UV-Visible spectrophotometer. Identification of the mixture of dye by this method involves as empirical comparison of the details of the spectrum, i.e. maxima and minima point of the unknown with those of the pure extract.

Economic consideration

Ten selected plants were subjected to evaluate the economic feasibility of these natural dyes. Standard depth calculations enabled in determining the required quantities for standard depth of shades. Standard depth calculations were carried out according to the American Association of Textile Chemists and Colorists AATCC Evaluation Procedure 4 (Standard Depth Scales for Depth Determination). Using the maximum dye yielding parameters, mercerized cotton samples were dyed with aqueous extraction of natural dyes until the standard depth shades were obtained. Finally the amount and cost of dye material needed to achieve standard depth was calculated.

Preparation of Ready – to – Use Dye Concentrates

The extracted colour yielding parts of the bio-materials were used for this purpose. The extracts were taken as Ready –to – Use -Dye Concentrates (RDC) Extract. Methy l Methy l paraben and Sodium benzoate were added to these dye solutions as preservatives. The efficiency of their chemicals as RDC extract preservatives were also tested as shelf life observations.

Evaluating an impact of environmental performance

It is important to evaluate natural dyes according to the environmental performance. Environmental Impact of the extracted natural dyes and the dyed fabric was assessed by testing for toxic heavy metals or trace elements. The significance of environmental impacts was determined by analyzing for trace elements and heavy metals present in selected natural dye yielding plants. These data were analyzed using Atomic Absorption Unit at the Atomic Energy Authority of Sri Lanka. Toxic heavy metals content in the dye and the dyed fabric were determined by using Inductively Couple Plasma Optical Emission Spectrophotometer (ICP). For analysis, 1000 ppm solution 0.1 g sample digested in conc. Hydrochloric acid and made up to 100 ml by adding distilled water was used. The upper limits of trace elements detected were 10.0 mg/l.

Equipment used for analysis

Test parameter	Equipment	Picture
Identification of Extracted dye	UV –Visible Spectroscopy (2001) (Make : Perkin Elmer : Model 295 spectrophotometer, USA)	
Colour Measurements (ref.3.13.3) & Equation (3-2)	Premier Colour Scan (1999) (Make :Perkin Elmer, Model : SS6200A, India)	

Chart A - List of the plant materials selected

Above mentioned parameters were evaluated by inserting data into an evaluation matrix. Prioritization was given only to ten (10) bio-materials for further studies. These ten bio-materials were subjected to the same experimental studies but in greater detail in a repetitive manner.

Local name	Part used	Botanical name	Total score
Big Onion	Skin	*Allium cepa*	134
Jak	Saw dust	*Artocarpus heterophyllus*	134
Kothala Himbutu	Bark	*Salicia reticulate*	116
Mangustene	Fruit skin	*Garcinia mangostana*	134
Marygold (Orange)	Petals	*Tegetes erecta*	128
Rambutan (Yellow)	Fruit Skin	*Nephelium lappaceum*	134
Tea	Used leaves	*Camellia sinensis*	134
Turmeric	Rhysome	*Curcuma domestica valet*	121
Venival	Stem	*Coscinium fenestratum*	115
Walmadata	Root and stem	*Rubia cordifolia*	119

