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Date: July 6, 19.
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS
METHODS OF GROWING AND DYEING
WITH WOAD ON HANDSPUN YARNS

This in depth study is presented
as a partial requirement
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METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

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DEFINITION

woad (wōd) n. 1. An Old World plant, Isatis tinctoria, formerly cultivated for its leaves that yield a blue dye. 2. The dye obtained from this plant. (Middle English wod(e), Old English wād.)

(Reader's Digest Illustrated Encyclopedic Dictionary)
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SUMMARY

In pursuing this paper it will be observed how woad can be grown today and color obtained by dyeing with the woad using controlled methods of variance in temperatures, recipes, mordants, etc., on handspun yarns of differing fibers.
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Woad, Isatis tinctoria
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INTRODUCTION

Since I can remember, blue has been my favorite color. The blue of a perfect summer sky, so deep you cannot touch it, changing to darker hues with the coming sunset. Or the reflection off a completely still lake, sometimes silver blue with the ripples where a longed for fish jumped, or turquoise blue if you are in the shadown of the Rocky Mountains. I find blue flowers to be the prettiest; blueberries to be the most tempting fruit and bluebirds the most beautiful birds in my area. I live in denim. I love shiny metallic blue cars and get a funny twitch in the pit of my stomach when approached by sparkling blue eyes.

Imagine my delight upon discovering that it was possible to actually grow a plant in my own backyard that would, if careful, deliver the color that brings the most pleasure to my life. I was thrilled! But what of this plant woad? Where did it come from and why hadn't any of my neighbors and friends outside of my spinning world heard of it? I was instantly captivated by its history and the stories surrounding it.

My first pre-research question about woad began with 'Where does the blue come from?' I know that blue spruce and blueberries require a more acidic soil, so would woad prefer this also? Would I get a better or different blue if the soil were different? Why do the books say not to use hard water to dye with and what would happen if I did? How important is the temperature of the dyebath? Does woad dye cellulose fibers such as cotton and flax the same as protein fibers like wool and silk? Would it be possible to get color by using woad as a normal dye plant; simmering it for an hour and using a mordant?
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Thus, this research evolved, by varying one or another detail in each controlled dyepot, on a small scale, to see what effect the dye had on the fiber. In a lot of cases I was very surprised by what I found and am very pleased to share it.
A HISTORY OF WOAD

Woad is indigenous to Assyria, Western Asia and the countries surrounding the Mediterranean Sea and may have been the first plant cultivated for its pigment. It spread by the movement of man until historic times where it was found to be in every European country and as far north as Scandinavia. Archeological excavations have shown that woad was used in prehistoric times with Bronze Age garments dyed blue found in Denmark.

When Roman invaders under Julius Caesar crossed the English Channel in 54 BC, they are reported to have found a race of men who stained their bodies blue.

Recipes using woad have been unearthed dating to 2 AD and the instructions which make use of a urine vat, indicate the recipes are in fact a lot older.

Tests made in BASF's laboratories provided even older evidence that the Celts had mastered the art of dyeing with woad. Tests were made on textile fragments found in the grave of a Celtic prince of the 5th century BC in Altrier (Luxembourg) and these were proven to have been dyed with woad.

References have been made to woad in literature as early as AD 709.
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EARLY CULTIVATION AND USE OF WOAD

In the middle ages most work was done by hand. Planting was done in the fall or early spring. Farmers used drills to plant and spaced the rows two feet apart to leave room for hoeing.

For a period of about five months from June to November, or until cropping was done, men, women, and sometimes children weeded the woad fields twice before cropping and once immediately after. The plants were hoed, thinned, weeded and the soil was stirred either by hand or horse tools. Woad spuds were short home-made hand-spades.

The fields were cropped two or three times as required. The leaves were then transported to the roller house, a circular structure built of sod. Inside, a series of rollers were worked by a horse, crushing the leaves to a pulp. The pulp was then piled in a heap allowing it to drain until dry enough to become coherent. Next it was hand kneaded by the workmen into balls between 2-6" in diameter, each weighing between 1-1\frac{1}{4} pounds. The balls were then carried to drying racks. A man could ball as much as a horse could crush. It left the man's hands nearly black, which stayed until new skin formed.

The balls were then dried by exposure to air for between one to four weeks and they were examined daily for cracks. If cracks appeared they were carefully closed by hand squeezing as air had to be excluded from the center of the fermenting ball. First, second and third pickings of the crop were kept separate.

The final preparation of the dye took place in the couching house. The balled woad had to go through a process of fermentation called couching - hence the name of the couching house. First the dried balls were ground to a
powder by the same rollers that had pulverized the leaves, then taken to the couching house and piled into a layer two or three feet deep. It was sprinkled with water and allowed to ferment for about nine weeks, turning frequently and sprinkled with more water until converted to a paste. The fermenting was hot, vigorous, steaming and emitted a disgusting odor. Queen Elizabeth disliked the smell so much that she issued a proclamation praying that during her progresses through the country she might not be driven out of the towns by the 'oade' infecting the air too near them.

Experienced woadmen were highly valued, as the fermenting process was critical to the success of the dye when it reached the vat. It must not exceed a temperature of 125°F and the entire mass must ferment to an equal degree. Every lump had to be broken up so that no portion escaped fermentation.

At the completion of fermentation the woad had become a dark, clay-like substance. It was then thoroughly dried, sifted and packed tightly into wooden barrels to ship to the dyer. Woad was said to improve greatly if kept for a while, owing to the action of the fermenting, with its efficiency in the vat being doubled in four years. Nine parts by weight of woad leaves would yield one part of woad dye prepared for market.

To dye the woad was made into a liquid solution, then alum or potash was added. The mixture was then heated and held for three hours. The cloth was them immersed, moved back and forth and removed when the color was uniform. The cloth would not show blue when first taken out of the dye vat, but changed upon the exposure to oxygen in the air.

Because woad was exhausting to the soil on which it was grown, the ancient woadmen would migrate. At a fresh site a new mill would be constructed of sod and timber and the old rollers and machinery would be fixed in place for a
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new round of operations. Some places deplored the coming of the woadmen and passed laws against the sowing of woad. They realized how taxing it was on their soil and claimed that after the woadmen had left, nothing would grow, no grass or anything else for the cattle to feed upon. At Ely the parish requested that woad cultivation be discontinued for fear of increasing the number of paupers.

