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How to achieve right first time dyeing with ecofriendly natural dyes

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Abstract
Today natural dyes are in great demand in the textile world. If the dyeing process is not followed accurately, highly sensitive behavior of natural dyes towards pH and metals often creates problem in achieving Right First Time Dyeing. Some textile mills are successfully producing fabrics dyed with natural dyes. The problem arises when the same recipe doesn't yield the same shade. It differs from Lab Dip to bulk with same Ready for Dye (RFD) fabric and same standard process parameters. The close correlation between all processes is essential to ensure consistent laboratory to bulk reproducibility in dyeing with natural dyes. When dyeing with natural dyes, dyer has to do work to deal with the error generation during the transfer of dyeing recipe from lab to the production unit. An investigation of the possible sources of an error occurring in the lab-to-plant dyeing correlation revealed that a comprehensive review of case studies and scientific analysis would be beneficial for any textile dye house in reproducing the shades obtained from natural dyes.

Keywords: Natural dyes, Lab dyeing, dye uptake, mallow, rubia, punica granatum, rubia cordifolia pretreatment, dyeing, after-treatments, dyes, auxiliaries, shades evaluation

1. Introduction
Today world is returning towards nature. Natural dyes are gaining demand in textile world. Natural dyes are extremely sensitive to dye bath physical and chemical conditions. Dyeing of a textile is the most important step in producing a fabric, it requires attentiveness to get it right by escaping re dyeing and sustaining process costing. When dyeing houses are working on Right-First-Time (RFT) dyeing concept the accurate correlation of a laboratory dyeing to a production dyeing lot is a matter of concern for dyeing houses using natural dyes. Unfortunately, there is no clear and practical guidebook which take guarantee to give the desired results.

With natural dyes maximization of "right-first-time" dyeing and minimization of re dyeing is not impossible. Color additions and off-quality problems such as shading within the dye lot can be successfully avoided by optimization of lab-to-plant dyeing correlation. For accuracy in dyeing in bulk the expertise in laboratory dyeing is necessary for dyeing house. By this only dyed fabric requirements demanded by the customer can be achieved regularly Today in textile world where consistent quality and service to the buyer are important but profit margins are reducing day by day so one approach useful for improving consistency in colors with natural dyes is to expertising the process to establish a plant-to-lab correlation. In the lab process dyers should consider each and every factor that might influence optimum dyeing conditions in the production process. Since natural dyes are highly sensitive each factor leading to shade variability, large or small, should be evaluated and controlled to the best possible extent.

2. Factors that influences lab-to-plant correlation when dyeing with natural dyes.
- Lab dyeing equipment and techniques
- Dye house water quality control
- Evaluation of fiber / Yarn / fabric properties on dye uptake
- Standardization and compatibility of Dye and auxiliary
- Weighing and measurements of dyes and auxiliaries
- Preparation of solutions

- Method of shade evaluation
- Fabric after-treatments

2.1 Lab dyeing equipment and techniques

Laboratory dyeing techniques, which are both accurate and repeatable to bulk dyeing processes, are absolutely essential for the optimization of the production output and the cost effectiveness of the competitive dyeing with natural dyes. In regular synthetic dyes it has been reported that the cost of each color correction during dyeing increases the cost of production which directly reduces the profitability. For natural dyes which are little bit costlier than synthetic one laboratory dyeing techniques are very important because if not accurate it can leads to difficulties in production planning, increased pollution loads on waste treatment facilities, and prolonged delivery times. It has become necessary for each dyeing house to understand two major points in dyeing. First the compatibility between natural dyes, auxiliaries and substrates and second the parameters that influence the rate and extent of natural dye uptake by the substrate. The lab dyeing equipment should duplicate the operational parameters of the production dyeing machine. Since production dyeing machines are complex and intricately designed laboratory equipment may not be available to simulate the exact conditions of the production machine.

To overcome this situation dyers should develop some conversion formulas to correlate lab to plant. The control systems of the lab and production equipment should identical. The use of microprocessor controls has greatly improved the ability to accurately control and repeat the dyeing cycle. For dyeing with natural dyes the important factors that should be the same between lab and plant machines are:-

- Dye liquor to fabric ratio.
- Dye bath pH monitor and control
- Machine induced fabric surface change.
- Accurate time and temperature controls
- Fabric movement and agitation level throughout the dye bath.
- Wet pickup.
- Washing cycle controls.
- Fabric drying temperature
- Dye cycle reproduction reliability.