Chart B - Characteristics of selected 47 natural dyes in Sri Lanka

No	Bio- Material	Botanical names	Part Used	Raw Material			Process Requirement					Fixation				Application			Environmental Aspects			Total
				Availability	Ease of Extr.	Yield	Temperature	Time	Salt	pH	MLR	Wash Fastness	Rubbing	Light	Perspiration	Ease of application	Levelness	Shade	COD	Trace elements	Waste or N'waste	
1	**Walmadata**	*Rubia cordifolia*	Root	10	10	10	4	4	3	3	5	9	8	8	8	10	7	9	10	0	1	119
2	**Madan Pothu**	*Syzygium cumini*	Stem	8	8	7	4	4	3	3	5	7	6	6	3	8	5	4	9	0	2	92
3	**Venival**	*Coscinium fenestratum*	Stem	10	10	10	4	4	3	3	5	9	8	7	4	10	8	9	10	0	1	115
4	**Turmeric**	*Curcuma domestica valet*	Rhysome	10	10	10	4	4	3	3	5	9	8	5	9	10	10	10	9	0	2	121
5	**Kothala Himbutu**	*Salicia reticulata*	Bark	10	10	10	4	4	3	3	5	9	7	7	7	10	7	8	10	0	2	116
6	**Delum (Skin)**	*Punica granatum*	Fruit Skin	8	8	8	4	4	3	3	5	8	6	7	6	8	7	8	8	0	8	109
7	**Rath Handun**	*Pterocarpus santalinus*	Stem	9	9	10	4	4	3	3	5	10	7	6	6	10	7	7	9	0	2	111
8	**Ranawara**	*Cassia auriculata*	Flowers	8	7	7	4	4	3	3	5	6	6	5	5	9	4	3	9	0	1	89
9	**Aralu**	*Terminalia chebula*	Bark	9	9	9	4	4	3	3	5	9	7	7	7	9	5	6	9	0	1	106
10	**Bulu**	*Terminalia belerica*	Bark	9	9	9	4	4	3	3	5	9	6	4	5	9	6	5	9	0	1	100
11	**Munamal Pothu**	*Mimusops elengi*	stem	8	8	8	4	4	3	3	5	8	6	5	4	8	3	6	9	0	1	93
12	**Jak**	*Artocarpus heterophyllus*	Saw Dust	10	10	10	4	4	3	3	5	10	9	9	9	10	9	9	10	0	10	134
13	**Mangustene**	*Garcinia mangostana*	Fruit Skin	10	10	10	4	4	3	3	5	10	9	9	9	10	9	9	10	0	10	134
14	**Rambutan (Yellow)**	*Nephelium lappaceum*	Fruit Skin	10	10	10	4	4	3	3	5	10	9	9	9	10	9	9	10	0	10	134
14	**Rambutan (Red)**	*Nephelium lappaceum*	Fruit Skin	10	10	10	4	4	3	3	5	10	8	8	8	10	9	9	10	0	10	131
15	**Merygold (Orange)-1**	*Tegetes erecta*	Petals	10	10	10	4	4	3	3	5	10	8	7	8	10	8	8	10	0	10	128