Eventually successful woad farms were established and the influence that the woad farms placed on the agricultural community in the Middle Ages benefited the entire sector by making their methods of cultivation an example to all other farmers. To be a really profitable industry, woad required constant selection and treatment of the soil and constant skilled labor to obtain a good supply of dye in the leaves. No other crop required the labor that woad did and as soon as woad was cultivated systematically, everything changed. Fields were ploughed deep, fertilized with manure and harrowed and hoed three or four times for weeds while the crop grew. It took ten people to pick, wash, crush and ball the woad leaves from one acre in a day. Previously, farming had been done haphazardly as there was no compelling force for efficiency, but because of efficient woad farming, intensive cultivation spread to other crops as early as the 13th century and slowly made its way across Europe. Production of wheat and other cereal crops were greatly increased.

In 1812 a recipe announced that 'Any housewife could now dye her wool as quickly as it was done centuries ago (300 years prior). Digest the woad at a temperature from 100°F to 140°F for a prolonged period. One-half pound woad to a gallon of water will yield good results. The water should be near boiling when poured on the woad and the vessel must be closely covered and remain at the above temperature. In ten to twelve hours small bubbles will appear on the surface. Add a little slacked lime (6 - 7 grams) and
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stir. It will generate an odor of ammonia. A small pattern of wool if immersed for an hour will turn pale blue on exposure to air. After a few hours the addition of a gram or so of bran will again set the fermentation going, which in turn can be controlled by the addition of lime. In this way the dyeing process may be kept in operation for several days.' (Hurry 44, 1930). Madder was often added to prevent a greenish tint in the cloth.

In the rural areas a more simple but effective method was used and there are various accounts of how this was done during the production of Harris Tweed yarns. Human urine kept for two to three weeks before use was an excellent reducing agent for the indigo in woad since it had enough bacteria and organic matter to create a ferment, as well as being adequately alkaline to hold the indoxyl in the solution. However, it was slow and the vat needed to be kept warm for about two weeks before the dyeing was complete.

Woad was also used in the Middle Ages as a healing herb, and goes back to Greek and Roman times. Hippocrates refers to it in 460 BC for ulcers; Pliny in AD 23–79 and Galen in AD 131. The leaves were thought to disperse tumors when applied to them and to cure all bleeding wounds. It stopped all forms of hemorrhage, attacks of St. Anthony’s Fire, gangrene, snake bite, and ulcers and was even more efficient if the crushed leaves were mixed with the flour of wheat, barley or polenta. If mixed with wine and drunk, it was believed to be beneficial to disorders of the spleen. Leaves made into poultices healed abscesses and closed fresh wounds. Sometimes the top of the stalk was used before the flowers appeared. Woad was believed to cause a flux in bees, but was considered to be beneficial to diseased sheep. As late as the 18th century, woad was used as an astringent, for fever, ruptures, sprains and strengthening joints. During
the 18th century advancement in medicine led to the testing of plants that had been used as remedies in disease and many were proven useless, including woad.

Seedlings of woad, about two inches high, were sometimes eaten as a salad. The flavor was similar to mustard or cress. Oil similar to linseed oil can be extracted from the seeds.

Woad was often used in conjunction with other plants, either together or as overdyes, and a great variety of shades could be obtained. A favorite combination was woad with madder which gave a rich dark blue or black when first boiled in a copper pot before going to the woad vat. Another way to get black was to immerse the fabric in the woad vat, then transfer to a cauldron containing logwood and nut-galls. Copperas and sumach were frequently added (1608-1661). A well known saxon green (1766) was obtained by dyeing the fabric blue with woad, then overdyeing with the yellow obtained from weld.

Overdyeing was not always reliable, as appears by a statute passed in 1533 in England which ordered that 'none should dye woollen cloth as browne, bleues, pewkes, tawnyes, or vyollettes unless they were perfectly boyled, greyned, or madered upon the wode, and shotte with good and sufficient corke or orchall.' (Hurry 48, 1930).

The poorer classes of people in the Middle Ages generally wore clothing of natural colored wool, eg. black, brown, grey and sometimes white. Garments woven from flax or hemp were usually grey. Owing to the complexity of the manufacture of woad it was never a cheap dye, but was highly fashionable as it withstood exposure to bright sunlight, rain and salt water. Dyed cloth was more expensive and therefore implied some degree of prosperity. Gradually, as the art of dyeing developed, the use of colored cloth became universal among all classes of society, where formerly
only the ruling classes, kings, army commanders and priests had been privileged to wear certain colors. Special sections of the population also wore woad dyed garments, thus the 'blue-coat' was the dress of the serving man in the 16th century and early 17th century. The same garment was also the dress of a beadle in Shakespearean days. Certain colors were more fashionable at different times of the year creating a seasonable demand for special dyes. Various periods of European history saw lavish indulgence in dress and as woad colors were very popular, large quantities of the dye were consumed. It is said that three pieces of cloth took about one barrel of woad to dye. Woad has been described as the 'universal dye of the Middle Ages' and has contributed greatly to bringing wealth to individual countries as well as to Europe as a whole.

Woad played a large part in the trade of commodities between different countries in the Middle Ages. Ships laden with woad and other goods navigated the Mediterranean and Adriatic Seas as well as the Eastern Atlantic and North and Baltic Seas. Robbers and pirates made transport over land and sea dangerous and costly and this caused insecurity for life as well as property. Inland communication was insecure and roads were rudimentary. Harbors were inadequate as were reliable maps and charts. Weather conditions were unreliable, making shipping uncertain and adventurous.

