In pursuit of antique fake purple using madder (*Rubia tinctorum*) and Woad (*Isatis tinctoria*)

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During the summer of 2022 and at the European Textile Forum 2022, I began researching the subject of 'fake purple' or 'Egyptian purple' made from madder (*Rubia tinctorum*) and woad (*Isatis tinctoria*). This is a dye found in Antiquity, when true shellfish purple was the most sought-after textile dye, often reserved for the elite. But what is for the powerful becomes in fact fashionable, and purple must have been a favorite color for the less endowed as well. Human beings haven't changed much over the last few thousand years… Ancient dyers, not the last to have business sense, developed a multitude of cheaper recipes to imitate purple. Or should we say 'the purples', because the shades obtained with the various species of shellfish from the Mediterranean are so varied!

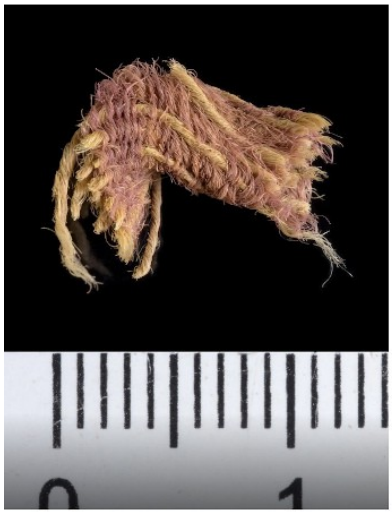
A few words about true shellfish purple

The use of shellfish purple for dyeing is very ancient, probably Bronze Age and it's the historical dye that has been the most prized of all. Faking the precious dye is probably as ancient as the dye itself. Shellfish purple is a vat dye, just like indigo and is composed of a mix of indigo dyes: indigo, monobromoindigo and dibromoindigo with smaller amounts of the corresponding indirubins. It is the bromoindigos which are exclusively the signature components, there being no other source. It is very lightfast and stable but dyeing with it requires great skills, as the procedures have to be precise and controlled.

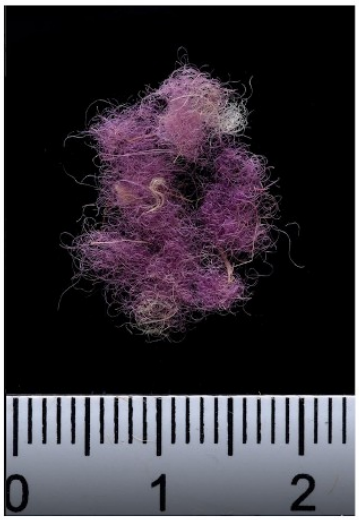
The dye is extracted from the gland of several species of mollusks and the colors obtained vary between species but also dye procedures and exposure or not to sunlight, ranging from blue to reddish purple. Vitruvius writes about it in De Arcitectura with the following words " *the color of purple does not yield the same color everywhere, but is modified naturally by the course of the sun*". The two prestigious colors in the Bible, Argaman (blue-reddish) and Tekhelet (bluish purple) probably derive from the Hexaples trunculus species. Pliny the Elder who wrote about the production and dyeing said that the most desirable hue was the one that looked like coagulated blood.

Archeological textiles dyed with true purple

Wool fragment with threads dyed with purple.
Around 1000BC Timna Valley, Israel



Wool fibers dyed with purple.
Around 1000BC Timna Valley, Israel



Credit: Dafna Hazit, Israel Antiquities Authority

The silk shroud of Charlemagne, some vestments of Queen Arnegundis and precious ecclesiastic textiles from the Middle Ages also feature the precious dye.

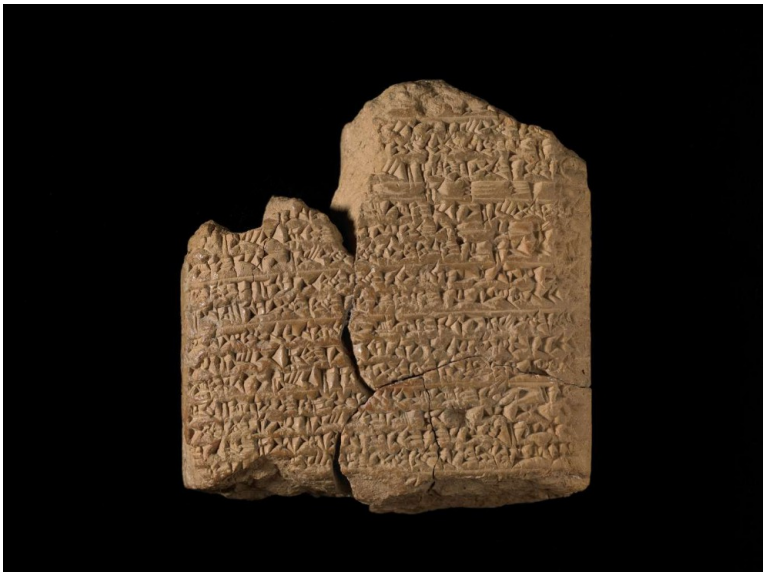
Some analyzed textiles from Antiquity show that purple dye was sometimes associated with insect dyes, such as Kermes or Cochineal.