16	**Big Onion**	*Allium cepa*	Skin	10	10	10	4	4	3	3	5	10	9	9	9	10	9	9	10	0	10	134
17	**Red onion**	*Allium rubrum*	Skin	10	10	7	4	4	3	3	5	7	8	8	8	10	8	7	10	0	10	122
18	**Wada**	*Hibiscus rosa-sinensis*	Flowers	10	10	2	4	4	3	3	5	1	2	3	3	2	1	3	2	0	10	68
19	**Tea**	*Camellia sinensis*	Used Leaves	10	10	10	4	4	3	3	5	10	9	9	9	10	9	9	10	0	10	134
20	**Katarolu**	*Clitoria ternatea*	Flowers	8	9	8	4	4	3	3	5	0	1	2	2	0	3	2	6	0	9	69
21	**Kuppamaniya**	*Allium porrum*	Leaves	8	2	3	4	4	3	3	5	0	3	2	1	0	1	3	5	0	8	55
22	**Kopi Dalu (Crushed)**	*Coffea arabica*	Leaves	8	9	9	4	4	3	3	5	7	3	2	3	6	5	3	8	0	7	89
22	**Kopi Powder**	*Coffea Arabica*	Seeds	8	9	9	4	4	3	3	5	8	6	4	5	8	4	6	7	0	0	93
23	**Kottamba**	*Terminalia catappa*	Ripped Leaves	9	9	9	4	4	3	3	5	6	5	6	6	8	7	7	8	0	9	108
24	**Devadara**	*Erythroxylumm onogynum*	Stem & bark	1	2	1	4	4	3	3	5	1	1	1	1	0	1	1	6	0	0	35
25	**Beet root**	*Beta vulgaris*	Stem	7	9	9	4	4	3	3	5	0	1	1	1	0	1	1	7	0	0	56
26	**Hik**	*Lannea coromandelica*	Stem	3	8	9	4	4	3	3	5	8	6	6	6	9	5	6	8	0	1	94
27	**Kumbuk**	*Terminalia arjuna*	Stem	3	8	9	4	4	3	3	5	8	5	4	5	9	6	7	8	0	1	92
28	**Mahogani**	*Swietenia macrophylla*	Stem	2	8	9	4	4	3	3	5	6	4	3	2	9	6	7	8	0	9	92
29	**Ehala**	*Cassia fistula*	Bark	5	6	6	4	4	3	3	5	5	2	3	2	6	4	5	7	0	6	76
30	**Thekka**	*Tectona grandis*	Leaves	1	8	9	4	4	3	3	5	3	4	5	3	7	6	7	6	0	1	79
31	**Pangiri mana**	*Cymbopogon nardus*	Leaves	2	3	4	4	4	3	3	5	1	2	1	2	6	1	2	7	0	8	58
32	**Beetle nut (Crushed)**	*Piper betle*	Leaves	7	9	9	4	4	3	3	5	5	3	2	4	8	3	2	7	0	1	79
32	**Beetle nut (Boiled)**	*Piper betle*	Leaves	7	3	2	4	4	3	3	5	2	3	2	1	1	1	3	7	0	1	52
33	**Eucalyptus**	*Eucalyptus resinifera*	Stem	1	2	2	4	4	3	3	5	2	1	2	3	3	2	3	7	0	1	48
34	**Marathondi (boiled)**	*Lawsonia inermis*	Leaves	1	2	2	4	4	3	3	5	3	8	6	4	2	4	6	7	0	0	64
34	**Marathondi (Crushed)**	*Lawsonia inermis*	Leaves	1	9	9	4	4	3	3	5	8	8	6	4	8	8	7	7	0	0	94
35	**Sera**	*Cymbopogon citrates*	Leaves	2	3	4	4	4	3	3	5	3	2	3	2	5	1	2	7	0	5	58
36	**Nuga**	*Ficus altissima var ferugsonii*	Stem and bark	2	3	4	4	4	3	3	5	5	2	3	2	5	3	2	7	0	1	58
37	**Beli**	*Aegle marmelos*	Fruit	2	5	8	4	4	3	3	5	6	3	2	3	6	5	7	7	0	1	74
38	**Ratu kaha**	*Bixa Orellana*	Seed coat	2	9	9	4	4	3	3	5	9	5	6	7	9	8	8	7	0	1	99
39	**Iramusu**	*Hemidesmus indicus*	Bark and stem	5	7	7	4	4	3	3	5	4	1	2	4	7	3	2	7	0	1	69
40	**King coconut**	*Eugenia bracteata*	Husk	10	8	8	4	4	3	3	5	9	8	3	4	5	3	5	8	0	10	100
41	**Sepalika**	*Nyctanthes arbor-tristis*	Flowers	10	10	10	4	4	3	3	5	7	6	6	5	9	9	9	7	0	10	117
42	**Areconut**	*Areca catechu*	seed	10	6	6	4	4	3	3	5	8	7	6	4	8	8	5	7	0	10	104
43	**Areconut + Beetlenut**	*Areca catechu + Piper betle*	N/A	10	9	9	4	4	3	3	5	9	8	7	5	7	8	9	8	0	6	114
44	**Kesel Muwa**	*Musa sapientum*	Muwa	10	8	8	4	4	3	3	5	9	7	7	7	8	7	8	8	0	2	108
45	**Ahu**	*Morinda citrifolia*	Bark	6	7	6	4	4	3	3	5	7	6	7	6	8	7	8	7	0	5	99
45	**Ahu**	*Morinda citrifolia*	Root	6	7	6	4	4	3	3	5	7	6	7	6	8	7	8	7	0	5	99
46	**Gammalu**	*Pterocarpus marsupium*	Milk	5	8	8	4	4	3	3	5	5	6	7	4	9	8	9	7	0	1	96
47	**Kohomba**	*Azadirachta Indica*	Bark	10	10	10	4	4	3	3	5	7	6	5	4	8	7	8	7	0	2	103

