

## NATURAL DYEING OF COTTON FABRIC EXTRACTED FROM ROSA (ROSE) AND GENUS TAGETS (MARIGOLD) FLOWERS

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### Abstract

In this study, the natural dye from rosa and genus taget flower is extracted through aqueous, alkaline and acidic extraction method and applied on cotton fabric and then evaluated its results. For dye extraction, petals of red rose was boiled and then filter the solution and decolorized petals were taken out of it. By using AATTC 61 dyeing method dye was applied on fabric in Industry. In aqueous, acidic and alkaline extraction same method used. In acidic extraction acidic acid and alkaline extraction sodium hydroxide was used. After applying natural dye on cotton fabric evaluated its result through colourfastness to wash and colourfastness to light tests. In colourfastness to wash the shade change and staining was measured through washing procedure. In colourfastness to light the shade change was measured through light procedure four readings were taken and mean was calculated. The result were interpreted in tables and graphs by using SPSS. In both test dyes from acidic extraction gives best results.

**Key words:** Genus Taget, Rosa, sodium hydroxide.

### Introduction

The art of dying is as old as our civilization. Archaeologists have located sign of fabric dyeing courting again to the Neolithic duration. In China, dyeing with plants, barks and insects has been traced back extra than 5,000 years. Because the name indicates, herbal dyes are derived from herbal resources. Primitive dyeing strategies blanketed sticking flora to material or rubbing crushed pigments into fabric. The essential method of dyeing modified little through the years. Generally, the dye material is put in a pot of water and heated to extract the dye compounds into answer with the water. The invention of artificial dyes in the mid-nineteenth century caused a protracted decline in the huge-scale market for herbal dyes (Rungruangkitkrai, 2017). Synthetic dyes, which can be fast produced in large quantities, speedy outmoded herbal dyes for the commercial fabric manufacturing enabled by the industrial revolution,

and unlike natural dyes, were appropriate for the artificial fibers that accompanied. Inside the early twenty first century, the marketplace for natural dyes in the style industry is experiencing a resurgence. Consumers have end up more concerned about the fitness and environmental effect of synthetic dyes which require using toxic fossil gasoline byproducts for his or her manufacturing in manufacturing and there is a developing demand for merchandise that use herbal dyes Dyeing of cotton cloth with natural dyes from flower extract (Yadav *et al.*, 2015).

Genus Tagets and Rosa plants were used for the extraction of natural dye. The experiments which become achieved for cotton cloth dyeing with sparkling Rose flower petals and dry Marigold flower petals. Rosa is a one of the maximum crucial ornamental plant especially growing in garden and wealthy in purple and purple pigments. Genus Tagets plant extracts as an antibacterial and antimicrobial first-rate dyer for textiles. Genus Tagets generally

referred to as Marigold is a vital wellspring of carotenoids and lutein, developed as a nursery plant. Genus Tagets blossoms are yellow to orange crimson in shade. These flowers do not require any extra care. They develop in all situations of the environment. Genus Taget plant life naked sun, warmth, and drought and grow in any well-drained soil (Patil *et al.*, 2016).

Genus Tagets is easy to grow even from transplants additionally. Genus Tagets requires a mild climate for easy increase and flowering. The herbal colorants particularly flavonoids and carotenoids gift inside the Marigold had been extracted via one-of-a-kind techniques and used as natural colorants on exclusive fabric. On this studies, the dyeing pigments present in flowers of purple rose and marigold have been extracted via the usage of three different solvent extraction methods. Dyeing performed in an alkaline, acidic or in aqueous extraction (Hossain, 2018).

Normally, herbal dyes have wide range, renewable, non-poisonous, non-carcinogenic, nonpoisonous, biodegradable, and non-unsafe to life. By means of the usage of herbal dyes over these other selections, you are helping hold the environment and reducing human dependence on harmful products. Natural Dye offer higher UV absorption in the fabrics they may be used on. Wearing garments dyed naturally, we are capable of extra absolutely defend our pores and skin from the sun's dangerous rays (Jothi, 2008).

Many plant life and a few animals were recognized as probably rich in natural dye contents, and a number of them were used for natural dyeing. Generally herbal dyes are extracted from the roots, stems, leaves, vegetation, end result of various plants, dried our bodies of positive bugs and minerals. Dyes are one of the maximum crucial makes use of of the plants. Currently, hobby inside the use of natural dyes

has been developing swiftly due to the result of stringent environmental standards imposed via many nations in response to toxic and allergic reactions associated with synthetic dyes. The waste from dyeing contains hundreds of pollutions and chemical compounds dumped onto rivers and canals nearby As end result with a wonderful lowering in synthetic dyestuff costs, the natural dyes have been truly unused at the start of 20th century (Ahmed and Saha, 2021).