Historical evidence for fake purple

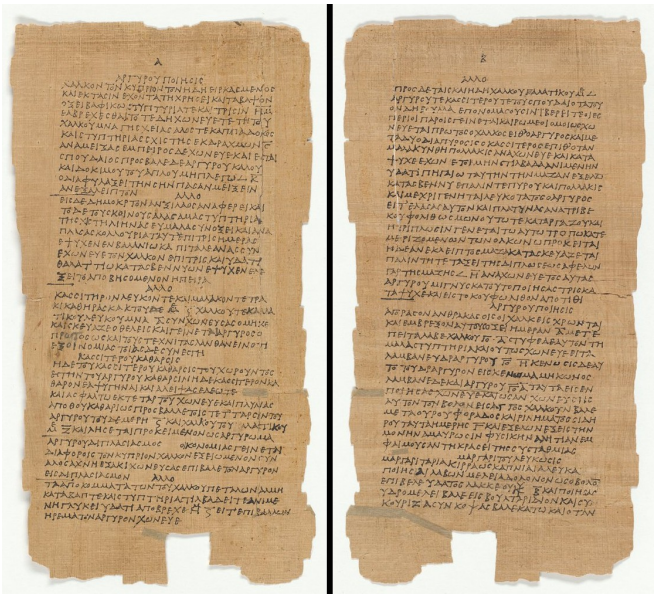
The written sources

We are lucky enough to have some ancient written sources with recipes.

One is quite exceptional because it's dated in the 6th millenium B.C., it's a Neo-Babylonian tablet (British Museum N°82978). From the transcription performed, we know that it gives information about dyeing wool fleece: a vat dye to obtain 2 shades of blue, dyeing yellow after mordanting with alum therefore giving green and at last dyeing red after mordanting on undyed or blue wool to give red and purple by using red on light blue (Cardon, 2003).



The other major antique sources are two Egyptian alchemical papyri from the 3rd century AD, the Papyrus Leydensis or Leyden Papyrus and the Papyrus Holmiensis or Stockholm Papyrus, named after their respective places of conservation. I have used the German translation by Otto Lagercrantz (Lagercrantz, 1913) and the English translation by Caley (Caley, 2008). Both documents list recipes for imitating precious metals and stones, as well as recipes for dyes, mainly purple. In the case of metals, stones and dyes, it is interesting to note that the most frequently cited ingredients are alum, vinegar and urine! Rather than detailed recipes, these writings must have been more like vade mecums, or reminders, intended for people already versed in these crafts.



The papyrus leydensis mentions alkanet (*Alkanna tinctoria*) in particular, whereas the papyrus holmiensis goes into more detail about dyes (on wool) based on woad (*Isatis tinctoria*), madder (*Rubia tinctorum* and/or *Rubia peregrina*), alkanet again and also orchil and insect dyes, as well as various other plants.

Other written sources are the works of Vitruvius and Pliny the Elder like I mentioned before, as well as several others. But the dye procedures are not described very precisely, there are always some steps or parts of the recipe missing, as dyers may have kept some secrets for themselves…

I began looking into fake purple based on madder and woad because, intuitively, I wouldn't have used these two plants to obtain what we call purple, i.e. violet shades, which are much easier to obtain with double dyes based on insect reds with blue. But it's important to bear in mind that colors and their names are subject to interpretation from one era to the next, and as Taylor (Taylor, 1999) says, there is a certain subjectivity in the definition of the terms 'red' and 'purple' and in the characterization of the shades that these two terms can evoke… However, there are direct archaeological sources of purples dyed with madder and woad.

The archaeological evidence

There are quite a lot of textiles that appear “purple” in Antiquity and the Middle ages, but very few are true shellfish purple dyes and very few have been analyzed for dyestuff. Below are two quite remarkable samples found in Israel, that feature a purple obtained with madder and woad.