A list of 90 varieties of Bio - materials used for natural dye sources

No.	Name	Botanical name	Family	Parts used
1	Thekka	*Tectona grandis Linn. f.*	Verbenaceae	Leaves, Bark
2	Dan pothu	*syzygium cumini L. Jamun*	Myrtaceae	Stem, Bark
3	Kohomba	*Azadirachtin indica*	Meliaceae	Bark,
4	Rambutan	*Nephelium lappaceum L.*	Sapindaceae	Skin
5	Bulath	*Piper Betle L.*	Piperaceae	Leaves
6	Jak	*Artocarpus hetorophyllus*	Moraceae	Saw dust
7	Weniwel	*Coscinium fenestratum Ga.col.*	Menispermaceae	Stem
8	Kurundu	*Cinnamomum verum Synonym c.*	Lauracea	Bark
9	Kothala Himbutu	*Salicia reticulata*	Hippocrateacaea	Bark
10	Delum	*Punica granatum*	Lithracaea	fruit skin
11	Rath Handun	*Pterocarpus Santalinus L.f.*	Fabaceae	Stem
12	Ranawara	*Gassia auriculata*	Cesalpinaceae	Flowers
13	Aralu	*Terminalia Chebula*	Combretaceae	Fruit
14	Bulu	*terminalia belerica*	Combretaceae	Fruit
15	Munamal Pothu	*Mimusops elengi L.*	Sapotaceae	Stem
17	Mangus	*Garicnia mangostana L.*	*Clusiaceae*	Skin
16	Welmadata,	*Rubia Cordifolia L.*	Rubiaceae	Root and Stem
18	Daspethiya	*Tegetus erecta*	Asteraceae	Petals
19	Big onion	*Allium cepa L.*	Eliaceae	Skin
20	Wada	*Hibiscus rosa-sinensis*	Malvaceae	Flowers
21	Tea	*Camellia Sinensis L.*	Theaceae	Used leaves

22	Katarou	*Clitoria ternatea L.*	Fabaceae	Flowers
23	Kuppamenia	*Acalypa indica L.*	Euphorbiaceae	Leaves
24	Kopi	*Coffea Arabica L.*	Rubiaceae	Leaves, seeds
25	Kottamba	*Terminalia catappa L.*	Rubiaceae	Riped leaves
26	Devadara	*Erithroxylum monogynum Linn.*	Euphorbiaceae	Stem
27	Beet root	*Beta vulgaris Linn.*	Amaranthaceae	Rysome
28	Kaippu	*Acacia catechu Lnn.*	Fabaceae	wood
29	Pethangi	*Caesalpinia sappan*	Fabaceae	wood
30	Marathondi	*Lawsonia intermis L.*	Lythraceae	wood, leaves
31	Seyum wel	*Oldeulandia umbellate L.*	Rubiaceae	Roots and tubers
32	Rasandun	*Berberis aristata*	Berberidaceae	Roots and tubers
33	Ahu, Dumbu	*Morinda citrifolia L.*	Rubiaceae	Roots and tubers
34	Kudu miris	*Toddalia asiatica Lamk*	Rutacea	Roots and tubers
35	Kaha	*Curcuma domestica Valet L.*	Zingiberaceae	Roots and tubers
36	Kela gas	*Butea monosperma Lam.*	Fabaceae	Flowers
37	Sepalika	*Nyctanthus arbo-tristis L.*	Oleaceae	Flowers
38	Maliththa	*Woodfordia fruitticosa*	Lythraceae	Flowers
39	Anaththa	*Bixa Ovellana L.*	Bixaceae	Seeds
40	Nil awariya	*Indigofera tinctora L.*	Fabaceae	Leaves and stem
41	Hamparilla	*Mallotus phillipiueses Lam.*	Euphobiaceae	Stem
42	Welikaha	*Memecyloa capitellatuae L.*	Melastomataceae	Rhysome
43	Sen kottan	*Semecarpus anacardium L.*	Anacardiaceae	seed
44	Kumbuk	*Terminalia arjuna L.*	Combretaceae	Bark
45	Hik	*Lannea coromandelica L.*	Anacardiaceae	Bark

46	Ipil Ipil	*Leucaena leucocephala L.*	Fabaceae	Bark
47	Gas Penela	*Sapindus trifoliatus L.*	Sapindaceae	Seed
48	Wal inguru	*Zingiber cylindricum Moon*	Zingiberaceae	Rhysome
49	Puwak	*Areca catechu L.*	Erecaceae	Seed
50	Kothala Himbutu	*Salicia reticulata L.*	Hippocrateacaea	wood and root
51	Bowitia	*Osbekia aspera L.*	Melastomataceae	Bark
52	Mal ehela	*Cassia fistula L.*	Fabaceae	Bark
53	Mahogani	*Swietenia mahagoni L.*	Meliaceae	Bark, Saw dust
54	Bulu	*Terminalia berelia L.*	Combretaceae	Bark
55	Madan	*Syzygium cumini L.*	Mirtaceae	Bark
56	Rath mal	*Ixora coccinea L.*	Rubiaceae	Flowers
57	Kaju	*Anacardium occidentale L.*	Anacardiaceae	Bark And fruit
58	Sera	*Cymbopogon cutratus L.*	Poaceae	Rhysome
59	Inguru	*Zingiber cylindricum Moon*	Zingiberaceae	Rhysome
60	Rata kaha	*Bixa orellana L.*	Bixaceae	Seed
61	Alisarin	*Hydrorcy anatharaquinones*		Stem
62	Masakka	*Quercus Infectoria L.*	Fagaceae	Rhysome
63	Pipigngna	*Cucumis sativusl L.*	Cucurbitaceae	Fruit
64	Gammalu	*Pterocarpus marsupium Roxb.*	Fabaceae	Stem
65	Rata-embilla	*Morus Tinctoria l.*	Moraceae	Fruit
66	Annasi	*Ananas Comosus L.*	Bromeliaceae	Leaves
67	Kesel	*Musa Sapientum L.*	Musaceae	Muwa
68	Goraka	*Ggarcinia Cambogia L.*	Clusiaceae	Fruit
69	Nelum	*Nelumbo Nucifera gaertn*	Nelumbonaceae	Flowers