Nowadays in maximum of the international locations, herbal dyeing is practiced handiest as a handcraft and artificial dyes are being utilized in all industrial dyeing tactics. But with the global situation over using environment friendly and biodegradable substances, the usage of natural dyes has over again received hobby. In comparison, natural dyes are environmental pleasant, show off higher biodegradability and commonly have a better compatibility with the environment than artificial dyes. The method is economically possible as the uncooked substances are to be had at low cost and so price of manufacturing is also very low. Natural dyes derived from flowers and fauna are believed to be safe due to its trustworthy, and biodegradable in nature (Joth, 2008).

Dyes derived from natural approach like plant leaves, roots, bark, end result, stem, insect secretions, and minerals were the most effective dyes to be had inside the history of mankind for dyeing textiles. But, the environmental threats and fitness risks to humans have driven them to the old and natural dyeing resources. Textiles colored with natural dyes are desired by means of buyers. Now not most effective is the usage of herbal dye reducing lower back on releasing chemicals into the environment, however also preventing pollutants from coming into

your home and frame. Anchal believes that by means of sourcing recycled cloth, natural fibers, herbal dyes, alongside growing best handcrafted textiles, we are able to start to make a distinction within the fabric enterprise (Ahsan and Masood, 2020).

Natural dyes must be accelerated to prevent us from pollutants and other dangerous effects. Using natural dyes within the shade system of fabric may be a step toward a brand new generation of much less polluting processing of textile. All style brands are now stepping forward for making the world much less polluted and greater livable. From the first actual of the twenty first century, the arena goes closer to more secure, less unsafe, recyclable generation. As a result using surroundings pleasant, biodegradable, non-poisonous, much less-polluting herbal dye is increasing every day in numerous sectors. The UV absorption belongings of maximum of the natural dyes makes it safer from harmful UV of sunlight. Foods, capsules, Cosmetics, and Textiles are the main market for herbal dyes (Gupta *et al.*, 2019).

In this research, the application of natural dye extracted from two different sources like, Rosa and marigold on cotton fabric was applied. Natural dyes and eco-friendly finishing of textile fabrics is gaining popularity because of the consciousness of people in saving the ecology. Rose flower has the dying potential as a source for cotton dying. Dyes obtained from red rose flower and marigold flower can be used as cost effective and economically.

#### **Research objectives**

- To develop natural dye from Rosa flower and Genus Taget flower.
- To apply rosa and genus taget flower natural dye on cotton fabric by use of Aqueous, Alkaline and

Acidic extraction.

- To evaluate colorfastness to wash and light from rosa dye and genus taget by using aqueous, alkaline and acidic extraction.

#### **Significance of the study**

Natural dyes are nontoxic, ecofriendly and non-allergic so the fabric dyed from natural dye is suitable for all people. Some persons are allergic from the synthetic dyes so the natural dyes are much beneficial for them in this regard. Today environment is much affected from the pollutants that's why people are bound to use such dyes that help in preserving our earth environment. The most important benefit of natural dyes includes the absorption of the rays that provide safety from the skin burns and cancers. Use of natural dyes has increased by several folds because of its raw material that is available naturally and also due to environment friendly nature. Some flowers as Rosa and Genus Taget are available at low costs and also have deep color pigments that are best for dying purposes. More natural the thing is, more advantages it has.

#### **Materials and Methods**

This research is quantitative in nature. Whole research is basically design on the extraction of natural dye. Apply it on natural fabric through aqueous, alkaline and acidic extraction methods and evaluate its effect by colorfastness to wash and colorfastness to light test.

#### **Preparation of fabric**

Cotton cloths used for dyeing were boiled in 10 % NaOH solution for 10 min to remove starch and other impurities from the cloth. The NaOH treated cotton cloths were then thoroughly washed with cold distilled water

#### **Development of Natural dye**

**Rose Aqueous extraction method:** In a beaker 10 gm fresh petals of pink rose were added and boiled in 100 ml distilled water at 100° C for 30 minutes. After 30 minutes the solution was filtered. The decolorized petals were taken out from extraction solvent. Then 25ml vinegar were added to retain color put the solution in steam soaping machine. The sample were died then rinse the sample and dry it under shadow to penetrate color. Then the sample was washed with tap water for 2 minutes to remove extra color.