The last transplanting of woad to another country was when the Pilgrim Fathers fled to North America. Along with seeds and food plants, well known dye plants were shipped with the emigrants to their new country. Even in the severe winters of Maine and Boston the plants survived and spread rapidly as the country was developed by the settlers. Until the southern stands of indigo of Florida and Carolina were discovered, woad was the only dye which gave fast blues on wool and cotton.
The use of woad as a blue dye source in England goes back to pre-Christian times and extends over two thousand years. One of the earliest recorded incidents in English history is the fact that ancient English people stained their bodies blue with woad. Julius Caesar in 54 BC said, 'All the Britons, without exception, stain themselves with woad, which produces a bluish skin, and this gives them a wild look in battle.' Pliny the Elder (c. AD 23-79) referred to woad when he said, 'There is a plant like plantain called in Gaul 'glastum' with which the wives and daughters of the Britons smear their bodies in certain ceremonies and go naked, being the color of the Ethiopians.' Ovid (43 BC - AD 17) describes the English as 'green Britons', and Pomponium Mela (c. AD 43), the earliest Roman geographer, confirms Caesar's findings saying, 'They dye their bodies with woad, but whether for ornament or any other reason is not known.' Herodian, the historian, speaks of the ancient Britons as being ignorant of the use of clothing. 'They mark their bodies with various figures of all kinds of animals and wear no clothes for fear of concealing these figures.' (Hurry 51 - 52, 1930).

11th century documents tell us that the cultivation of woad was a recognized operation in agriculture but there is no evidence that it was grown on any large scale at this early time. The woad men of this day roamed the country in search of new rich fields as soon as one district became exhausted. The supply of home grown woad appears to have been insufficient for demand during the reign of Henry II, and some was imported. The English woad industry was never as organized as that of France, Germany or Italy, and that left the door open for these countries to do business.
In the 13th century large quantities of woad were also imported. In 1261, under the reign of Henry III, the exportation of wool was temporarily prohibited, and no one could wear wool clothing unless it had been manufactured in England. This was done to encourage the manufacturing of cloth at home, but the ban led to great interference with the importation of commodities from abroad and this resulted in a great scarcity of woad. The prohibition did not last long and by the close of the 13th century, large quantities of woad were again entering the country.

In the 13th century a serious quarrel broke out between the English weavers and dyers. For a very long time the weavers had complete control of the dyeing industry, even having the right to dye their cloth with any pigment they chose with the single exception of woad. The Queen Regent, Blance of Castile, added to this right the privilege of using woad in two especially favored workshops which naturally upset the dyers. If the weavers could encroach upon the dyers' trade, could the dyers not tread upon the weavers'? Soon afterwards a few looms were set up in dyers homes which the weavers declared to be an invasion of their rights and in turn they refused to supply the dyers with any more cloth. Eventually the King ordered that neither the weavers nor the dyers should 'meddle with one another's trade'.

Various guilds at times seemed to be governed by the wealthier members and often excluded the poorer craftsmen. No one with 'dirty hands' or 'blue nails' or 'who hawked his wares in the street' could become a member of the Guild.

During the reign of Edward III the French wars began and lasted over one hundred years. Agriculture came nearly to a stand still except for the wool trade and large quantities of wool was exported to Flanders. Considerable amounts of Flemish cloth was in turn imported into England,
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of higher quality and better dyed than the cloth manufactured at home. It revealed the fact that the English weavers and dyers did not have the skills required to produce the finest cloth. And so the government introduced the Flemish weavers and dyers to England which began a great immigration of foreign artisans. This gave a great boost to the English cloth manufacture and especially manufacture for export.

Until the middle of the 16th century woad was grown in England but supply of the dye was short and the dyeing itself was inferior to that done in Flanders, Holland, or other countries. So large amounts of undyed cloth was exported from England, dyed and dressed, then sold back to the English at a much higher price. Greater efforts were then placed on the cultivation of the plant and as English woad became more abundant less French woad was required.

The close of the 16th century was the golden era of the woad industry in England. Large quantities of the dye was required by the cloth manufacturers. Much French woad was being imported and it had been published that all fitting ground should be used for the purpose of woad cultivation. Then in 1587 a Proclamation was made strictly regulating the woad industry. The sowing of the plant was forbidden except in strict moderation and every woad farmer had to pay 20 shillings per year to the queen for the right to grow woad. It could not be grown within five miles of any of the queens' residences, or any city, market towns, or thoroughfares. No one farmer could grow more than twenty acres, nor one parish more than sixty acres. And it was not to be cultivated in any place where there was a risk of depriving the poor of their livelihood, or damaging fruitful ground.

In 1589 another Proclamation was issued, cancelling the previous one in 1587 and allowing anybody to grow woad who wished to do so, provided they did not grow it within
three miles of the queens' houses, the city of London, or any other city or town. 1638 is the last record of woad being imported from France, and in 1650 English farmers were once again encouraged to grow woad, along with weld, madder and saffron, as they were all very lucrative crops.

Woad dye was described in statutes as the 'honest color' and at one time formed the basis of nearly every dyeing process connected with wool. It shared with the great wool trade the honor of largely contributing to the prosperity of England.

The numerous woad entries that have been found, along with the bequests of woad in wills, prove that the dye was a highly valued item in the commerce of England and on the continent.

The taxes on woad were extremely heavy. National customs included taxes on imports and exports while semi-national customs were taxes due to the king but collected locally. Local taxes were either tolls for bringing or taking goods out of a town or special payments for services or utilities owned by the town. The earliest tax records in England are under the reign of Richard I in 1198. In the 14th century the taxes in Winchester, England were as such, 'Every cart that brings woad for sale will pay fourpence, a horse load one penny. Every country man that brings into the city potash for use with woad owes the King as customs six pence a year and one penny to the clerk for enrolling his name, unless he come not more than once a year.' (Hurry 191 - 192, 1930).

In London the woad trade was largely controlled by the mayor and alderman, who also appointed the officials connected with the woad trade. This included the brokers, measurers, assayers, and porters. The brokers were sworn into office by the mayor and aldermen. If the broker was found guilty of stalling merchandise on its way to the city
he was imprisoned for 40 days. A second offence was liable for another 40 days jail plus revoking of his office. They were forbidden to do business on their own and no woad broker could be host to a woad merchant. Some brokers were restricted to certain areas. Measurers were sworn to faithfully measure woad for buyers as well as for sellers. Woad was measured by a small beam scale and sold by the pound. Assayers were to assay the woad that was offered for sale by the woad farmer, then assign it a proper price according to the result of the tests.