Dyers often use some techniques to prepare recipes and procedures using color matching instruments and historic dyeing databases of synthetic dyes. Since natural dyes are not pure or single compound this approach has the potential for poor dyeing correlation. Practically it is seen that a bulk correction of a 300-kg production batch may cost as much as 25 laboratory dyeing depending on the process and dye house infrastructure. Due to the relatively low cost of lab dyeing compared to production and the low cost of lab dyeing mistakes dyers should perform multiple lab dyeing (at least three) as an alternative.

Difference in shade dyed from Natural Dye Rubia (Rubia cordifolia) using same recipe same RFD fabric

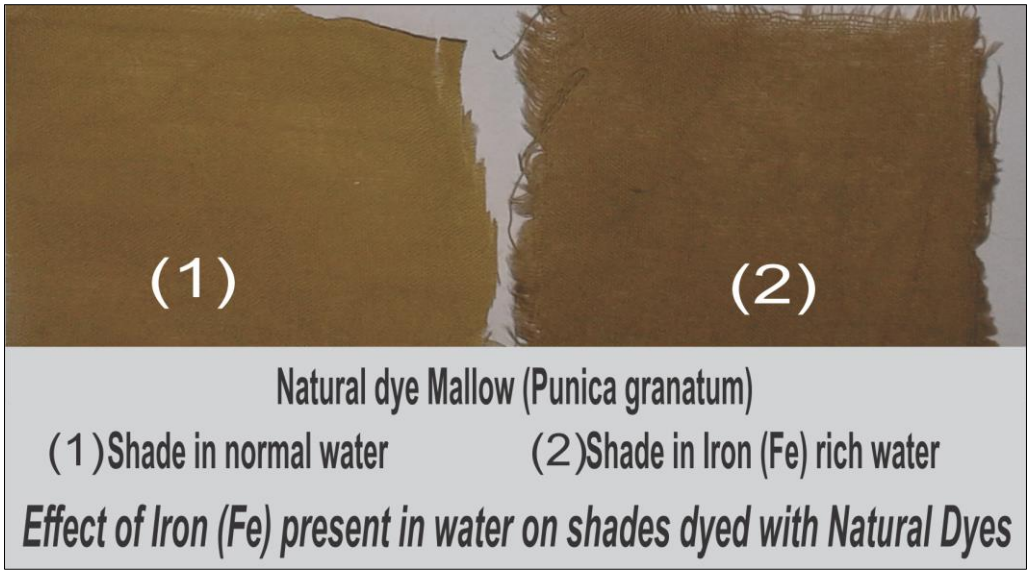
On the grounds of the unavoidable processing differences between various types of lab equipment and the variety of production processes, it has been proven that the natural dye formula correlation can be improved by employing sample scale dyeing equipment. In this approach, lab dye formulas developed on small fabric swatches must be dyed on sample scale equipment, normally 50 to 100 gm fabric capacity, which closely resembles the construction and operation of the actual plant production equipment. Once the lab formula is used on the sample scale equipment, any corrections necessary should be made to be used with production dye lots. To minimize errors caused by inconsistent procedures within the lab between working staff it is important for lab staff to follow SOP.

2.2 Dye house water quality control

This is the most important and often overlooked factor which has great impact on dyeing with natural dyes. Single natural dye gives different colors by reacting with different metal salts and change in pH. The source of the water should be as consistent as possible. All incoming process water should meet minimum specifications for purity, so as not to interfere with dyeing. Most routine analysis of process water will include tests for:

- Water hardness.
- pH
- Color /odour/Clarity
- Total minerals such as iron, copper, calcium, magnesium, aluminum etc.
- Total organic matter.
- Bleaching agents as Chlorine, hydrogen peroxide etc.

Sometimes due to particular location of plant specific unique impurities are found in water which may require special testing. Excess of iron makes drastic change in shade. Different hue appears by single natural dye with difference in water TDS chemistry. The water used for laboratory dyeing must be the same as that used for dyeing bulk. In practice plants use analytical quality water for laboratory dyeing, such as specially deionized or distilled water. This practice leads definitely to poor lab-to-bulk correlation.



2.3 Evaluation of fiber / Yarn/ fabric properties on dye uptake

This is an important, though frequently overlooked, issue. The fiber / Yarn/ fabric for laboratory dyeing should be identical to that of production lots. Natural dyes have excellent affinity with protein fibers as wool and silk. Shades vary a lot with protein structures in different types of wool and silk.

Fabrics for laboratory dyeing should be from production lots prepared on production equipment. It is must to prevent avoidable shade discrepancies. Any special preparation processes used for production lots should also be performed on the fabrics used for laboratory dyeing for those lots. Any variability in preparation can lead directly to production shade variability. Any factor that affects the weight of the fabric that the laboratory dyeing recipe is based on must be taken into account. For instance, if the production dye formula is based on the greige fabric weight, then the lab dye formula should be based on greige weight, not on prepared fabric weight. Additionally, the moisture content of the fabric for lab dyeing should be the same as that of production fabrics. Scales used for weighing both laboratory and production fabrics should be routinely calibrated and serviced.