#### Rose Alkaline extraction method

Same method was repeated as in aqueous extraction method. After repeating following steps 25ml of sodium hydroxide was taken in a beaker the sample was dipped in it for 5 minutes rinse the sample.

#### Rose Acidic extraction method

Same method was repeated as in aqueous extraction method. After repeating following steps 25ml of acidic acid was taken in a beaker the sample was dipped in it for 5 minutes rinse the sample.

#### Marigold Alkaline extraction method

Same method was repeated as in aqueous extraction method. After repeating following steps 25ml of sodium hydroxide was taken in a beaker the sample was dipped in it for 5 minutes rinse the sample.

#### Marigold Acidic extraction method

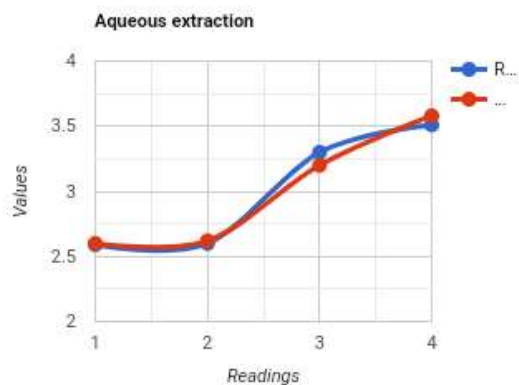
Same method was repeated as in aqueous extraction method. After repeating following steps 25ml of acidic acid was taken in a beaker the sample was dipped in it for 5 minutes rinse the sample.

### Results and discussion

#### Colorfastness to washing

##### Aqueous extraction

After dyeing cotton fabric from aqueous extraction rinse the sample. **In colourfastness to wash the shade change was measured through washing procedure four reading were taken out in order to avoid any mistake and then calculate the mean of all four readings.** Evaluate it in 4 different level and calculate mean.



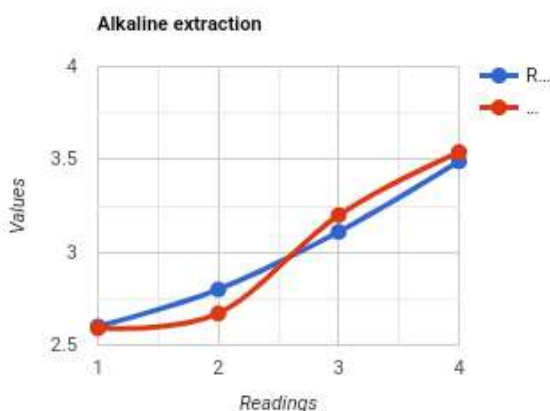
**Figure 4.4:** AATCC 61-2A trend of shade change in aqueous extraction

In figure 1 the curve lines indicating that the behavior of fabric dyed with rosa and genus taget the red line indicate genus taget shade change values while blue line indicate rosa values. At first reading the value of shade change in rose is 2.59 while at the end the reading is 3.51 and after evaluate the mean of shade change is 3. Same in the case of marigold the shade changes from 2.60 to 3.58 and its mean is also 03. This indicate that the this is less appropriate rating in dyeing and there is need to improve the procedure

#### Alkaline extraction

After dyeing cotton fabric from aqueous extraction. 25 mL of sodium hydroxide was taken in a beaker the sample was dipped in it for 5 minutes rinse the sample. **In colourfastness to wash the shade change was measured through washing procedure four reading were taken out in order to avoid any mistake and then calculate the mean**

**of all four readings.** Evaluate it in 4 different level and calculate mean.

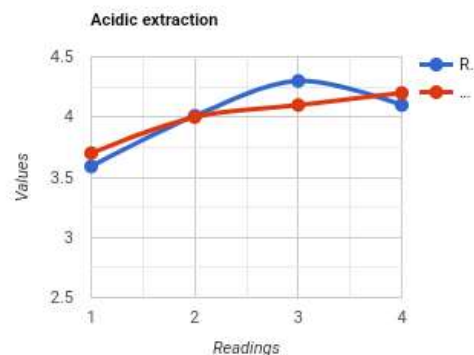


**Figure 2:** Presenting trends of shade changes in alkaline extraction

In figure 2 the curve lines indicating that the behavior of fabric dyed with rosa and genus taget the red line indicate genus taget shade change values while blue line indicate rosa values. At first reading the value of shade change in rose is 2.6 while at the end the reading is 3.49 and after evaluate the mean of shade change is 3. Same in the case of marigold shade changes from 2.59 to 3.54 and mean is 03. This indicate that the this is less appropriate rating in dyeing and there is need to improve the procedure.