The dyeing of cloth was a mystery and special regulations were imposed upon the dyers. In 1362 under Edward III dyers who dyed wool with woad were forbidden to dye hats, caps, linen thread or silk. The fine was 100 shillings. The cappers trade was a distinct one and they wished to avoid the competition of the more expensive woad dyes. Under Henry III rule, the wardens had the right to search the dyehouses, shops, warehouses, workhouses, grounds, and drying places to ensure that all regulations were observed. In the 17th century logwood had been introduced as a cheaper source of black but it was found to be a less permanent dye and so in 1782-3 under George III an Act was passed for preventing 'Frauds and Abuses in the Dyeing Trade.' Dyers were not permitted to dye cloth 'mather black' without having first dyed it throughout with woad and indigo. Dyers were not allowed to use any logwood to dye any cloth blue. The penalty for each offence was 20 pounds per piece of cloth.

In 1579 the Privy Council was making inquiries as to the possibility of substituting indigo for woad. It was introduced around 1587 and in 1643 the King of Portugal sent a dyer, Pero Vaz Devora to England to demonstrate the value of indigo. By the 19th century the woad industry of England felt a rapid decline because of the introduction of indigo, and then by the discovery of artificial indigo by German chemist Adolf von Baeyer in 1878.
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WOAD IN THE HISTORY OF FRANCE

French woad was of high quality and in much demand and the industry was at one time a source of great wealth to the country. France used most of its own woad but also exported a great deal to the English and Flemish dyers. In a good year the profits from woad were often the same or more than the value of the land it was grown on. It created much employment. Forty acres planted with woad are said to have kept 140 people constantly at work, of which the majority were women and children.

The woad industry in France was a very organized one and even minute details were controlled. There were two types of dyers; the dyers of fast colors and the dyers of fugitive colors. The two classes of dyers continually broke the rules and trespassed on each others domain. Dyers of the last class were forbidden to have in their possession, dyes allocated to the other class. Many regulations were made enforcing the use of certain fast dyes for high class materials, prohibiting other dyes, appointing inspectors of dyes and many other details. For example indigo was regarded as inferior to woad and the use of it alone was not allowed, although it could be used with woad in the same vat, usually 6 pounds of indigo to one bale of woad.

Eventually the French dyers were divided into three classes:
1. The master dyers who used only fast dyes and only the best dyes, such as woad, indigo (in proportion), madder and weld, and dealt with cloth at least eighty inches wide or other articles of very high quality. Mordants and woad were reserved exclusively for the master dyers.
2. The second class included master dyers who used cheaper and more or less fugitive dyes and dealt with woollen
fabrics of an inferior quality as well as certain articles of silk, wool, or flax. They were allowed to use cheaper and less stable dyes such as logwood, archil, and verdigris. They could use black, grey and brown dyes but were not allowed to dye their cloth black until it had first been dyed with woad or woad and madder. Some dyes were available to both the first and second classes of dyers, such as walnut, oak, nut galls, sumach, copperas and redoul. Some dyes were considered fugitive such as brazilwood and annatto and were not allowed to be used by either class.

3. These dyers were restricted to small inexpensive articles of silk, wool, or linen and yarn before it had been woven.

It was required that all fabrics dyed with fast colors must be labelled with the dyes used, the order of use, the name of the dyer and other necessary details. Master dyers work was subject to inspection by jury and any breach of regulation resulted in the confiscation of the cloth and a fine. As a result of the strict regulations, the art of dyeing was very advanced and beautiful colors and shades evolved which greatly pleased the fashion world, with some French colors surpassing every other country. Home grown woad was encouraged and in 1737 regulations were revised allowing the use of indigo alone. At the end of the 16th century there were 220 master dyers listed in Paris.

The English had great desires for French wine and in the 12th century woad was often part of the same cargo. Export of woad in 1333 began to Wales, Scotland and Ireland. By the mid 16th century the export of much woad was going to Antwerp and to Germany. 16th century woad production had enormously increased and from the single port of Bordeaux 200,000 bales were annually exported. This trade was so important that even in wartime unarmed ships were allowed to enter the port and load up with woad.

On November 21, 1806 Napoleon attempted to seal the
ports of Europe against English commerce. Great Britain retaliated by blockading all countries under Napoleon's rule. By proclaiming war on English commerce, Napoleon's object was to ruin England by excluding her goods from the continent. England gradually gained control of economic products upon which France and other European countries had become dependant. Much of continental Europe was affected and it caused a remarkable rise in the prices of commodities throughout. Because of the deprivation of raw materials such as cotton, sugar, coffee and indigo which was by now in use, France tried desperately to resurrect the woad industry on a large scale and rewards were offered for an efficient substitute of indigo that could be grown in a temperate climate. Various elaborate researches were carried out but woad contains only small amounts of indigo and it could not be extracted as easily as from the exotic indigo. Napoleon's hopes of discovering an indigenous plant of France to replace the exotic indigo were doomed to disappointment and in 1812 an international agreement to abolish the continental blockade brought the economic crisis and shortage of indigo to an end. No further attempt to rejuvenate the woad industry was ever made in France.
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WOAD IN THE HISTORY OF GERMANY

No reliable information is available as to when woad was first cultivated in Germany as a source of dye. The early Teutons appeared to have blackened grey hair and daubed their skin with woad dye, as primitive races were accustomed to painting themselves. In the middle of the 11th century, the Slavs from the Orlagau presented to the monastery of St. Peter at Cologne a black pigment called 'worin' which is believed to have been woad. The earliest document for cultivation comes from 1236 where woad dyed cloth is referred to as well as the tax charged to the merchants at Altmark on the woad sent to Flanders. This makes us assume that woad for some time had been a dutiable commodity.

Woad trades were controlled by councils and fraternities and foreign merchants wishing to buy the woad had to become members of the fraternity.

During the Middle Ages woad was grown over a large part of Germany, but not every district was able to cultivate it on a profitable basis. Cultivation of woad in favorable districts were usually very efficient with high yields and profits. Farmers here used a special implement called the 'great woad plow' drawn by six horses that could plow much deeper and more efficiently than hand labourers. The existence of no less than 11 woad mills over a small area proves that woad cultivation must have been fairly extensive. The province of Thuringia had the largest production with at least three hundred villages devoted to the cultivation of woad.

