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Natural dyeing Cotton fabric Mordanted with Alum and Soymilk using Avocado pits, Avocado skins, Straw berry and Madder root – their colour fastness test & FTIR analysis

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Abstract

The avocado (Persea americana) is a medium-sized, evergreen tree in the laurel family (Lauraceae). Raw avocado flesh is 73% water, 15% fat, 9% carbohydrates, and 2% protein. Polyphenol compounds, such as tannins and flavonoids, are natural color sources found in avocado seeds. The garden strawberry is a widely grown hybrid species of the genus Fragaria, collectively known as the strawberries, which are cultivated worldwide for their fruit. The fruit is widely appreciated for its characteristic aroma, bright red color, juicy texture, and sweetness. Raw strawberries are 91% water, 8% carbohydrates, 1% protein, and contain negligible fat. Purple minor pigments consisting of dimeric anthocyanins (flavanol-anthocyanin adducts: catechin(4α→8) pelargonidin 3-O-β-glucopyranoside, epicatechin(4α→8) pelargonidin 3-O-β-glucopyranoside, afzelechin (4α→8) pelargonidin 3-O-β-glucopyranoside and epiafzelechin (4α→8) pelargonidin (3-O-β-glucopyranoside) can also be found in strawberries. Rubia is the type genus of the Rubiaceae family of flowering plants, which also contains coffee. It contains around 80 species of perennial scrambling or climbing herbs and subshrubs native to the Old World. The genus and its best-known species are commonly known as madder, e.g. Rubia tinctorum (common madder), Rubia peregrina (wild madder), and Rubia cordifolia (Indian madder).Rubia was an economically important source of a red pigment in many regions of Asia, Europe and Africa. The plant's roots contain an anthracene compound called alizarin that gives its red colour to a textile dye known as Rose madder. It was also used as a colourant, especially for paint, that is referred to as Madder lake. Present paper deals with natural dyeing cotton fabric mordanted with Alum and Soymilk using avocado pits, avocado skins, straw berry and madder root. This also includes their Colour Fastness test for Water Fastness and Light Fastness and FTIR analysis.

Keywords: Natural dye, Avocado Pits, Avocado Skins, Straw Berry, Madder Root, Alum, Soymilk, Colour Fastness Test, FTIR Analysis.

Introduction

Avocado (Persea Americana): The avocado (Persea americana) is a medium-sized, evergreen tree in the laurel family (Lauraceae).Raw avocado flesh is 73% water, 15% fat, 9% carbohydrates, and 2% protein. In a 100 gram reference amount, avocado supplies 160 calories, and is a rich source (20% or more of the Daily Value, DV) of several B vitamins (such as 28% DV in pantothenic acid) and vitamin K (20% DV), with moderate contents (10–19% DV) of vitamin C, vitamin E, and potassium. Avocados also contain phytosterols and carotenoids, such as lutein and zeaxanthin[1].

Avocados have diverse fats. For a typical one: about 75% of an avocado's energy comes from fat, most of which (67% of total fat) is monounsaturated fat as oleic acid. Other predominant fats include palmitic acid and linoleic acid. The saturated fat content amounts to 14% of the total fat. Typical total fat composition is roughly: 1% ω-3, 14% ω-6, 71% ω-9 (65% oleic and 6% palmitoleic), and 14% saturated fat (palmitic acid)[2]. In 2022, a prospective cohort study following 110,487 people for 30 years found that eating two servings of avocado per week reduced the risk of developing cardiovascular diseases by 16–22%. The study involved replacing half a daily serving of saturated fat sources, including margarine, butter, egg, yogurt, cheese, or processed meats, with an equivalent amount of avocado[3].

Possible valorisation routes of waste avocado seeds are discussed. The recommenda-tions made in study could inform the possible investment areas by identifying which technologies and processes; in order to address various technical, economic and market-related barriers that may hinder R & D progress to commercialisation[4].