#### Acidic extraction

After dyeing cotton fabric from aqueous extraction. 25 mL of acidic acid was taken in a beaker the sample was dipped in it for 5 minutes rinse the sample. **In colourfastness to wash the shade change was measured through washing procedure four reading were taken out in order to avoid any mistake and then calculate the mean of all four readings.** Evaluate it in 4 different level and calculate mean.



**Figure 3:** Determining the behavior of shade change in acidic extraction

In figure 3 the curve lines indicating that the behavior of fabric dyed with rosa and genus taget the red line indicate genus taget shade change values while blue line indicate rosa values. At first reading the value of shade change in rosa is 3.59 while at the end the reading is 4.10 and the mean is 4. Same in the case of marigold the shade changes from 3.7 to 4.2 and its mean is 04. This indicate that the this is appropriate rating in dyeing and there is no need to improve the procedure.

#### Comparison of aqueous, alkali and acidic extraction

After comparing shades of aqueous, alkali and acidic extraction the most suitable extraction was Acidic extraction as it has more precise value of shade change.

#### Staining test

Staining is color bleeding from a fabric that cause color stain on other fabric that was washed with it. The test used for staining was AATCC 61-2A

#### Standard of staining test

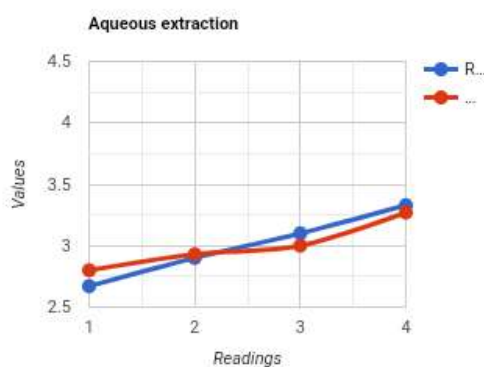
In AATCC 61-2A the perfect rating is 5 the sample with rating 5 has best dyeing absorbency capacity. The grey scale for staining rates the staining of and un dyed material tested with the specimen on a

scale is from 01 (greater color transfer) to 05 (no color transfer). The aim of color staining rating is 4-5.

#### Aqueous extraction

After dyeing cotton fabric from aqueous extraction rinse the sample. **In colourfastness to wash the staining was measured through washing procedure four reading were taken out in order to avoid any mistake and then calculate the mean of all four readings.** Evaluate it in 4 different level and calculate mean.

In table 4.4 at first reading the value of staining in rose is 2.67 while at the end the reading is 3.33 and after evaluate the mean of stainig is 3. Same in the case of marigold staining changes from 2.80 to 3.27 and its mean is 03. This indicate that the this is less appropriate rating in dyeing and there is need to improve the procedure.



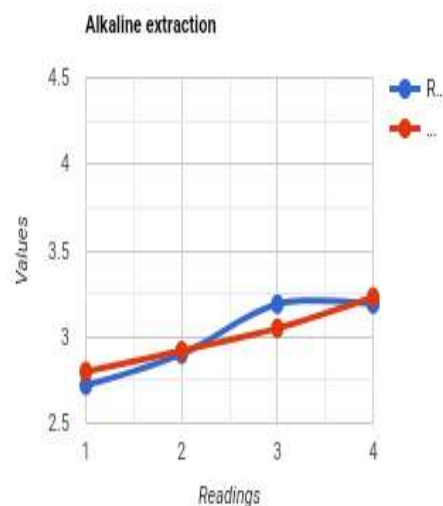
**Figure 4:** AATCC 61-2A staining test in aqueous extraction

In figure 4 the curve lines indicating that the behavior of fabric dyed with rosa and genus taget the red line indicate genus taget staining values while blue line indicate rosa values. At first reading the value of staining in rose is 2.67 while at the end the reading is 3.33 and after evaluate the mean of stainig is 3. Same in the case of marigold staining changes from 2.80 to 3.27 and its mean is 03. This indicate that the this is less appropriate rating in dyeing and there is need to

improve the procedure.