Farmers who grew woad also crushed the leaves and manufactured woad balls, also known as green woad, which they sold in adjacent towns. Taxes were levied on each cask of woad balls, payable by both buyer and seller. Woad was not
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allowed to be sold in their own town. They could not carry out fermentation or couching which was done by another class of people called woad refiners. Woad could be sold only at the woad market where the farmer drove his wagon load to the market and waited until the woad bell was rung by the woad master, indicating that business could begin. There may be a hundred or more wagons lined up and each driver was required to stay with his wagon and not display the woad he had for sale. The buyers were not allowed to enter the market, but waited in the side streets, and when the bell rang a brisk business began. Woad balls were sampled by passing moistened fingers over the surface and then smearing them over a sheet of white paper. All transactions were under supervision of the woad master and his assistants thus insuring full publicity and public control and promoting the use of the market hall and town weigh house. The buyer must pay cash, even though the seller would allow him credit and both parties were up for penalty if the rule was disobeyed. Buying in advance was prohibited and a farmer was not allowed to sell in the field or while the woad had been dried. When a bargain had been struck the farmer drove his wagon to the public market hall where the woad was measured. After the purchase the woad balls were taken to the couching house where they were stored, then smashed with heavy wooden mallets into powder which was sprinkled with water from time to time activating the fermentation. The heat and vapours were often so great that the workmen turning the mass often could not see one another for the mist. The fumes were very offensive and annoying to the neighborhood. It was finally left in a heap to dry for six to eight weeks, then passed through a sieve, put into casks and sold to the woad merchants.

Licensed woad merchants bought the couched woad and sold it to the dyers or exported it. Woad merchants held a
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

higher social position than the woad refiners and paid a higher price for the woad they bought. A woad merchant required a license for which he paid a fee but he also had to earn an annual minimum income from the woad to retain the license. The sale of prepared woad was forbidden except in the public market and through a broker. This sale of prepared woad was often a credit transaction.

In Cologne a broker was not to buy or sell woad on his own or allow any other person to act for him. If the broker bought woad in the country districts and then sold it on the Cologne market, he was dismissed from his post and banished from the city for one year. Measurers had to report to the tax collector daily as to the quantity of woad that had been measured. And if a dyer dyed with woad that had not been duly assayed, he was fined. He was also fined for dyeing silk with woad. Woad taxes were also charged to the woad merchant when a wagon load had crossed into another state.

In the Middle Ages, as early as the 13th century, Germany exported to many parts of Europe and England. Other exports went to Poland, Hungary, lower Austria and Italy.

Where the woad industry was highly prosperous, woad guilds were established to benefit the workers of the industry. The first kind of the two guilds in Germany involved the workmen in charge of the couching and fermenting process. Their complex methods were very secret so that no outsider could ever discover the methods of preparing the dye. The second guild was a guild of dyers, but for many generations woad was almost the only dye used and the term 'dyer' became synonomous with 'woad dyer'. Madder did not come into general use in Germany until the 15th century.

Some guilds owned dye houses but the weavers were strong enough to defy the Dyers' Guild when they chose and carried out independant dyeing of their own. But in larger towns most dyers had their own individual vats and dyed the
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cloth supplied by the manufacturer.

The regulations required that the masters of the Guilds choose the wardens of the woad market, who made sure the regulations were enforced. No member of a woad guild could trade woad with a non-member. A woad merchant who charged too much for his dye was fined and not allowed to carry on business until the fine had been paid. If he failed to pay within one year his membership was revoked. If a guild member wanted to buy woad and was unable to pay for the whole in cash, the woad merchant was obliged to accept security for the unpaid part of the purchase.

Woad was such a valued commodity and reaped large profits. From the farmers who grew it, to the refiners, merchants, measurers, assayers, dyers, carters, not to mention the increased revenues of the churches and farm landlords who benefited from the huge sums of taxes derived from woad. Woad villages were known far and wide for their prosperity.
In the Middle Ages the woad industry of Italy reached a high level of development, giving it a leading place among the commercial nations of Europe. Woad was grown in many parts of Italy but the main concentration was in the Tuscany area and was associated with the famous wool and cloth manufacturing industry centered in Florence. The thriving cloth industry stimulated the dyeing industry and enormous amounts of woad were used. In addition to what was grown at home, considerable amounts of the dye were imported from abroad.

Most of the guilds in Italy were as old as the beginning of the 13th century and serve as a good example of the industrial organization known in the Middle Ages. The Wool Guild imported enormous amounts of fine wool of very high quality from England, Flanders and Spain and manufactured from it an excellent cloth, beautifully dyed, that became famous all over Europe. The Wool Guild controlled the scourers, spinners, weavers, fullers, dyers, etc. and handled the wool from the raw to finished stages. By the 14th century it had built abundant supplies of skilled labour and considerable amounts of capital and became one of the most flourishing guilds of all time. The guilds also controlled the woad halls where the woad industry was concentrated. In this way it could control the quality of woad and other pigments that the dyers needed for their vats and it also ensured a constant and sufficient supply of the raw materials. In 1308 the Wool Guild owned at least three hundred extensive workshops and annually produced 100,000 pieces of cloth.

The Guild was divided into two classes with the wealthy merchants belonging to the first, while the second class included a more humble people, the weavers, dyers and crafts-
men who had little influence on management. A lower class still was the common workmen who were not guild members and had no voice in management.

Another guild, the Guild of Foreign Cloth Merchants is thought to have originated as far back as the 11th century and imported coarse, cheap cloths of unattractive colors from Flanders, Holland, Brabant and northern France. They sheared, trimmed and rolled the cloth; removing all knots until the surface was smooth, redyed it with delicate colors and eventually resold it to the same markets that it had been bought from. By the second half of the 13th century the Foreign Cloth Merchants had world wide fame.