The development of textiles in Indonesia grows steadily, which increases the use of synthetic dyes. Textile industry uses synthetic dyes because they are cheaper and easier to obtain. Moreover, the color availability is guaranteed and more varied. However, when introduced to the environment, these synthetic dyes have a negative impact on health. The natural dye from avocado (Persea americana Mill) seeds can become an alternative. Polyphenol compounds, such as tannins and flavonoids, are natural color sources found in avocado seeds. The extraction of natural dyes from avocado seeds can be done by using ultrasonic-assisted extraction which offer high efficiency and rapid processing. This study examined the parameters that affect the yield of dye extraction from avocado seeds, namely solvent concentration and extraction time. Qualitative analysis on the pigment content in the yield of extraction using UV-Visible Spectrophotometry and GC-MS were also done[5].

Strawberry: The garden strawberry is a widely grown hybrid species of the genus Fragaria, collectively known as the strawberries, which are cultivated worldwide for their fruit. The fruit is widely appreciated for its characteristic aroma, bright red color, juicy texture, and sweetness. It is consumed in large quantities, either fresh or in such prepared foods as jam, juice, pies, ice cream, milkshakes, and chocolates. Artificial strawberry flavorings and aromas are also widely used in products such as candy, soap, lip gloss, perfume, and many others[6].

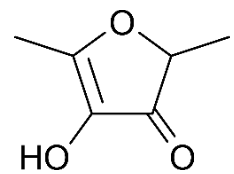
Raw strawberries are 91% water, 8% carbohydrates, 1% protein, and contain negligible fat. Strawberries contain a modest amount of essential unsaturated fatty acids in the achene (seed) oil[7].

Garden strawberries contain the dimeric ellagitannin agrimoniin which is an isomer of sanguiin H-6[8,9]. Other polyphenols present include flavonoids, such as anthocyanins, flavanols, flavonols and phenolic acids, such as hydroxybenzoic acid and hydroxycinnamic acid[7]. Strawberries contain fisetin and possess higher levels of this flavonoid than other fruits[9,10]. Although achenes comprise only about 1% of total fresh weight of a strawberry, they contribute 11% of the total polyphenol in the whole fruit; achene phytochemicals include ellagic acid, ellagic acid glycosides, and ellagitannins[11].

Pelargonidin-3-glucoside is the major anthocyanin in strawberries and cyanidin-3-glucoside is found in smaller proportions. Although glucose seems to be the most common substituting sugar in strawberry anthocyanins, rutinose, arabinose, and rhamnose conjugates have been found in some strawberry cultivars[7].

Purple minor pigments consisting of dimeric anthocyanins (flavanol-anthocyanin adducts: catechin (4α→8) pelargonidin 3-O-β-glucopyranoside, epicatechin (4α→8) pelargonidin 3-O-β-glucopyranoside, afzelechin (4α→8) pelargonidin 3-O-β-glucopyranoside and epiafzelechin (4α→8) pelargonidin 3-O-β-glucopyranoside) can also be found in strawberries[12].

Sweetness, fragrance and complex flavor are favorable attributes[13]. In plant breeding and farming, emphasis is placed on sugars, acids, and volatile compounds, which improve the taste and fragrance of a ripe strawberry[14]. Although often sweet tasting, strawberries actually have relatively low sugar levels compared to other fruits. Esters, terpenes, and furans are the chemical compounds having the strongest relationships to strawberry flavor, sweetness and fragrance, with a total of 31 out of some 360 volatile compounds significantly correlated to favorable flavor and fragrance[14-16]. In breeding strawberries for the commercial market in the United States, the volatile compounds, methyl anthranilate and gamma-decalactone prominent in aromatic wild strawberries, are especially desired for their "sweet and fruity" aroma characteristics[15,16].



Furaneol an important component of the fragrance of strawberries.

As strawberry flavor and fragrance are characteristics that may appeal to consumers[15-17], they are used widely in a variety of manufacturing, including foods, beverages, confections, perfumes and cosmetics[18,19].

Rubia: Rubia is the type genus of the Rubiaceae family of flowering plants, which also contains coffee. It contains around 80 species of perennial scrambling or climbing herbs and subshrubs native to the Old World[20]. The genus and its best-known species are commonly known as madder, e.g. Rubia tinctorum (common madder), Rubia peregrina (wild madder), and Rubia cordifolia (Indian madder)[21].