#### Alkaline extraction

After dyeing cotton fabric from aqueous extraction. 25ml of sodium hydroxide was taken in a beaker the sample was dipped in it for 5 minutes rinse the sample. **In colourfastness to wash the shade change was measured through washing procedure four reading were taken out in order to avoid any mistake and then calculate the mean of all four readings.** Evaluate it in 4 different level and calculate mean.



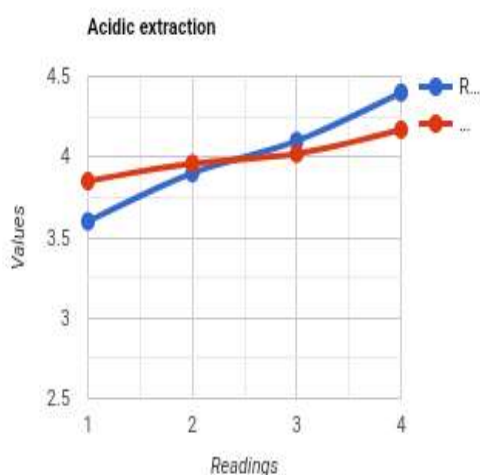
**Figure 5:** determining the trend of alkali extraction

In figure 5 the curve lines indicating that the behavior of fabric dyed with rosa and genus taget the red line indicate genus taget staining values while blue line indicate rosa values. At first reading the value of staining of rose is 2.72 while at the end the reading is 3.19 and after evaluate the mean of stainig is 3. Same in the case of marigold the staining value changes from 2.80 to 3.23 and its mean is 03. This indicate that the this is less appropriate rating in dyeing and there is need to improve the procedure.

#### Acidic extraction

After dyeing cotton fabric from aqueous

extraction. 25ml of acidic acid was taken in a beaker the sample was dipped in it for 5 minutes rinse the sample. **In colourfastness to wash the staining was measured through washing procedure four reading were taken out in order to avoid any mistake and then calculate the mean of all four readings.** Evaluate it in 4 different level and calculate mean.



**Figure 6:** Acidic staining determination

In figure 6 the curve lines indicating that the behavior of fabric dyed with rosa and genus taget the red line indicate genus taget staining values while blue line indicate rosa values. At first reading the value of staining in rose is 3.6 while at the end the reading is 4.4 and after evaluate the mean of stainig is 4. Same in the case of marigold staining is changes from 3.85 to 4.17 and its mean is 04. This indicate that the this is appropriate rating in dyeing and there is no need to improve the procedure.

#### Comparison of aqueous, alkali and acidic extraction

After comparing shades of aqueous, alkali and acidic extraction the most suitable extraction was

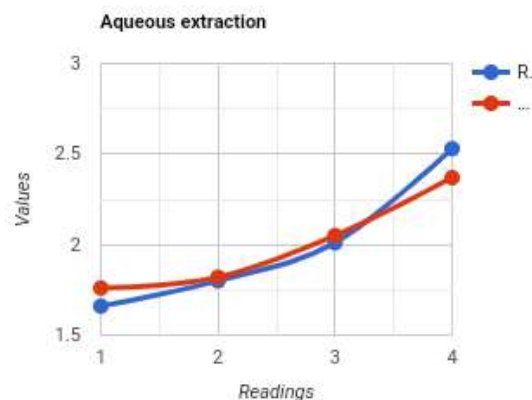
Acidic extraction as it has more precise value of shade change.

#### Colorfastness to light

The level of *change* in color it undergoes when exposed to light. The test use for colorfastness to light was ISO 105 BO2.

#### Aqueous extraction

After dyeing cotton fabric from aqueous extraction rinse the sample. **In colourfastness to light the shade change was measured through washing procedure four reading were taken out in order to avoid any mistake and then calculate the mean of all four readings.** Evaluate it in 4 different level and calculate mean.