Dyers are referred to as early as 1096 in the history of Florence, even earlier than the weavers. In 1212 there is evidence of a guild of cloth workers but it does not appear to have been as organized. Dyers held a good position among the cloth workers and the woad dyers took first rank and were paid the highest wages. As in other countries, they were bound by regulation. For example, in 1334 no woad could be mixed with madder or other red dyes. In 1367 all wool to be dyed with woad needed to be inspected for quality and in 1370 all wool that had been dyed with woad must be inspected within fourteen days of completion. Night work was strictly banned and dyers were not allowed to migrate from Florence to another town for fear they divulge the secret Florentine processes.

The affairs between the Wool Guild and the woad dyers is one of almost uninterrupted quarrels, with each of the parties enjoying temporary successes. In the early days of the Wool Guild the ruling management imposed intolerable conditions on the second class in spite of the skills of the craftsmen. Their wages were reduced to that of inferior employees who worked under them. The Guild recognized the highly skilled work of the dyers and even though they knew they could not be
replaced in the event of a strike, the wages were lowered as low as could safely be done. The dyers were subject to strict supervision and every flaw in their work was punished by a deduction in wages. The regulations and low wages reduced the efficient artisans to a helpless position.

From time to time the dyers made attempts at emancipation and it was the woad dyers who were first to take action in the struggle for higher wages. In 1342 they made a petition to the Duke of Athens stating their oppression by unjust ordinances which had reduced them to poverty. Grievances included only receiving wages every four or five years when it suited their employers, and even more, they could only take their complaints to the Guild whose superior members were at the same time their judges and employers. They begged to be removed from the Wool Guild and be granted a guild of their own having the same rights, privileges and duties enjoyed by the political guilds. In 1343 the plea was answered, they were set free from the powers of the Wool Guild and granted a guild of their own.

This lasted only one year as the dyers were reduced to complete dependency on the Wool Guild as the overbearing officials declared that every worker connected with any branch of the wool industry must submit to the authority of the Wool Guild and abstain from independent activity. Help was even sought from civic authorities against discontented wool workers. The dyers did gain some respect from the strength shown and some attempts were made to meet their wishes. In 1348 a dyer was appointed consul and in 1361 a new statute was passed where dyers in woad and other dyes were to be among the first class of the Wool Guild, giving them the opportunity to fill any office in the Guild. This gave dyers a better status than any other group belonging to the Guild.

Before long new unrest was among the dyers because even
though they were ranked higher, the consuls still had control of them and they had not gained much economically. In 1378 various dissatisfied classes of workers revolted and attempted to establish themselves as an independent party equal to other existing guilds. The dyers were successful this time in forming a guild, although they included other trades such as soap merchants, wool combers, cloth repairers, silk weavers, wool scourers and wool tenters. Maximum wages from the earlier Wool Guild were replaced with minimum wages for every member of the Dyers Guild. But before long economic conditions and commerce forced the Dyers Guild back into dependence on the Wool Guild. Conspiracies broke out between members who had been banished from the Wool Guild. Their own leaders disobeyed and in 1382 by armed forces, a new form of government was introduced and the Wool Guild once again took the leading place. The Dyers Guild dissolved and members returned to their former places. The gap between capital and labour was to be closed and employees enrolled in the second class, including the dyers, who were granted ten seats on the council of the Guild. But these craftsmen were not able to govern well and in 1393 fresh conspiracies threw the workers back into the 24 guilds they had previously been, including the dyers. Consuls disappeared from members of the Guild and complaints of low wages and unfair treatment were heard. Capitalism prevailed leaving behind a chronic state of industrial chaos and unrest.

In the 14th and 15th centuries the Wool Guild progressed and enjoyed prosperity in the European market. But then shortages of fine wool to manufacture their famous cloth became a problem, as did difficulty in importing the rough undressed cloths. The Florentines decided then to do the cloth dressing and dyeing at home, but to set up workshops in other countries such as Flanders, Holland, France and England where they were closer to raw materials and preliminary processes.
could be carried out. The half finished cloths were then brought back to Florence for final processing. This proved so successful that soon foreigners were carrying on the same business and factories sprung up everywhere. And so the raw materials on which they had depended were gradually filched away and a serious decline in the wool industry pushed the guilds out of their former markets. The silk trade soon began to replace the wool commerce and in 1770 the Wool Guilds of Italy were abolished.
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TROPICAL INDIGO AND THE WOAD INDUSTRY

From descriptions of both Dioscorides Pendanius, the Greek physician (c. AD 40-90), and Pliny the Elder, the Roman writer (AD 23-79), it is evident that indigo from the Orient was already known in the Mediterranean region. In fact, Herodotus, the Greek historian (c. 484-425 BC) described the way in which indigo was being used in 450 BC. The earliest evidence of the introduction of tropical indigo as a dye source in Europe is at Genoa, Italy where it was described in 1140, and then in Bologna in 1194. It reached England in 1274 and France in 1288, but the long overland journey from India made its price too outrageous to be used extensively. When Marco Polo returned from China in the 13th century, he brought with him information on the preparation of indigo used in the Orient.

About 1560 geographical discoveries opened up new trade routes via the Cape and small quantities of the exotic indigo reached Europe. Larger quantities were now available at a more reasonable price. At first indigo was not used alone in a dye vat, but added in small proportions in order to brighten the blue obtained from woad. Toward the end of the 16th century, the European dyers discovered that indigo was a much more economical dye than woad and supplied a richer color. By this time woad was still used in the vat but only to aid in the fermentation of the indigo.

The Dutch East India Company was formed and eventually imported enough indigo into Holland to supply the entire world. In 1631 seven Dutch ships imported 580,345 pounds of indigo into Europe, a freight worth over five tons of gold. Commercial quantities and reasonable prices eventually led to the triumph of indigo.

This greatly threatened the woad growers as well as the trade of the woad merchants. For many centuries woad merch-
ants had accumulated large fortunes from the manufacture and sale of woad and they did not want to see their business decline because of this tropical dye. Protective legislations were made in favor of woad as a result of vigorous campaigns. Under the reign of Queen Elizabeth, indigo was denounced by Parliament as a dangerous drug and described as 'food for the devil'. Searchers were authorized to burn every dye house where it was found and this Act remained in effect until the time of Charles II. The prejudice against indigo subsided by 1726 but it was still required to use woad in the vat and the failure to do so resulted in fines.