Rubia was an economically important source of a red pigment in many regions of Asia, Europe and Africa[22]. The genus name Rubia derives from the Latin ruber meaning "red". The plant's roots contain an anthracene compound called alizarin that gives its red colour to a textile dye known as Rose madder. It was also used as a colourant, especially for paint, that is referred to as Madderlake. The synthesis of alizarin greatly reduced demand for the natural compound[23].

R. tinctorum was extensively cultivated in south Europe, France, where it is called garance, and the Netherlands, and to a small extent in the United States. Large quantities were imported into England from Smyrna, Trieste, Livorno, etc. The cultivation, however, decreased after alizarin was made artificially[24].

Madder was employed medicinally in ancient civilizations and in the Middle Ages. John Gerard, in 1597, wrote of it as having been cultivated in many gardens in his day, and describes its many supposed virtues, but any pharmacological or therapeutic action which madder may possess is unrecognizable. It's most remarkable physiological effect was found to be that of colouring red the bones of animals fed upon it, as also the claws and beaks of birds. This appears to be due to the chemical affinity of calcium phosphate for the colouring matter[25].

This property was used to enable physiologists to ascertain the manner in which bones develop, and the functions of the various types of cell found in growing bone[24].

Present paper deals with natural dyeing cotton fabric mordanted with Alum and Soymilk using avocado pits, avocado skins, straw berry and madder root. This also includes their Colour Fastness test for Water Fastness and Light Fastness and FTIR analysis.

Methodology

Natural Dyeing Cotton Fabric using Avocado Pits, Avocado Skins, Straw Berry and Madder Root: Step-1: Cleaning Cotton Fabric for dyeing -Cotton Fabric is soaked in water and detergent (1% weight of fabric) and heated for 30 minutes. After cooling soaked cloth rinsed with cold water then excess water is squeezed out and fabric is dried. This helps dye to penetrate fabric better.

Step-2: Mordanting Cotton Fabric with Alum - Alum (15 % weight of fabric) is dissolved in water. To it cleaned cotton fabric is soaked and heated for 1 hour. After cooling excess water is squeezed out and fabric is dried.

Step-2: Mordanting Cotton Fabric with Soymilk - To 4:1 ratio of Water:Soymilkcleaned cotton fabric is soaked for 12 hours. Then excess water is squeezed out and fabric is dried.

Step-3: Making Natural Dye using Avocado Pits, Avocado Skins, Straw Berry and Madder Root-Avocado Pits, Avocado Skins, Straw Berry and Madder Root is taken in separate Glass beakers to it water is added and boiled for 1 hour. Then kept overnight as it is and strained. Filtrate is used as dye bath.

Step-4: Dyeing Mordanted Cotton Fabric - Mordanted cotton fabric is kept in Dye bath and heated for 1 hour. Then it is removed from dye bath and rinsed with water and bit of detergent and dried.

Step-5: Ironing Dyed Cotton Fabric – Dyed cotton fabric is ironed. The obtained colours were measured and matched with the names of RAL Color Chart. Then colour and fastness testare performed.

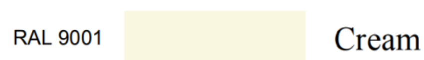
Colour Fastness test for Water Fastness and Light Fastness to Avocado Pits, Avocado Skins, Straw Berry and Madder Root Dyed Fabric: Gray Scales are used for assessing colour change and staining during colour fastness testing. Both scales are used for visual assessment to enable us to specify a rating from 1 to 5, with 5 being 'good' and 1 being 'poor'. The colour change gray scale consists of nine pairs of grey coloured chips, from grades 1 to 5 in accordance with ISO 105-A02 and A03. Grade 5 represents no change and grade 1 shows large change. The staining scale consists of nine pairs of grey and white coloured chips from grades 1 to 5. Water fastness and light fastness test was performed by regular washing and drying fabric in sunlight.

FTIR Analysis of Avocado Pits, Avocado Skins, Straw Berry and Madder Root Dye Extract FTIR can be routinely used to identify the functional groups. FTIR spectra of Natural Dye made from Avocado Pits, Avocado Skins, Straw Berry and Madder Rootare obtained at room temperature by using an FTIR Spectrophotometer - Shimadzu - IR Affinity – 1. The spectra iscollected in range from 400 - 4500 cm-1.