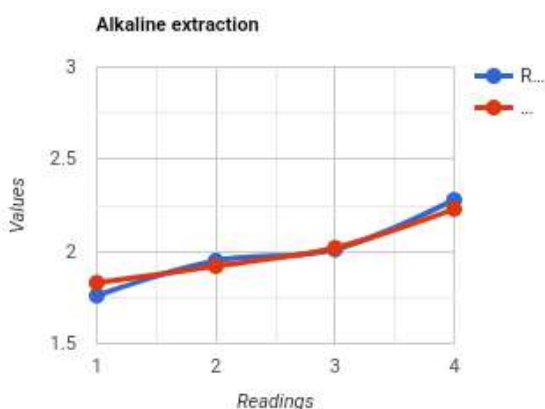
**Figure 7:** Trend of shade change in aqueous extraction

In figure 7 the curve lines indicating that the behavior of fabric dyed with rosa and genus taget the red line indicates genus taget shade change values while blue line indicate rosa values. At first reading the value of shade change of rose is 1.66 while at the end the reading is 2.53 and after evaluate the mean of shade change is 2. Same In the case of marigold shade changes from 1.76 to 2.37and its mean is 02. This indicate that the this is less appropriate rating in dyeing and there is need to improve the procedure.



### Alkaline extraction

After dyeing cotton fabric from aqueous extraction. 25 mL of sodium hydroxide was taken in a beaker the sample was dipped in it for 5 minutes rinse the sample. Evaluate it in 4 different level and calculate mean.



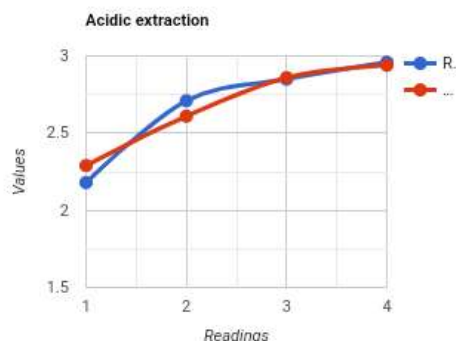
**Figure 8:** Indicating trend of alkaline shade change

In figure 8 the curve lines indicating that the behavior of fabric dyed with rosa and genus taget the red line indicate genus taget shade change values while blue line indicate rosa values. At first reading the value of shade change of rose is 1.76 while at the end the reading is 2.28 and after evaluate the mean of shade change is 2. Same in the case of marigold shade changes from 1.76 to 2.28 and mean is 02. This indicate that the this is less appropriate rating in dyeing and there is need to improve the procedure.

### Acidic extraction

After dyeing cotton fabric from aqueous extraction. 25 mL of acidic acid was taken in a beaker the sample was dipped in it for 5 minutes rinse the sample. **In colourfastness to light the shade change was measured through washing procedure four reading were taken out in order**

**to avoid any mistake and then calculate the mean of all four readings.** Evaluate it in 4 different level and calculate mean.



**Figure 9:** Shade determining in acidic extraction

In figure 9 the curve lines indicating that the behavior of fabric dyed with rosa and genus taget the red line indicate genus taget shade change values while blue line indicate rosa values. At first reading the value of shade change of rose is 2.18 while at the end the reading is 2.96 and after evaluate the mean of shade change is 2-3. Same case in marigold shade changes from 2.29 to 2.94 and its mean is between 2-3. This indicate that the this is less appropriate rating in dyeing and there is need to improve the procedure.

### Comparison of aqueous, alkali and acidic extraction

After comparing shades of aqueous, alkali and acidic extraction the most suitable extraction was Acidic extraction as it has more precise value of shade change.

### Discussion:

The petals of pink rose flower have the death potential as a source for cotton loss of life. Dyes acquired from the petals of crimson rose can be used for dyeing of cotton using alum as mordant. Study revealed that the petals of red rose could be used as a



dye for dyeing cotton yarn and the dye does not make any problems to the environment. Using natural dye instead of it will be good option that will help to save environment as well as living organisms (Mustafa, 2014). In this study red rose is used to dye cotton fabric using vinegar as mordant to maintain color of fabric rose is a natural substance and having dyeing potential so it helps textile industry to save environment. So, the previous study support current study.

Rose flower can be used as dyeing substance it offer exclusive shades of shade the usage of one-of-a-kind mordants and the color fastness, wash fastness homes also may be stepped forward by using one of a kind extraction tactics natural dye (Papita, 2018). This study reveal that the red rose is available and in reach of everyone using vinegar as mordant it provide awesome shade on cotton fabric. Different extraction methods were used like aqueous, alkaline and acidic it improve wash fastness properties on cotton fabric. Previous study by Papita supporting the current study.

Natural dye has color fastness and good washing properties. Natural dye obtained from red rose and marigold are good in shade change properties and also in staining. Extraction was done using aqueous, alkaline and acidic methods. All results are compared to each other and it was found that acid has a strong effect on cotton fabric (Ghazi, 2018). In this research it is found that red rose and marigold flower are poor in color bleeding so they resist stain and shade change properties the acidic acid gives strong shade on cotton fabric as compare to the aqueous and alkaline extraction in both tests colorfastness to wash and staining test so, previous study done by ghazi supporting the present study.