71	Carrot	*Daucus carrota L.*	Apiaceae	Fruit
72	Daisiya	*Chrysanthemum Leucanthemum L.*	Asteraceae	Flowers
73	Grass	*Zingiber cylindricum Moon*	Zingiberaceae	Leaves
74	Rosa	*Rosa Indica L.*	Rosaceae	Flower
75	Suriyakantha	*Helianthus Annuus L.*	Asteraceae	Flowers
76	Thakkali	*CSolanum Lycopersium L.*	Asteraceae	Fruit
77	Eucalyptus	*Eucalyptus globules L.*	Myrtaceae	Bark
78	Lemon grass	*Zingiber cylindricum Moon*	Zingiberaceae	Leaves
79	Nivithi	*Basella alba L.*	Basellaceae	Seed
80	Kudalu	*Impatiens flaccida*	Balsaminaceae	Flower
81	Canas	*Canna ediulis L.*	Cannaceae	Flower
82	Boganvila	*Bougainvillea spectabilis L.*	Nyctaginaceae	Flower
85	Beligeta	*Aegle marmelos L.*	Rutaceae	Fruit
86	Kaduru	*Cerbera manghas*	Apocynaceae	Fruit
87	Katakaluwa	*Myrica nagai L.*	Myricaceae	Fruit
88	Thembili	*Eugenia bracteata L.*	Myricaceae	Husk
89	Jak	*Artocarpus heterophylus L.*	Moraceae	Stem/ root
90	Turmeric	*Curcuma Domestica Valet L.*	Zingiberaceae	Rysome

GLOSSARY

Ahu: (*Morinda tinctoria*) : origins in Ceylon, India and Malaya (Worthington,1959.300) This plant is also ayurvedic medicinal plant. Srub or small tree with shoot branchlets marked with leafe scars. Leaves are simple.

Alum :'ælum/ is both a specific chemical compound and a class of chemical compounds. The specific compound is the hydrated potassium aluminium sulfate (*potassium alum*) with the formula $KAl(SO4)_2 .12H_2O$. Historically, alum was used extensively in the wool industry from classical antiquity, during the Middle Ages, and well into 19th Century as a mordant or dye fixative in the process of turning wool into dyed bolts of cloth. Alum is a earthen soil and a non-toxic mordants always being used in the dyeing process.

American Association of Textile Chemists and Colorists: professional association that was founded in 1921provides test method development, quality control materials, educational development, and networking for textile and apparel professionals throughout the world. AATCC has developed more than 200 textile-related standards, including test methods, evaluation procedures, and monographs. These standards are published each year in the AATCC Technical Manual.

Aniline: a colourless oily liquid present in coal tar. It is used in the manufacture of dyes, drugs, and plastics, and was the basis of the earliest synthetic dyes.

Aqueous extraction: an extract prepared by evaporating a watery solution of the soluble principles of a vegetable drug (such as licorice) to a semisolid or solid consistency.

Aralu : (*Terminalia chebula*): origins in Ceylon, India, Burma and Malaya habitat in Talawas and grass-lands; e.g. Bibile and Nilgala (Uva); below 2500 feet; associates with *Daminiya, Damba, Nelli, Kina, Dawu, Gammalu, Kela, BuIu, Kahata* and other fire resistants 50 feet; a tree with a corrugated bark; gregarious Dirty grey Green . Leaves are green. Fruits are collected for dyes, tanning and medicines. (Worthington,1959.235).