France had much the same regulations as England. As early as 1598 the use of indigo was prohibited and in 1609 King Henry IV announced that anyone using indigo would be put to death. Not until 1737 were French dyers allowed to use indigo as they chose.

In Germany, similar protective measures were taken by the woad merchants who possessed great political influence and considered indigo as the 'devil's dye'. Both the Emperor Rudolf in 1607 and the Elector of Saxe in 1650 entirely banned the use of indigo. Indigo was said to injure the woad trade, damage the fabrics and carried money out of the country. Dyers were made to take an oath against the use of indigo and anyone who did use it was threatened with the death penalty.

Bringing indigo into the Papal States of Italy was also prohibited.

All the important woad growing countries of Europe had taken steps to protect the home grown woad against its tropical competitor. Absolute prohibition of indigo, confiscation of supplies and even the death penalty threatened those who infringed the protective laws that were passed. In Germany however, the legislation was far from universal, owing to the number of small states and to a great extent was dis-
regarded by the commercial community. For example, in Ham­burg as early as 1610 dyers were using indigo, and in Silesia it was being imported in large quantities without police in­terference. At the beginning of the 17th century more than twenty firms sold indigo in Leipzig and the demise of the woad industry became more and more apparent. The success of protection of the woad industry was only temporary and in time the prosperity known to the great woad industry rapidly declined.

The woad industry was all but extinct by the 18th cen­tury only to be suddenly and temporarily resuscitated at the time of the Napoleonic wars. Importation of indigo had been stopped by the continental blockade and Napoleon issued a Decree, ordering woad to be cultivated over all of France and Germany. It proved to be a failure and soon Napoleon fell along with concurrent economical and political changes and the last serious attempt to save the woad industry was brought to an end. By the 19th century indigo entirely re­placed woad as a source of blue dye commercially.

In Germany the industry survived on a small scale in three Thuringian towns until 1865. The last surviving woad mill came down in 1910.

In England woad was used until 1932 and was included in the vats used for dyeing the uniforms of the British police force. A typical recipe of this period is as follows:

15 kg indigo
300 kg woad
10 kg bran
2.15 kg madder
12 kg slaked lime (very freshly made)

In the Fenlands of England two remaining woad farms operated until 1932 when the last woad mill, the Shirlbeck Mill of Lincolnshire closed.
THE WOAD PLANT

A member of the mustard family, woad is of the genus 'Isatis' which includes about thirty annual, biennial, and perennial Old World herbs with more than one containing the indigo pigment. Dyers woad 'Isatis tinctoria' is a cruciferous biennial which in its first year of growth, starting from seed, makes a low rosette of glossy dark green foliage. The leaves are oblong, up to 12 inches in length with widths of 2-5 inches with fairly smooth but slightly wavy edges. The plants will be about 8-12 inches high but can be up to 18 inches. Harsh winters will freeze the plant down to the ground but in milder climates it remains green.

In the spring the plant comes up early, sending stalks as high as 5 feet. Smaller leaves are along these upright stems, while at the top are masses of small four petalled bright yellow flowers. Woad in bloom is very pretty and resembles mustard. As the plant matures the branches holding the flowers grow outward from the main stalk as much as two feet in either direction and the flowers mature into dangling seed pods. The seed pods are about one half inch long, flat, and turn from light green to a dark brown, almost black color as they mature. This plant is ideal for wind dispersal over open plains, since each seed is practically individually winged. As a result, some places have deemed woad a noxious weed. The stems can be cut and the seeds easily removed before they spread on their own.

Woad adapts to most soil types and sites but prefers rich soil in full sun. The earth should be tilled fairly deep because of a long tap root, up to 2 feet long. Woad is taxing on the soil, depleting it of nutrients and so plenty of compost or manure with regular water is favorable to its growth.
METHODS OF GROWING AND DYING WITH WOAD ON HANDSPUN YARNS

Woad seeds can be sown in the fall for early spring plants or early in the spring. In harsher climates they can be started indoors and transplanted at the four leaf stage. Allow 12 to 18 inches between plants in a garden.

Pick the leaves when they are full grown and still retain their rich green color. As the leaves pale their dye value diminishes. Two or three gatherings per season is possible, but the first crop is the best.

FIRST YEAR WOAD PLANTS
SECOND YEAR WOAD PLANTS - Note the date is May 31. The plants are already 4½ Feet high and in bloom.

THE TOP OF A WOAD PLANT IN SEED - The plant had been cut off.
METHODS OF GROWING AND DYING WITH WOAD ON HANDSPUN YARNS

A SMALL WOAD LEAF
(The dark green indicates frost damage)

WOAD SEEDS
THE WOAD DYE

In the leaves of the indigo-bearing woad plant is the indican, a colorless water-soluble substance that is easily hydrolysed to glucose and indoxyl. Glucoside will not change into a blue insoluble compound until it has been combined with atmospheric oxygen. Dye material, in this case indigo, must be dissolved in a liquid before fibers can absorb the color. 'The Dyeing of Textile Fibers' by J.J. Hummel (1896) describes the process; 'The method in dyeing with indigo is founded on the property it possesses of being converted under the influence of reducing agents, i.e. bodies capable of yielding nascent hydrogen, into indigo white, which is soluble in alkaline solutions.' The formula for this change is this: \( \text{Indigotin} = \text{C}_{16}\text{H}_{10}\text{N}_2\text{O}_2 + \text{H}_2 = \text{C}_{16}\text{H}_{12}\text{N}_2\text{O}_2 = \text{indigo white} \). On oxidation this gives \( \text{C}_{16}\text{H}_{12}\text{N}_2\text{O}_2 = \text{indigo} \).

To dye the indican must be converted to indigo white with a reducing agent. The indigo white is then dissolved in an alkali. Little is known historically about the way reducing agents were discovered by primitive cultures, but two of the most simple ferments, stale urine and wood ash were used very successfully. Today we use sodium dithionite in the form of Spectralite or Rit Color Remover. When dyeing is done with clean wet fibers, the fibers will emerge from the dye vat yellow and slowly turn yellow-green, green, green-blue, then blue as it is exposed to the oxygen in the air. The dye is a permanent fast blue and the longer the fibers are soaked, the deeper the color will be. The fibers can be redipped and aired for darker colors.