This research indicate that cotton is a good fabric for dyeing as it has high absorbency power so it absorbs dye. Cotton is a natural fabric so applying

natural dye on it is ecofriendly too. Cotton due to high absorbency power resist shade change and staining properties in colorfastness to wash and colorfastness to light test. The diverse color sun shades may be obtained using safe and ecofriendly mordants. The research imply that herbal dyes are safe and using exclusive mordants give distinctive sun shades that create appropriate effect on textiles enterprise (Nallathambi, 2017). This study reveals that cotton is a good fabric for dyeing it gives positive result in both test colorfastness to wash and colorfastness to light. Using vinegar as mordant help to fix color on cotton fabric. The previous research supporting the present study.

### **Conclusion**

In this study, the objectives of research are to develop natural dye extracted from rosa and genus taget using aqueous, alkaline and acidic method. Apply natural dye on cotton using vinegar as mordant. And then evaluate natural dye effect on cotton through colorfastness to wash and colorfastness to light method. In a beaker add fresh petals of red rose were added and boiled in distilled water at for sometime. After sometime the solution was filtered. The decolorized petals have been taken out from extraction solvent. Then vinegar turned into brought to hold colour positioned the solution in steam soaping system. The sample was died then rinses the sample and dry it under shadow to penetrate color. Then the sample was washed with tap water for few minutes to remove extra color. After this take a beaker add acid or alkali in it and put the sample for few minutes. This was the whole method of natural dyeing of cotton. The results are evaluated in tables and graph of colorfastness to wash test and colorfastness to light test.

### **Acknowledgements**

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### Conflict of Interest

There is no conflict of interest to show.

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There is no funding for this research work.

### Authors' contribution

SS gave the concept of idea, design of work, and interpretation of data. AK is a designer of work and also does the drafting of the manuscript. KH performed the drafting of the manuscript. ZA give revisions to the manuscript and interpreted data. AS also performed interpretation of data and give revision of the manuscript.

### References

- Adeel, S., T. Gulzar, M. Azeem, M. Saeed, I. Hanif, I., and N. Iqbal. 2017. Appraisal of marigold flower based lutein as natural colourant for textile dyeing under the influence of gamma radiations. *Radiation Physics and Chemistry*, 130: 35-39.
- Ahsan, R., A. Hossain, R. Sherwani, R. and H. Khushbakhat. 2018. Extraction and application of natural dyes on natural fibers: an eco-friendly perspective. *Review of Education, Administration and LAW*, 3(1): 63-75.
- Křížová, H. and J. Wiener. 2016. Dyeing of woolen fabric pre-treated with tin chloride using yellow blossoms. *International Education and Research Journal*, 2.
- Ali, S., T. Hussain and R. Nawaz. 2009. Optimization of alkaline extraction of natural dye from Henna leaves and its dyeing on cotton by exhaust method. *Journal of Cleaner Production*, 17(1): 61-66.
- Angelini, L. G., L. Pistelli, P. Belloni, A. Bertoli, and S. Panconesi. 1997. *Rubia tinctorum* a source of natural dyes: agronomic evaluation, quantitative analysis of alizarin and industrial assays. *Industrial Crops and Products*, 6(3-4): 303-311.
- Budeanu, R., A. Curteza, and C. D. Yadav. 2015. Experimental researches regarding the ecological dyeing with natural extracts. *AUTEX Research Journal*, 14(4): 290-298.
- Buket, A., E. CANİTEZ, and A. KİRTAK. 2020. Investigation of Dyeing properties of red cabbage to cotton fabrics in different pH and mordanting conditions. *Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, 24(2): 244-255.
- Cristea, D., and G. Vilarem. 2006. Improving light fastness of natural dyes on cotton yarn. *Dyes and Pigments*, 70(3): 238-245.
- Deo, H. T., and B. K. Desai. 1999. Dyeing of cotton and jute with tea as a natural dye. *Coloration Technology*, 115(7-8): 224-227.
- Gokilamani, N., N. Muthukumarasamy, M. Thambidurai, A. Ranjitha, D. Velauthapillai, T. S. Senthil, and R. Balasundaraprabhu, R. 2020. Dye-sensitized solar cells with natural dyes extracted from rose petals. *Journal of Materials Science: Materials in Electronics*, 24(9): 3394-3402.
- Gopalakrishnan, M., S. Anubama, E. Prasanth, and M. Srinithi. 2021. Natural dyes for cotton fibre. *International Journal of Recent Advances in Multidisciplinary Topics*, 2(6): 60-65.
- Guha, A. K. 2019. A review on sources and application of natural dyes in textiles. *International Journal of Textile Science*, 8(2): 38-40.
- Guinot, P., A. Gargadennec, G. Valette, A. Fruchier, and C. Andary. 2008. Primary flavonoids in marigold dye: extraction, structure and involvement in the dyeing process. *Phytochemical Analysis: An International Journal of Plant Chemical and Biochemical Techniques*, 19(1): 46-51.
- Haji, A. 2019. Dyeing of cotton fabric with natural dyes improved by mordants and plasma treatment. *Progress in Color, Colorants and Coatings*, 12(3): 191-201.
- Hamdy, D., A. G. Hassabo and H. A. Othman. 2021. Various natural dyes using plant palette in coloration of natural fabrics. *Journal of Textiles, Coloration and Polymer Science*, 18(2): 121-141.
- Jha, C. K., K. Ratan, S. V. Kumar, and V. D. Rajeswari. 2018. Extraction of natural dye from marigold flower (*Tagetes erecta* L.) and dyeing of fabric and yarns: a focus on colorimetric analysis and fastness properties. *Der Pharmacia Lettre*, 7(1): 185-195.