Arecanut: (*Areca catechu linn*) : areca nut (*Areca catechu*) /betel quid (BQ) is said to be the fourth most commonly used psychoactive substance in the world and is chewed regularly by at least 10% of the world's population. High prevalences of BQ chewing were observed especially in South and Southeast Asia.

Ashtaparikkara: or an "ata pirikara" is known as "eight monastic requisites" (pariccara) which are accepted to be use by the Buddhist monk. The personal belongings of the Buddhist monk.

1. One sheet robe (Thanipota sivra)
2. Double sheet robe (Depota Sivra)
3. Lower robe (Andanaya)

4. Belt (Banda Patiya)
5. Alms bowl (Paththaraya)
6. Vixen blade or Shaving knife (Dalipihiya)
7. Needle and thread
8. Cloth filter (Perahankadaya)

Batik : a method (originally used in Java) of producing coloured designs on textiles by dyeing them, having first applied wax to the parts to be left undyed.

Beeswax : commercially useful animal wax secreted by the worker bee to make the cell walls of the honeycomb. Beeswax ranges from yellow to almost black in colour, depending on such factors as the age and diet of the bees, and it has a somewhat honey like odour and a a faint balsamic taste. It is soft to brittle, with a specific gravity of about 0.95 and a melting point of more than 140° F (60° C), and it consists mainly of free cerotic acid and myricin (*myricyl palmitate*), with some high-carbon paraffins. Although insoluble in water, it can be dissolved in such substances as carbon tetrachloride, chloroform, or warm ether. Wax obtained from bees of East Asia may be somewhat different from that of the common, or Western, honeybee. https://www.britannica.com/topic/beeswax

Bixa Orellana: (*Rata Kaha /Anaththa*): (Bixa orellana) is a shrub or small tree originating from the tropical region of the Americas. North, Central, and South American natives originally used the seeds to make red body paint and lipstick, as well as a spice.

Bleaching: generic name for any chemical product which is used industrially and domestically to whiten clothes.

Bombu leaves:(*Symplocos spicata* / *Symplocos cochinchinensis*): is a tree with origins in ceylon, India,china,Malaya and Japan (Worthington, 1959. 225). Leaves give greenish yellow is extracted.In traditional practice, Bombu leaves are used as calour fastner in dyeing. Once taken out of the boiling dye bath, the yarns are washed a few times with cold water until the colour is not washed off with the fabric. Moreover, to achieve better colour fastness, bombu leaves (*Symplocos cochinchinensis* synonym: *Symplocos stawellii*) are put into the cold water. Finally the yarns are dried in air.

Bulu: (*Terminalia beleria*):Origins in Ceylon, India and Malaya. Fruits are collected for tannings .(Worthington ,1959. 233).

Calico :Calico, all-cotton fabric woven in plain, or tabby, weave and printed with simple designs in one or more colours. Calico originated in Calicut, India, by the 11th Century, if not earlier, and in the 17th and 18th Centuries calicoes were an important commodity traded between India and Europe. https://www.britannica.com/topic/calico-textile

Cellulosic: relating to, or made from cellulose cellulosic fibers.

Chaya: (*Oldenlandia umbellate*) : Chaya root colour is a dull pinkish purple and very durable. Chaya root can be seen in the Northern province specially in the Mannar District.

Colour Fastness: : used in the dyeing of textile materials that characterizes a material's colour's resistance to fading or running. The term is usually used in the context of clothes.

Cotton : a soft white fibrous substance which surrounds the seeds of the fruit of a cotton plant and is made into textile fibre and thread for sewing.

Detergent: is a surfactant or a mixture of surfactants with cleaning properties in dilute solutions.

Dyeing : process of adding a colour to or change the colour of (something) by soaking it in a solution impregnated with a dye.

Fabrics: is cloth or other material produced by weaving together cotton, nylon, wool, silk, or other threads. Fabrics are used for making things such as clothes, curtains, and sheets.

Fibre:a thread or filament from which a vegetable tissue, mineral substance, or textile is formed.

Galleha : grass used for weaving of mats. This is a Sinhala term.

Gallnuts: a gall resembling a nut such as aralu (*Terminalia chebula*) and bulu (*Terminalia beleria*)

Hin- bowitiya : (*Osbeckia octandra*) a much branched shrub up to about 2m tall. 5 petal flower is pink to mauve and purpling colour. Ayurvedic medicinal plant.

Indigo : (*Indigofera*) One is of a large genus of over 750 species of flowering plants belonging to the family Fabaceae. They are widely distributed throughout the tropical and subtropical regions of the world and produce the colour blue.