Results and Discussion

Natural dyeing cotton fabric using avocado pits, avocado skins, straw berry and madder root are shown in following figures.

Figure-1: Cotton Fabric: 00-not Mordanted and not Dyed, 0A - Mordanted with Soymilk and not Dyed, 0B - Mordanted with Alum and not Dyed.



Cotton Fabric not Mordanted and not Dyed, Mordanted with Soymilk and not Dyed and Mordanted with Alum and not Dyed shows Cream color.

Figure-2: Cotton Fabric: 1A-Mordanted with Soymilk and Dyed with Avocado Pits, 1B - Mordanted with Alum and Dyed with Avocado Pits.

Cotton Fabric Mordanted with Soymilk and Dyed with Avocado Pits, Mordanted with Alum and Dyed with Avocado Pits, shows Beige Red color.

Figure-3: Cotton Fabric: 2A-Mordanted with Soymilk and Dyed with Avocado Skins, 2B - Mordanted with Alum and Dyed with Avocado Skins.

Cotton Fabric Mordanted with Soymilk and Dyed with Avocado Skins, Mordanted with Alum and Dyed with Avocado Skins shows Beige Red color.

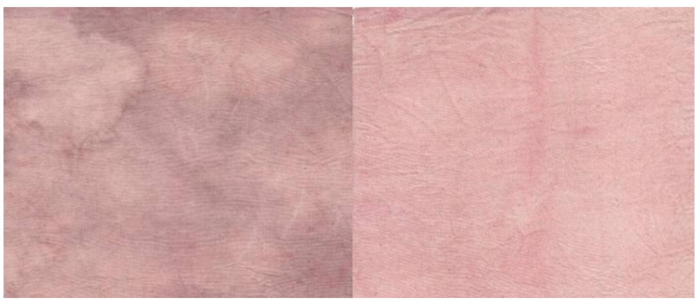
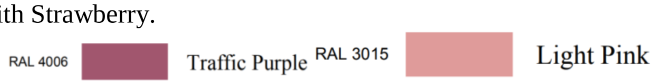


Figure-4: Cotton Fabric: 3A - Mordanted with Soymilk and Dyed with Strawberry, 3B - Mordanted with Alum and Dyed with Strawberry.



Cotton Fabric Mordanted with Soymilk and Dyed with Strawberry shows Traffic Purple color while Mordanted with Alum and Dyed with Strawberry shows light pink Color.

Figure-5: Cotton Fabric: 4A - Mordanted with Soymilk and Dyed with Madder Root, 4B - Mordanted with Alum and Dyed with Madder Root

Cotton Fabric Mordanted with Soymilk and Dyed with Madder Root shows Light pink while Mordanted with Alum and Dyed with Madder Root shows Rose Color.

Table-1: Colour Fastness test for Water Fastness and Light Fastness to Avocado Pits, Avocado Skins, Straw Berry and Madder Root Dyed Fabric.

Cotton Fabric	Colour Fastness Test	
	Water Fastness	Light Fastness
00 - not Mordanted and not Dyed	5	5
0 A - mordanted with soymilk and not dyed	5	5
0 B - mordanted with alum and not dyed	5	5
1 A - mordanted with soymilk and dyed with avocado pits	4-5	4-5
1 B - mordanted with alum and dyed with avocado pits	4-5	4-5
2 A - mordanted with soymilk and dyed with avocado skins	4-5	4-5
2 B - mordanted with alum and dyed with avocado skins	4-5	4-5
3 A - mordanted with soymilk and dyed with strawberry	4-5	4-5
3 B - mordanted with alum and dyed with strawberry	4-5	4-5
4 A - mordanted with soymilk and dyed with madder root	4-5	4-5
4 B - mordanted with alum and dyed with madder root	4-5	4-5

Colour Fastness test for Water Fastness and Light Fastness to Avocado Pits, Avocado Skins, Straw Berry and Madder Root Dyed Fabric shows 4-5 range in gray scale method which indicates excellent to Water Fastness and Light Fastness.