Wool fleece dyed with madder and woad,
Cave of Letters, Israel, Roman period.
(Photo by Clara Amit, Courtesy of the Israel Antiquities Authority)

1996-9131

Textile fragment with purple band dyed using vegetal woad and madder
in a double dyeing method.
Murabba'at cave, Roman period.
(Photo by Clara Amit, Courtesy of the Israel Antiquities Authority)

A lot of coptic textiles also show a typical purplish color, or a burgundy, both could have been achieved by double-dyeing with madder and woad or insect dyes and woad. Other examples include the textile finds in Massada, 1st century AD, also Israel (thank you dry climate!) that show many madder-dyed textiles in shades of red, orange and pink but also browns with tannin use and purples with woad as well as black (Koren, 1994 in Cardon, 2003).

The papyrus holmiensis also mentions usage of Alkanet and orchil, which are known to give purple shades.

Summer 2022
Preliminary work

When I first heard about fake purple using madder and an indigo-yielding plant like woad, my first thought was “how can that be ?” Because as a dyer, I never use these two plants in a double dye to make purple, but rather all the shades of black, maroon, brick red, burgundy etc.

To dye shades of what we call purple or lilac or violet, I use insects, mainly cochineal because other dye insects are either impossible to get anymore (like Polish or Armenian cochineal) or as expensive as a costly drug (like Kermes). Combined with indigo or woad in a double dye, they give an incredibly rich color palette.

Cochineal, unlike madder, produces what I would call some “cold” reds and pinks, there’s no yellow component that pulls the color towards orange, like with madder. Madder (*Rubia tinctorum*) is a little chemical factory containing many molecules that are interacting with the dye process. Two main substances that are tinctorial are alizarin, purpurin and pseudo-purpurin, the first one giving the typical crimson madder red (Cardon, 2003).

The dyer’s many troublemakers...

Dyeing with madder is a challenge, because it’s a very complex dye, sensitive to many factors. It’s one of the difficult dyes among plant dyes. Factors affecting the color outcome are mostly:

- the water quality: madder likes “hard water” containing much calcium carbonate

- the dyestuff quality: this is crucial when you are using plants for dyeing. The quality of the dyestuff is strongly affected by the soil, for example humid terrains from southern France with much organic matter will produce madder giving scarlet shades, whether some clayey soils will produce more brick-red, like in younger madder roots (Cardon, 2003). Madder is harvested after 3 to 5 years to have the maximum dye potential and in this time, the weather and climate will also affect the quality.

- the mordanting procedure and recipe: madder requires a mordant, mainly alum-based on wool and other protein fibers in order to dye properly. Several different mordant procedures are possible and will affect the results. It’s also reactive to changes in pH, not as strongly as cochineal, but still.

- Some containers can affect the outcome, like iron pots which will “sadden” i.e. dull the color, due to the release of ferrous ions. It can also make the color appear darker.

- the extraction and dye procedures will strongly affect the outcome as well: time, temperature etc.

In natural dyes, the practice of over-dyeing was common, both in Antiquity and in the Middle Ages, obviously to broaden the color palette but also sometimes to deepen or improve the brilliance or fastness of a particular shade. It is a sometimes difficult art, requiring a good knowledge of each dye ingredient individually, as well as good control of the different shades obtained with it. It requires what I would call, in a very unscientific way, "the sense for color" and also the knowledge of the chemical reactions involved in superimposing two dyes. I should point out here that knowledge of these chemical reactions can be entirely empirical, and ancient dyers undoubtedly mastered their subject perfectly without having access to our current knowledge of chemistry…

In 2022, after receiving a new delivery of madder from my usual supplier, a root grown in the Netherlands, I was surprised to find that it didn't work at all in the same way, giving almost burgundy reds in the first bath and very orange tones in the subsequent baths, so I had to start with a series of tests to compare it (and incidentally I had to completely change my usual recipes...). Here are some of the results of tests performed on the two madder types.

All the samples in this experiment and the following were dyed in my workshop using non-reactive glass beakers and stirrers.

For each sample, the wool was mordanted with 20% alum and a madder bath was prepared (the madder was soaked overnight and the dye performed the following day). I used the first bath on day 1, the second on day 2 and the third on day 3, each time dyeing for about an hour at a maximum temperature of 75°C.