Iron : is a chemical element with symbol Fe (from Latin: *ferrum*) and atomic number 26. It is a metal in the first transition series. It is by mass the most common element on Earth, forming much of the Earth's outer and inner core. In traditional practice of produsing darker shades such as brown, purple or black an iron nails (ferrous (Fe2+) is to dissolve in water with dye substance as mordant (fixing agents)in the process of natural dyeing.

Iron Oxide : Iron(II,III) oxide is the chemical compound with formula Fe3O4. It occurs in nature as the mineral magnetite. It is one of a number of iron oxides, the others being iron(II) oxide (FeO), which is rare, and iron(III) oxide (Fe2O3) also known as hematite.

Jak:(*Artocarpus integrifolia*) The jak fruit (*Artocarpus heterophyllus*), also known as jak tree, is a species of tree in the fig, mulberry, and breadfruit family (*Moraceae*) native to southwest India. the bark and roots are used for Buddhist robe dyeing.

Kebella : (*Aporosa lindleyana*) :origins in Ceylon and South India (Worthington, 1959. 377) *Aporusa lindleyana* (Kebella) is used as a leafy vegetable in Sri Lanka. Although the root and bark of this plant showed many biological activities, only antioxidant activity by DPPH mechanism and anti-inflammatory activity are reported in leaf.

Khandhaka : Pali term for division or chapter.

Korakaha: (*Memecylon umbellatum*) :generally known as Iron wood tree. A large shrub or small tree,up to about 5m tall. branches subterete. Korakaha is known as naturl mordant in the dyeing tradition of Sri Lanka.

Madder : (*Rubia tinctorum*) : the common madder or dyer's madder, is a herbaceous perennial plant species belonging to the bedstraw and coffee family *Rubiaceae.* It has been used since ancient times as a vegetable red dye for leather, wool, cotton and silk. For dye production, the roots are harvested in the first year.

Mahavagga: a section of the Vinaya Pitaka, divided into chapters called Khandhakas.

Methylparaben: Parabens are chemicals that are often used as preservatives to give products a longer shelf life. They're added to food or cosmetics to prevent the growth of mold and other harmful organisms.

Mordants : The word mordant has been derived from the Latin word 'modere' which means 'to bite,' as it bites the surface of a substrate and helps to fix a pigment on the substrate where alone it cannot. Majority of the natural dyes need mordants for dyeing to get permanent colours.It is a dye fixative a substance used to set (i.e. bind) dyes on fabrics by forming a coordination complex with the dye, which then attaches to the fabric (or tissue). It may be used for dyeing fabrics or for intensifying stains in cell or tissue preparations.

Munga silk :is a variety of wild silk geographically tagged to the state of Assam in India. The silk is known for its extreme durability and has a natural yellowish golden tint with a shimmering, glossy texture. It was previously reserved for the use by royalty.

Niyanda: (*Sansevieria zeylanica*): Niyanda is a common indigenous herb of dry rocky and sandy places of the low country dry zone to mid hills. Fibers extracted from leaves are used in the reed industry. Roots are used in indigenous medicine to treat bile and gonorrhea.

Patangi : (*Coesalpinia sappan*): Sappan is a small thorny tree, The heartwood yields a red dye.

pH : pH is a scale of acidity from 0 to 14. It tells how acidic or alkaline a substance is. More acidic solutions have lower pH. More alkaline solutions have higher pH. Substances that aren't acidic or alkaline (that is, neutral solutions) usually have a pH of 7.

pH conditions :soil pH is a measure of the acidity and alkalinity in soils. pH levels range from 0 to 14, with 7 being neutral, below 7 acidic and above 7 alkaline.

Potassium oxide : Potassium oxide (K2O) or Kalium oxide is an ionic compound of potassium and oxygen. This pale yellow solid, the simplest oxide of potassium, is a rarely encountered, highly reactive compound.

Preservative : is a substance or a chemical that is added to products such as food, beverages, pharmaceutical drugs, paints, biological samples, cosmetics, wood, and many other products to prevent decomposition by microbial growth.

Ratmulgas : (*Knoxia platycarpa*) Knoxia platycarpa is a species of plant in the family Rubiaceae. https://en.wikipedia.org/wiki/Knoxia. According to Ananda Coomarsamy Kiribat- mul are also known as root of *Knoxia platycarpa*.