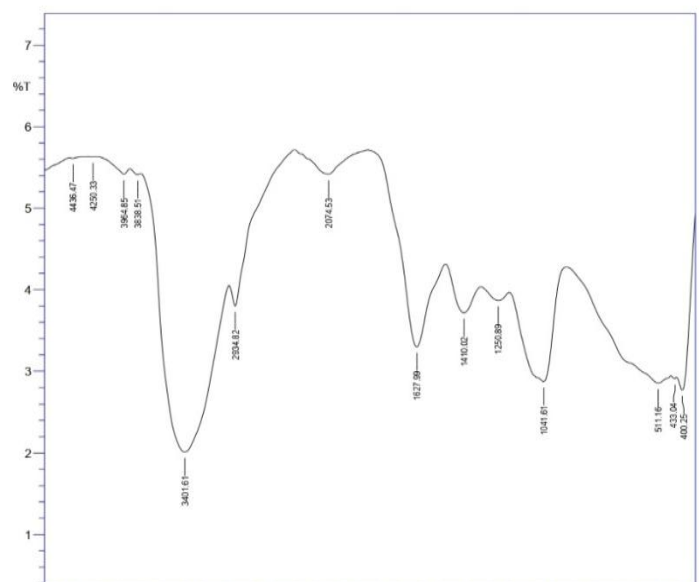


Figure-6: FTIR spectra of Natural Dye made from Avocado Pits.

Table-2: Interpretation of FTIR spectra of Natural Dye made from Avocado Pits is done as follows.

Spectra region wave number cm^{-1}	Intensity and Pattern of peak	Bond causing Absorption	Compound Class
400.25	Weak and Broad	-	-
433.04	Weak and Broad	-	-
511.16	Weak and Broad	-	-
1041.61	Medium and Broad	CO-O-CO Stretching	Anhydride
1250.89	Weak and Broad	-	-
1410.02	Weak and Broad	-	-
1627.99	Strong and Sharp	C=C Stretching	Alkene, α, β-unsaturated ketone
2074.53	Weak and Broad	-	-
2934.82	Medium and Broad	C-H Stretching	Alkane
3401.61	Strong and Broad	O-H Stretching	Alcohol
3838.51	Weak and Broad	-	-
3964.85	Weak and Broad	-	-
4250.33	Weak and Broad	-	-
4436.47	Weak and Broad	-	-

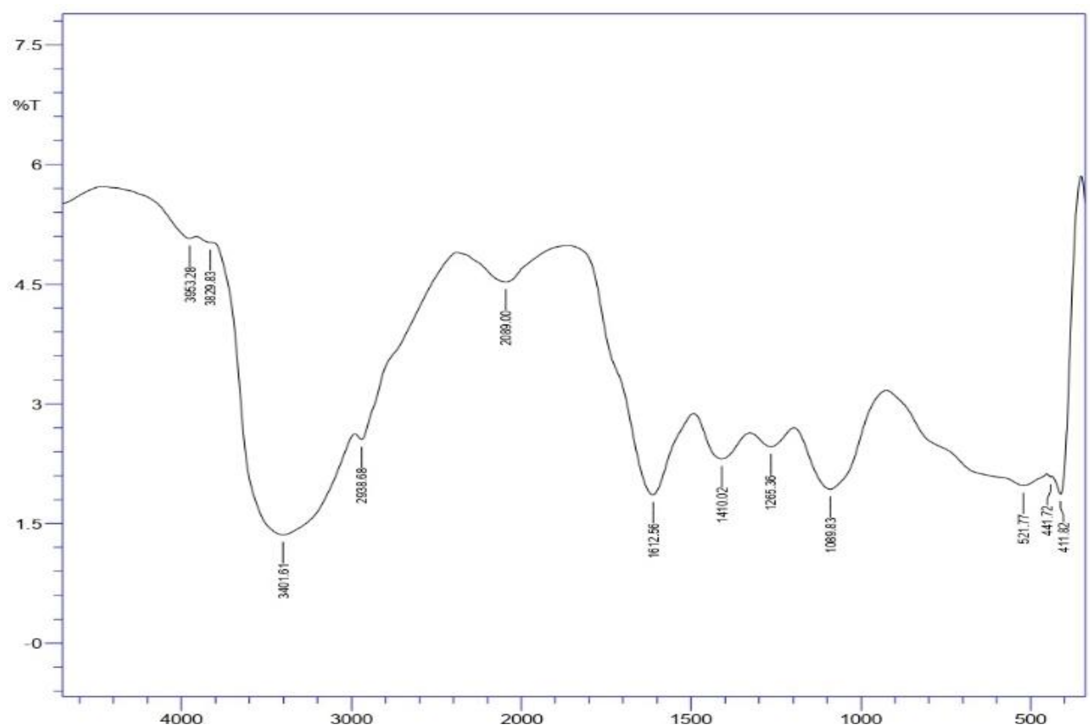


Figure-7: FTIR spectra of Natural Dye made from Avocado Skins.