100% Madder
20% Alum mordant

Madder 2022
100%

Madder 2022
20% Alum mordant

You can clearly see the major differences between the 2021 madder and my new one! So the quality and provenance of this dyestuff is of major importance for the outcome. For my trials to get towards “purple”, I felt I had to “push” the madder towards a rosy red, because if the madder dye has too much orange in it, you

won’t get the right hue. To have a reference of the many shades you can get using madder associated with woad, I did a lot of sampling.

Madder over woad

First, the madder dye was performed over a woad dye, with a mordanting procedure in between of course, using a rather classical warm 20% alum mordant bath. 4 shades of blue were dyed which were the over-dyed with 100% madder, then the bath was re-used two times. For this set, I used my “old” madder of 2021 and the samples were dyed in the same water-bath at about 75°C max for an hour. For more convenience and predictable results, the woad dye was performed in a modern hydrosulfite/soda vat using woad pigment from France.

This way of over-dyeing (madder over woad) is recommended in one of the papyrus holmiensis recipes, but when you know madder, you know that it will shift towards rosy reds in an alkaline bath, so the opposite seemed more appropriate: dyeing madder first, then over-dyeing with woad.

Woad over madder

Here are the results. Based on what I had obtained before, I chose a concentration of 15%, 30% and 50% madder . The samples were mordanted with 20% alum then dyed at 75% max. The red samples were subsequently dyed in a woad vat together with an undyed/unmordanted sample for blue color reference.

No “what **we** could call purple”, but it was definitely more towards the goal. I think my blue shades weren’t dark enough.

At that stage, I didn’t have the time to make another series of tests, but I did something I can call an “instinctive” dye… I chose my old, well-known, madder (whole Turkish madder roots that I use for demonstrations in public), chopped them up and made a slow extraction with added alkalinity over a few days (pH9) , using 50% of roots. I immersed the wool for a few days as well and slowly raised the temperature to 75°C, then stopped the dye. I then over-dye with woad. The result was definitively going into the “right” direction, a distinct purple hue, but the recipe from the papyrus still needed to be investigated...

European Textile Forum 2022

After my summer experiments, I had planned a few things at the European textile Forum and was grateful to be able to use the lab of the L.E.A in Mayen (Labor für Experimentelle Archeologie) there. The plan was to try and find ways of dyeing “the papyrus holmiensis way” i.e. madder over woad, so the idea was to find ways of kind of flushing the “yellow” parts of the madder dye out of the roots. Many trials were made at the forum, in fact I spent most of my hours in the lab, including late at night. For me, dyeing isn’t just about figures, percentages and numbers, it’s also about “feeling” what is going on, trying out things and using my senses. Part of my work as a historical dyer is to understand the work of dyers of old, working without measuring equipment and having to rely on observation and experience. That’s what I often do in my professional work as a dyer, so that’s partly what I did at the forum with the chance of matching the empirical with the measurabe.

I tested a way of getting rid of the orange components in madder using a method mentioned by Jenny Dean (Dean 1999), involving rinsing the madder roots with boiling water once or twice. I also chose to alkalize a bit (pH 9) with potash addition.

Madder over woad
100% turkish madder,
rinsed twice with boiling water + alkali

1st bath **2nd bath**

The results looked much more like something “purple”, mainly due to the absence of some of the yellow components in madder. How exactly the chemistry of that is working, I still have to research more.

I didn’t discard the rinsing water from this test and dyed some samples with it to keep a record of the result, which were rich deep orange-red shades. I also repeated the experiment on loose wool samples. The wool dyed with rinsed roots, whether on skeins or on loose fibers. Definitely have rosy-red color.

Rinsing madder with boiling water (Dean, 2014)

The over-dye of the rinsed roots dye with woad actually gave a nice purplish tone… I realized only later after re-reading all the dye recipe translations that I had overlooked a crucial word in the “Madder purple” dye recipe of the papyrus holmiensis, that being the use of “roasted” madder roots. Could that be the secret of the “madder over woad purple”? It is interesting to compare that with some medieval practices involving steaming or roasting madder roots as well. This will the topic of another set of experiments.