Robe: is a loose fitting outer garment which signifies honorary stature of the wearer. According to the historical evidences Buddhist monks practiced wearing of a tradition of robes goes back to 25 Centuries. The robe was known as *Cīevara* in Pali language and still being commonly used by the Sri Lankan Buddhist monks who adhere to the philosophy of Buddhism. These are recorded in the *Vinaya-pitaka* of the Pali Canon or *Tripitaka*. The great chronicle of *Mahavaggapali* in its 8th Chapter- 'C*ī*varakkhandhakaya' is devoted to describe the robe of Buddhist priests and its traditional practices (Max Muller, 1982).

Rubia (Madder) : was formerly cultivated for the red dye obtained from its roots (alizarin); the roots of crosswort (*Crucianella*) contain a red dye once used in medicines.

Shrouds :a length of cloth or an enveloping garment in which a corpse is wrapped for burial.

Silk : Silk, animal fibre produced by certain insects as building material for cocoons and webs, some of which can be used to make fine fabrics. In commercial use, silk is almost entirely limited to filaments from the cocoons of domesticated silkworms (caterpillars of several moth species belonging to the genus Bombyx) https://www.britannica.com/topic/silk

Sivpasa: The Primary needs of a Buddhist Monk are known as follows; Cloth (*Cīvaraya*), Food (*Pindapatha*),Shelter (*Senasana*), Medicine (*Gilanaprathya*)

Tannins and Tannic acid: Tannins are natural vegetable mordants, which improve the affinity of fibres towards dyes by forming an effective cross-link between the substrate's protein and other macromolecules. Thus, tannins forms an important ingredient in the dyeing of natural dyes yellow, brown, gray and black. (Kumar, J. K., & Sinha, A. K. ,2004)

The International Commission on Illumination: is the international authority on light, illumination, colour, and colour spaces. It was established in 1913.

The mordanted dye: Mordant dye, colorant that can be bound to a material for which it otherwise has little or no affinity by the addition of a mordant, a chemical that combines with the dye and the fibre. As the principal modern mordants are dichromates and chromium complexes, mordant dye usually means chrome dye. Most mordant dyes yield different colours with different mordants. Mordant dyes can be used with wool, wool blends, silk, cotton, and certain modified-cellulose fibres. https://www.britannica.com/science/mordant-dye

Turmeric: (*Curcuma longa*) : is a flowering plant of the ginger family, Zingiberaceae, the roots of which are used in cooking. The plant is native to the Indian subcontinent and Southeast Asia. Plants are gathered each year for their rhizomes**.**

Vinaya-pitaka: the *Vinaya Pitaka* (pitaka means : basket of discipline) is a Buddhist scripture, one of the three parts that make up the *Tripitaka* (Three Baskets) It is the basic monastic rules of conduct governing the daily affairs within the ordained monks.

Vinegar : Vinegar is an acidic liquid product prepared from alcoholic fermentation by yeast followed by acetous fermentation by acetic acid bacteria of any suitable food. Good for acid dyes. The most common proper use of vinegar in dyeing is to produce an acid pH for acid dyes. Acid dyes, which are used to color protein fibers such as wool, as well as nylon, require a mildly acidic pH to form a permanent bond to the fiber.

Welikaha : (*Memecylon caitellatum*): A large shrub or small tree up to about 5m tall.Branches suterete. Endemic plant used as ayurvedic medicinal plant. Parts used is rhizome. http://www.instituteofayurveda.org/plants/plants_detail.php?i=807&s=Local_name

Weniwel: (*Coscinium fenestratum*) : weniwel native to South Asia and Mainland Southeast Asia. This is a large woody climber, grows with cylindrical and yellowish stem. This is an ayurvedic medicinal plant. http://www.instituteofayurveda.org/plants/plants_detail.php?i=833&s=Family_name

Wood Ash : Wood ash is the residue powder left after the combustion of wood, such as burning wood in a home fireplace or an industrial power plant. It is used traditionally by gardeners as a good source of potash.

Wool : Wool, animal fibre forming the protective covering, or fleece, of sheep or of other hairy mammals, such as goats and camels. Prehistoric man, clothing himself with sheep skins, eventually learned to make yarn and fabric from their fibre covering. Selective sheep breeding eliminated most of the long, coarse hairs forming a protective outer coat, leaving the insulating fleecy undercoat of soft, fine fibre. https://www.britannica.com/topic/wool

Yarn : spun thread used for knitting, weaving, or sewing.

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