Table-3: Interpretation of FTIR spectra of Natural Dye made from Avocado Skins is done as follows.

Spectra region wave number cm^{-1}	Intensity and Pattern of peak	Bond causing Absorption	Compound Class
411.82	Weak and Broad	-	-
441.72	Weak and Broad	-	-
521.77	Weak and Broad	-	-
1089.83	Medium and Broad	-	-
1265.36	Medium and Broad	-	-
1410.02	Medium and Broad	O-H Bending	Alcohol
1612.56	Strong and Broad	C=C Stretching	α, β-unsaturated Ketone
2089	Medium and Broad	-	-
2938.68	Strong and Broad	N-H Stretching	Amine salt
3401.61	Strong and Broad	O-H Stretching	Alcohol
3829.83	Weak and Broad	-	-
3953.28	Weak and Broad	-	-

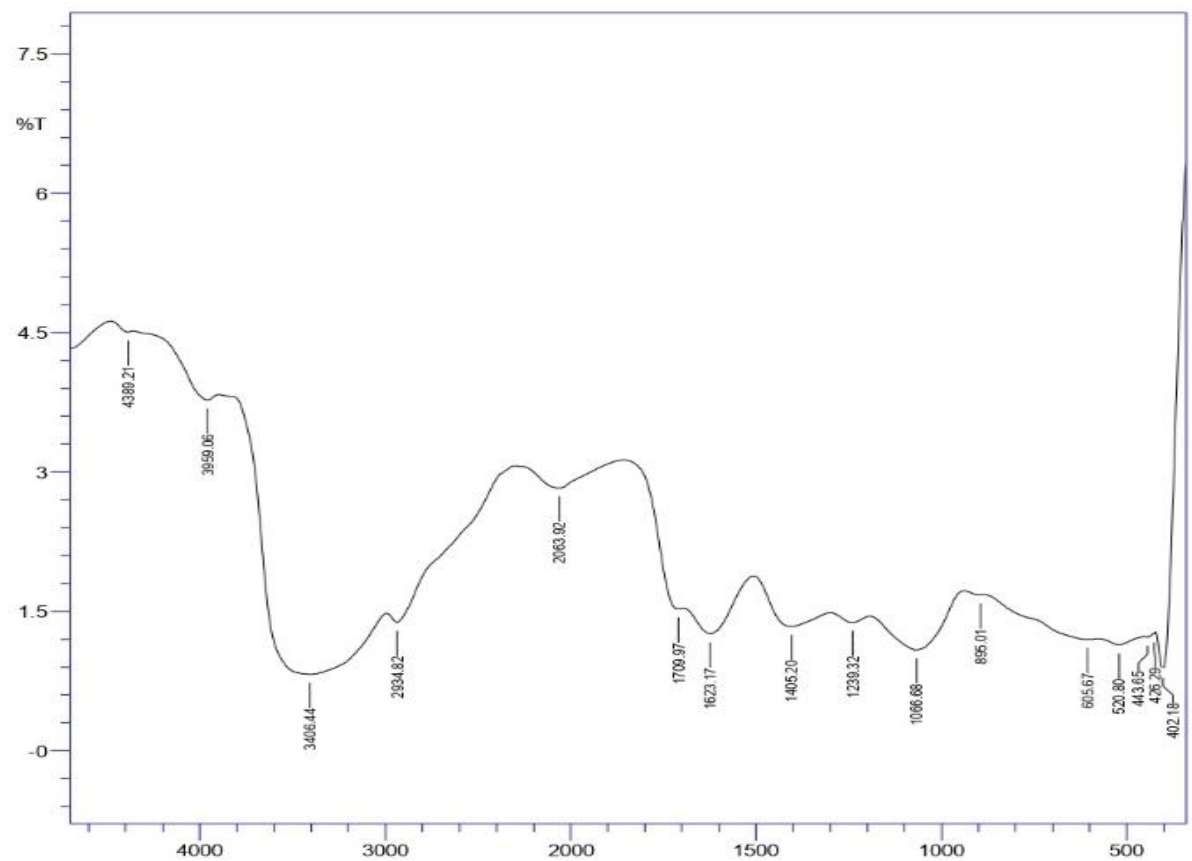


Figure-8: FTIR spectra of Natural Dye made from Straw Berry.

Table-4: Interpretation of FTIR spectra of Natural Dye made from Strawberry is done as follows.

Spectra region wave number cm^{-1}	Intensity and Pattern of peak	Bond causing Absorption	Compound Class
402.18	Weak and Broad	-	-
426.29	Weak and Broad	-	-
443.65	Weak and Broad	-	-
520.8	Weak and Broad	-	-
605.67	Weak and Broad	-	-
895.01	Weak and Broad	-	-
1066.68	Weak and Broad	-	-