It is to be noted that, as mordanting plays a crucial part in the dye outcome, this preparation was done using commercial grade alum (which is a sulfate of aluminium and potassium $KAl(SO_4)_2 \cdot 12\ H_2O$). The papyrus holmiensis doesn’t give very precise details about mordanting procedures, although it mentions different ways of doing it. That’s because it was probably given that that the users knew what was meant. It does mention calcinated « Phrygian stone » which is probably alunite, a mineral found in native form in deserts or zones of volcanic activity, where it can be mixed with halotrichite, a sulfate of aluminium and iron $FeAl_2(SO4)_4 \cdot 22\ H_2O$. The calcination of alunite (resulting in soluble alum and insoluble alumine) was know in Antiquity, but different qualities of alum can be found, as described by Pliny the Elder in his natural history (book 35, chapter 52). Some alums seem to contain iron, which was considered less valuable than purer forms because they could affect the dye outcome. For experimental archaeology, the nature of alum used in dyeing will have to be considered.

“Never boil madder”

A commonly given advice for dyeing with madder is not to cross the 80°C line to get good “true” reds and in a lot books and resources about natural dyeing, especially more recent ones, it is said that boiling madder should be avoided. The Neo-babylonian tablet I mentioned in the beginning gives the following recipe, as quoted in Cardon (2003):

“ *Comb the wool and boil it with alum, equal parts of both. Bring madder to the boil with the wool, equal parts of both with water and “eau sûre” and after an hour, you will have red*”.

“eau sûre” is sour water, water where bran has been fermented). The tablet also mentions 3 different types of madder qualities, like some medieval sources who will differentiate qualities as well.

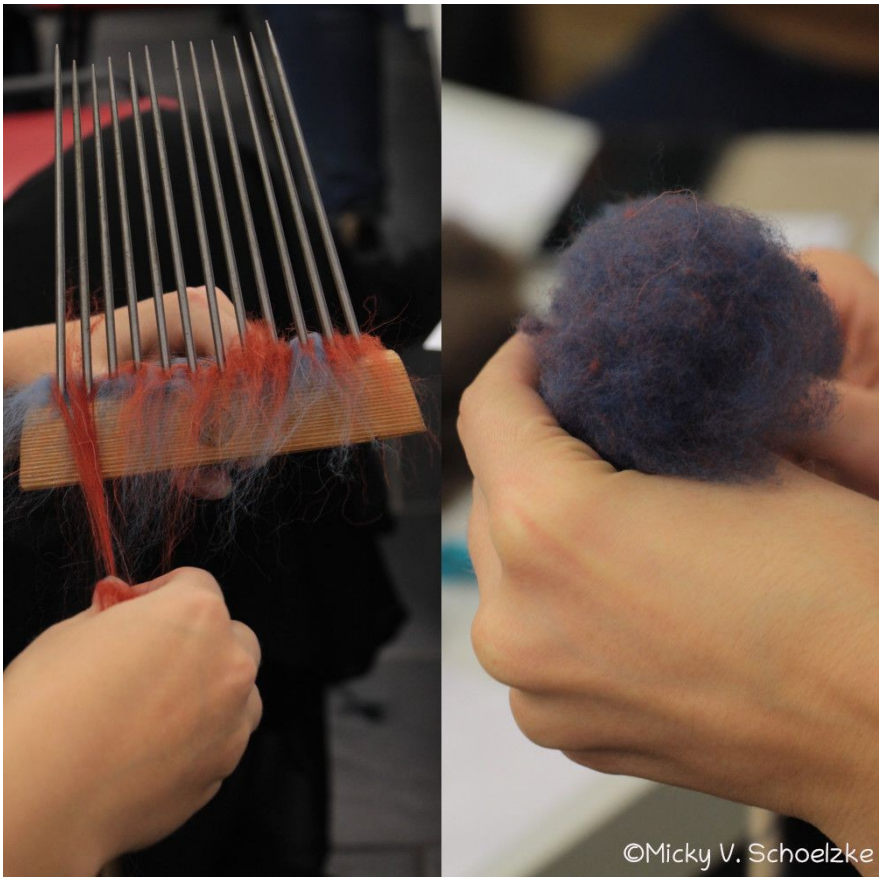
Of course, this very simple recipe had to be tested as well and we kept close to the original, with the exception of using vinegar instead of “eau sûre” but mordanting and dyeing was performed at 90°C for an hour each time. As a comparison, the same procedure was performed with 50% and 20% alum as well.