- Jothi, D. 2018. Extraction of natural dyes from African marigold flower (*Tagetes erecta* L.) for textile coloration. *Autex Research Journal*, 8(2): 49-53.
- Karaboyaci, M. 2014. Recycling of rose wastes for use in natural plant dye and industrial applications. *The Journal of the Textile Institute*, 105(11): 1160-1166.
- Kipruto, A., M. Arusei, and E. Kerich. 2015. Towards technical development of natural dyes for the textile industry in Kenya: A case study of *Bixa orellana* solvent extracts. *African Journal of Education, Science and Technology*, 4(2): 222-239.
- Kulkarni, S. S., A. V. Gokhale, U. M. Bodake, and G. R. Pathade. 2011. Cotton dyeing with natural dye extracted from pomegranate (*Punica granatum*) Peel. *Universal Journal of Environmental Research and Technology*, 1(2).
- Morshed, M. N., H. Deb, S. A. Azad, M. Z. Sultana, and A. K. Guha. 2016. Aqueous and solvent extraction of natural colorants from *Tagetes erecta* L., *Lawsonia inermis*, *Rosa indica* L for coloration of cellulosic substrates. *American Journal of Polymer Science and Technology*, 2(2): 34- 39.
- Nutchawanit, M., C. Satirapipathkul, and R. Mongkholrattanasit. 2019. The Effects of cationization on dyeing properties of cotton fabric dyed with marigold and rose. *International Journal of Chemical Engineering and Applications*, 10(2): 60-63.
- Patil, D. B., K. N. Patil, P. V. Gaikwad, P. J. Patil, U. L. Shewale, and S. B. Bhamburdekar. 2008. Extraction of natural dye from rose flower for dyeing cotton fabrics. *International Journal for Innovative Research in Multidisciplinary Field*, 2(8): 135-37.
- Rungruangkitkrai, N., and R. Mongkholrattanasit. 2017. Eco-Friendly Dyeing and Printing of Textiles with Natural Dyes Nattadon Rungruangkitkrai1, Rattanaphol Mongkholrattanasit2, b.Samanta, A. K., and Agarwal, P. (2017). Application of natural dyes on textiles.
- Shahid, M., and F. Mohammad. 2013. Recent advancements in natural dye applications: a review. *Journal of Cleaner Production*, 53: 310-331.
- Siva, R. 2007. Status of natural dyes and dye-yielding plants in India. *Current Science*, 916-925.
- Vandekar, V. D. 2019. Extraction of natural dyes from rose, pomegranate rind, common marigold, and walnut. *Journal of Natural Product and Plant Resources*, 5(2): 33-36.
- Zhou, H., L. Wu, Y. Gao, and T. Ma. 2011. Dye-sensitized solar cells using 20 natural dyes as sensitizers. *Journal of Photochemistry and Photobiology A: Chemistry*, 219(2-3): 188-194.