1239.32	Weak and Broad	-	-
1405.2	Weak and Broad	-	-
1623.17	Medium and Broad	-	-
1709.97	Medium and Broad	-	-
2063.92	Weak and Broad	-	-
2934.82	Weak and Broad	-	-
3406.44	Strong and Broad	O-H Stretching	Alcohol
3959.06	Weak and Broad	-	-
4389.21	Weak and Broad	-	-

Table-5: Interpretation of FTIR spectra of Natural Dye made from Madder Root is done as follows.

Spectra region wave number cm^{-1}	Intensity and Pattern of peak	Bond causing Absorption	Compound Class
396.39	Strong and Sharp	-	-
467.76	Strong and Broad	-	-
489.94	Strong and Broad	-	-
510.19	Strong and Broad	C-I Stretching	Halo Compound
909.48	Weak and Broad	-	-
1066.68	Strong and Broad	C-O and S=O Stretching	Primary Alcohol Sufoxide
1242.21	Weak and Broad	-	-
1408.1	Medium and Broad	O-H Bending	Carboxylic acid, Alcohol
1613.52	Strong and Broad	C=C Stretching	α, β-unsaturated Ketone
2067.78	Weak and Broad	-	-
2285.74	Weak and Broad	-	-
2350.36	Weak and Broad	-	-
2930	Strong and Sharp	O-H and N-H Stretching	Carboxylic acid Amine Salt
3378.47	Strong and Broad	O-H Stretching	Alcohol
3848.15	Weak and Broad	-	-
3967.74	Weak and Broad	-	-
4395	Weak and Broad	-	-