The results were quite astonishing, with a very deep and lustrous red on the 100% alum sample! The wool suffered a bit during the procedures however , and was left a bit brittle but boiling madder is definitely worth investigating further. A 16th century dyer’s manual (The plictho of Gioanventura Rosetti) also recommends to boil madder for dyeing wool cloth (Debbie Bamford, pers. Comm. , watch video here : https://youtu.be/WoyybpflbgM)

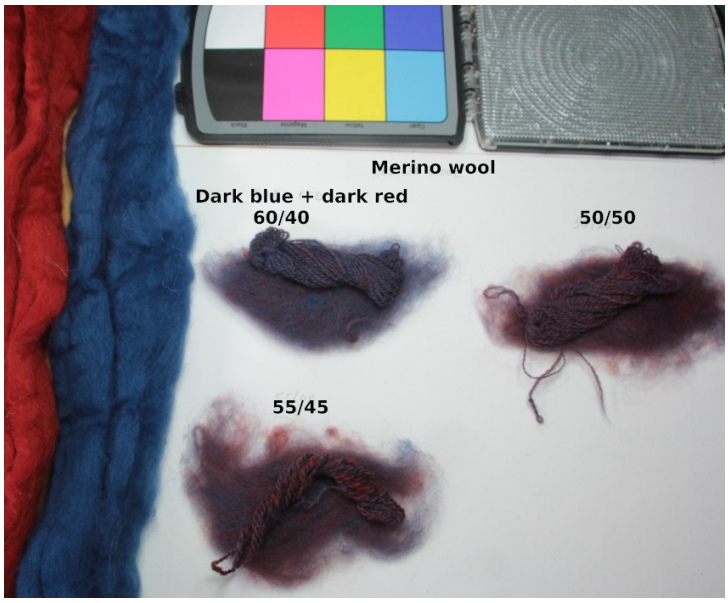
Faking purple by mixing colors

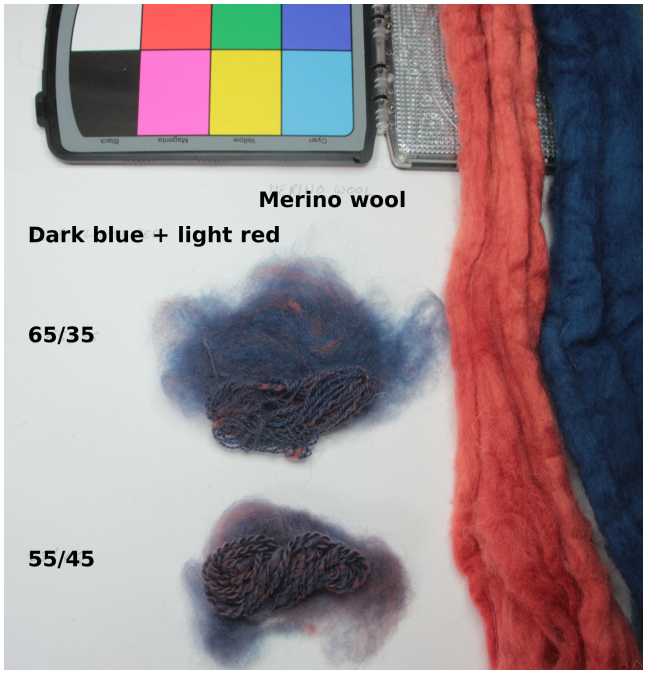
During the 2022 Forum, I dyed a lot of wool samples, and some of them were intended for another test. A solution known from medieval times in Europe to fake purple on wool is to dye fleece and combine madder and woad-dyed wool, as well as some white one by carding. Mixing blue and red fibers together is also known from some finds in Antiquity it seems (pers.comm. to be validated).

I was able to count on the enthusiastic Forum participants to take my samples dyed with woad and madder and try different combinations. There were 3 different wools used: combed Merino and Coburger Fuchs as well as an unknown sheep in carded form. Forum participants used the different samples and mixed the colors with wool combs and/or cards and a lot of them even spun and plied the samples.



Some of the samples gave nice purple shades, even when using wool that has a bit of an orange hue, making it clear that mixing wool is much easier with a bit of know-how of the right proportions than over-dyes.





Comparison of a madder-dyed sample with a medieval sample from Schloss Lengberg (Tirol) where the mixing of two colors of wool was performed to make the threads woven into fabric.

The aim of these preliminary experiments is to obtain enough empirical and practical knowledge to replicate certain recipes from the papyrus holmiensis in an experimental archaeological context, in particular the imitation of purple with madder and woad, starting with whole plants (woad leaves and madder roots) and using tools, materials and compounds available in that period and place. Some further experiments will be performed at the 2023 European Textile Forum to better understand the way madder could have been pre-treated for dyeing and further research is planned to set up an experiment that will both be consistent with archaeological evidences and on a scale that would be useful for a commercial production of that time period and place.

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