2.4 Selection and standardization of natural dye and auxiliaries

It is important that the selection of natural dye for both laboratory and production dyeing must not base only on the technical requirements of shade, fixation and fastness, but also on the dye quality and reliability of the natural dye supplier. Routine quality control test must be done for all natural dyes for the production lots and lab. Exact specifications for acceptable quality should be established for each natural dye and auxiliary. Testing should be done in standardized, acceptable methods.

Some of the main tests must be done are

1. Incoming natural dye and auxiliaries should be tested by the lab using standard methods.
2. The stability and compatibility characteristics of natural dyes and auxiliary in combination within the bath and foaming properties during the dyeing cycle should be recorded and evaluated in regard to the agitation created by the lab and production dyeing machines.
3. pH and shade change sensitivity of the natural dye
4. Adverse effects of specific natural dye diluent.
5. Storage conditions of natural dyes in Lab and production.

2.5 Weighing and measurement of natural dyes and auxiliaries

The accuracy in measurement of weight or volume of the dyes and auxiliary in the lab apparatus and subsequently in the production machine is core of dye recipe development. Weighing or measuring errors in either process cause poor lab-to-plant correlation. Recording scales and balances that are accurate to the required degree of precision are the minimum requirement. Care should be taken when measuring the amount of natural dyes and auxiliary required for laboratory dyeing. Small weighing or measuring errors in lab dyeing lead to large variability in production with natural dyes.

There must be proper SOP for mixing. Proper training to lab and production personnel should be given and routine observation to ensure that correct procedures be followed. Managerial staff should evaluate the common practice of the plant in an attempt to minimize the potential for weighing errors, contamination of natural dye and auxiliary storage containers, and the possibility of using mislabeled products.

2.6 Preparation of solution

All natural dyes are highly hygroscopic and susceptible to changes in strength due to the absorption of water from atmospheric humidity. Natural dyes are also prone to water hydrolysis so always fresh solutions must be prepared of natural dyes before dyeing every day. Preparation and storage of natural dyes stock solutions should be avoided. Due to natural hydrolysis some unavoidable compound formation may take place in stock solution. This may produce many problems in repeatability in lab to bulk transfer.

2.7 Method of shade evaluation

Here too the lab and production dyeing should be evaluated in an identical manner. The shade developed in the lab equipment or taken from the production machine must be evaluated after the fabric is dried and conditioned. Hot and bone dried samples should not be taken as shade indicators since natural dyes are very sensitive to the heat and the moisture content of the fabric. It is very important that the

shade sampling technique and dyed sample presentation be systematic, so that the color evaluated is representative of the true shade of the lab dyeing or production lot. For accuracy in dyeing with natural dyes it is a good to keep a dye-by-lot history of each accepted shade for both lab and production dyeing. Under conditions of controlled illumination, sample size and background color, the technique of instrumental color measurement can be used with the aid of a reflectance spectrophotometer.

2.8 Fabric after-treatments

In case of natural dyes chemical and mechanical finishing techniques have a great potential to change the shade of the dyed lot. The customers of dyeing companies often compare a lab dyeing that is unfinished with fabric from the finished production lot. Any chemical or mechanical finishing techniques used on the production lot should also be used on the lab dyed swatches.

3. Conclusion

As far as dyeing with natural dyes is concern the fact is no detailed information is available anywhere in the literature. It is evidence enough for the difficulty of the task, which stems mainly from the involvement of a vast number of factors that govern and affect the textile dyeing with natural dyes. A methodical and continuous effort should be made to achieve the best possible lab-to-bulk recipe transfer.

The high cost of shade corrections in production justifies extraordinary efforts to improve lab-to-plant dyeing reproducibility with natural dyes. The simulation of any potential dyeing circumstance encountered in the production dyeing process should be replicated in the lab dyeing process. Automating lab processing can have a positive effect on dyeing accuracy and consistency. Careful selection of compatible natural dyes and auxiliary for the lab and production lots is crucial. Current practice should be routinely evaluated for overlooked inaccuracies and avoidable errors. Good lab-to-plant dyeing correlation is a constant work in progress due to the sensitive and complex nature of textile dyeing with natural dyes.

The successful and repeatable transfer of a recipe from the laboratory to the bulk production is the single most important issue and our ultimate goal of dyeing houses using natural dyes. All the above discussions aim to simulate and successfully relate the bulk processes with those carried out in the laboratory and to achieve Right First Time Dyeing with natural dyes.

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