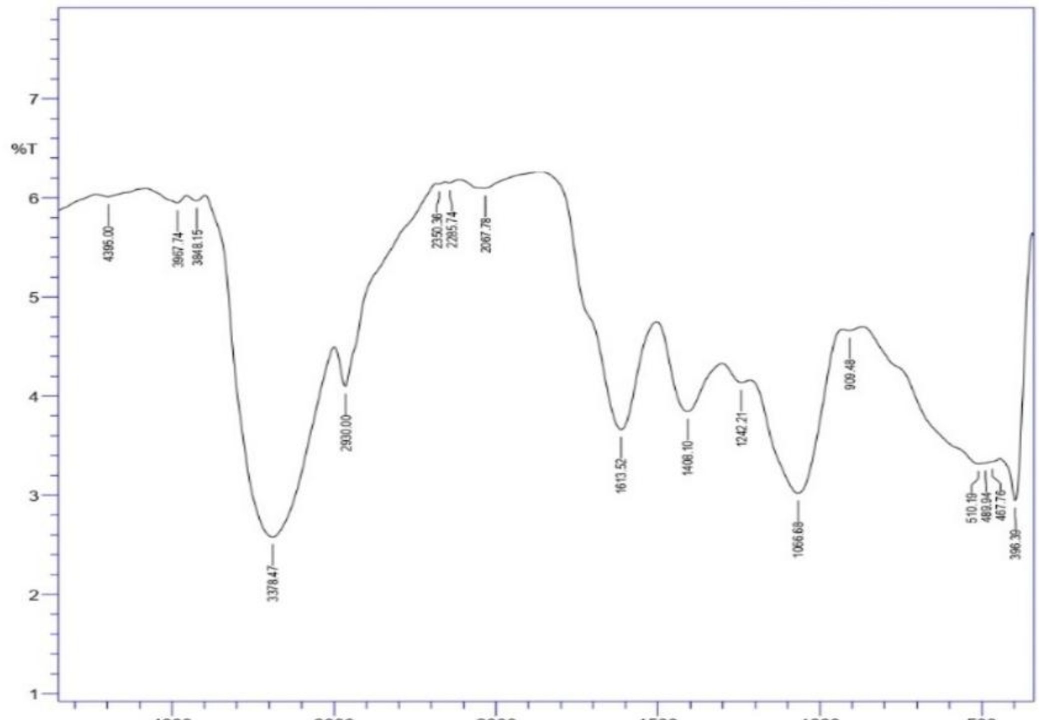


Figure-9: FTIR spectra of Natural Dye made from Madder Root.

Table-6: Colour fastness test for water fastness and light fastness to avocado pits, avocado skins, straw berry and madder root dyed fabric shows 4-5 range in gray scale method which indicates excellent to water fastness and light fastness.

Cotton Fabric	Colour obtained RAL Color Chart	Colour Fastness Test	
		Water Fastness	Light Fastness
00 - Not Mordanted and Not Dyed	RAL 9001 Cream	5	5
0A - Mordanted with Soymilk and Not Dyed	RAL 9001 Cream	5	5
0B - Mordanted with Alum and Not Dyed	RAL 9001 Cream	5	5
1A - Mordanted with Soymilk and Dyed with Avocado Pits	RAL 3012 Beige Red	4-5	4-5
1B - mordanted with alum and dyed with avocado pits	RAL 3012 Beige Red	4-5	4-5
2A - mordanted with soymilk and dyed with avocado skins	RAL 3012 Beige Red	4-5	4-5
2B - mordanted with alum and dyed with avocado skins	RAL 3012 Beige Red	4-5	4-5
3A - mordanted with soymilk and dyed with strawberry	RAL 4006 Traffic Purple	4-5	4-5
3B - mordanted with alum and dyed with strawberry	RAL 3015 Light Pink	4-5	4-5
4A - mordanted with soymilk and dyed with madder root	RAL 3015 Light Pink	4-5	4-5
4B - mordanted with alum and dyed with madder root	RAL 3017 Rose	4-5	4-5

Figure-7: Interpretation of FTIR Spectra shows presence of various functional groups such as.

Bond causing Absorption	Compound Class	Bond causing Absorption	Compound Class
Natural Dye made from Avocado Pits		Natural Dye made from Strawberry	
C-H Stretching	Alkane	O-H Stretching	Alcohol
O-H Stretching	Alcohol	Natural Dye made from Madder Root	
C=C Stretching	Alkene, α, β-unsaturated ketone	C-I Stretching	Halo Compound
CO-O-CO Stretching	Anhydride	C-O Stretching S=O Stretching	Primary Alcohol Sufoxide
Natural Dye made from Avocado Skins		O-H Stretching N-H Stretching	Carboxylic acid, Alcohol Amine Salt
O-H Stretching	Alcohol	O-H Bending	Carboxylic acid, Alcohol
O-H Bending	Alcohol	C=C Stretching	α, β-unsaturated Ketone
C=C Stretching	α, β-unsaturated Ketone		
N-H Stretching	Amine salt		

Conclusion

Cotton fabric not mordanted not dyed, mordanted with soymilk not dyed, mordanted with alum not dyed shows cream color. Cotton fabric mordanted with soymilk dyed with avocado pits, mordanted with alum dyed with avocado pits, mordanted with soymilk dyed with avocado skins, mordanted with alum dyed with avocado skins shows beige red color. Cotton fabric mordanted with soymilk dyed with strawberry shows traffic purple color while mordanted with alum dyed with strawberry shows light pink color. Cotton fabric mordanted with soymilk dyed with madder root shows light pink color while mordanted with alum dyed with madder root shows rose color.

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