Drying woad leaves for storage loses much of the indigo so it is much better to use the leaves fresh. To store, make it into a solution; add an alkali; beat the liquid to introduce oxygen; add sodium metabisulphite as a preservative, cap with no air in the container and store.
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

GENERAL INFORMATION ABOUT THE DYE PROJECT

The four fibers I used for the dye experiments were, a Border Leiscester lambs wool, cultivated silk, bleached tow flax, and ginned pima cotton. The fibers were all weighed carefully and scoured before dyeing. The fiber weight totalled 1 1/4 ounces for the main dye baths and consisted of 1/2 ounce wool, 1/8 ounce silk, 3/8 ounce flax and 1/4 ounce cotton. The afterbath fibers totalled 1/2 ounce, but not all dye experiments had afterbaths. I used 5 ounces of fresh woad leaves for each dye pot. This gave a 4:1 ratio of dye-plant to fiber, which is what is recommended for woad. The leaves were picked, weighed and torn into about 1" pieces in preparation for the dyepot.

The two recipes that were used through the dyeing are as follows. For blue dye:

8 cups of near boiling (200°F) rain water was poured over the torn leaves and left to sit for 45 minutes. Strain the leaves and set aside.

At this point the temperature can be checked, and if necessary brought up to 125°F. Usually it was around 110°F and left at that. At no point beyond here should the temperature exceed 125°F.

To this tea add alkali. I used 1 Tablespoon washing soda. Beat about 5 minutes to introduce oxygen. The bath will turn yellow-green and form bubbles on top.

Carefully, without disturbing the bath, add a reducer, in this case 1/2 Tablespoon Spectralite and let sit 45 minutes.

Still without disturbing the bath too much, add the clean wetted fiber and let sit for 45 minutes. Remove the fiber; squeeze out excess liquid and watch it change from yellow to blue at it receives oxygen from the air. Magic!
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

The afterbath procedure is this:
Simmer the scalded leaves left over from the blue dye-bath in rain water for 60 minutes. Strain.
Add 1 teaspoon alum and 1/2 teaspoon cream of tartar per ounce of fiber, dissolve.
Add clean, wet fiber and enough water to swim. Bring to 180°F and hold for 60 minutes.
Rinse and dry.

The fiber was dyed, then spun and washed. All yarn is spun Z and plied S. The flax was spun dry. I found dyeing the fiber before being spun not completely satisfactory because the fiber did not always dye evenly. This was caused by the wet fibers clumping together in the dye pot, but was remedied by evening the colors out on the hand cards afterwards. The most trouble seemed to come from the ginned cotton. It was hard to get it carded to where it would give a smooth yarn, but the texture will be used to add interest to a garment. In hindsight I should have used combed cotton roving.

The dye experiments are dated in succession through the summer to compare difference in color by the age of the plant. Would the plant give the same color of dye on the first date of dyeing as it did on the last? Due to a late spring, the seeds were not planted until the first of June, and so the plants were not ready for dyeing until later in the year. But thanks to an unusually late fall the dyeing was extended.

Rainwater was used for all dyeing unless otherwise noted. The same dye recipe was used except where otherwise noted. I tried to keep everything as consistent as possible to give a true evaluation of the varying factors in each dye experiment.
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

RAW FIBERS USED

WOOL - BORDER LEICESTER LAMB

CULTIVATED SILK

BLEACHED TOW FLAX

GINNED PIMA COTTON
TEMPERATURE VARIANCES
(Temperatures Maintained)

It is said that the temperature of the dyepot of woad can not exceed 125°F after the alkalai is added. In this session I used three different temperatures, 100°F, 125°F, and 150°F, for the entire process. From the time the water first went onto the fresh leaves until the fiber was finally removed, the temperatures remained constant.

On beating after the addition of the washing soda I find the 100°F bath forms white bubbles, the 125°F bath forms yellow green bubbles and the 150°F bath forms yellow bubbles. Add the spectralite and the 100°F bath turns light green with white bubbles, the 125°F bath is blue green with blue bubbles, and the 150°F bath is dark yellow with yellow bubbles. The resulting colors from the 100°F bath show almost no color, the 125°F bath gives a nice light blue and the 150°F bath gives a slight grey on the wool but not much else on the other fibers. The wool from the last bath is not nice to handle. It is almost sticky.

My conclusion here is that the dyepot should not exceed 125°F. This dyeing was done on August 22.
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

TEMPERATURE VARIANCES
(Temperatures Maintained)

100°F  125°F  150°F

WOOL

SILK

FLAX

COTTON
Methods of Growing and Dyeing with Woad on Handspun Yarns

Afterbaths for Temperature Variances
(Original Temperatures Maintained)

Because the temperature seemed to extract differing degrees of dye from the plant, how much dye is potentially left in the leaves for an afterbath?

After simmering the leaves for 60 minutes, then straining, I find the 100°F pot is a deep cherry brown color while the other two are much lighter. After adding alum and cream of tartar, the 150°F pot seems to be more pink than the one that was 125°F.

The resulting fiber tells us that the 100°F dyepot did not extract the dye that it could have as this fiber is a lot brighter than the other two. I should think then that the original water used to scald the leaves should be very hot.
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

AFTERBATHS FOR TEMPERATURE VARIANCES
(Original Temperatures Maintained)

100°F  125°F  150°F

WOOL

SILK

FLAX

COTTON
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

TEMPERATURE VARIANCES
(Temperatures Not Maintained)

What happens then, if a higher temperature of water is used to scald the leaves, and the actual dyeing is done at a lower temperature?

Use 200°F water and 150°F water to scald the leaves and dye the fiber at 120°F. When removing the leaves from the pot the 150°F bath is just a little darker brown or rust than the 200°F one. When adding washing soda the baths turn dark blue-green and the beating gives yellow bubbles. Add spectralite and the 200°F pot is noticeably more green while the other is yellow. Both have bluish bubbles or scum. The temperature on both is 100°F when the fiber is entered.

The resulting color on the fiber shows that the higher temperature did give more color on all the fibers. The 150°F pot was redone because the temperature was inadvertently raised part way through the process. The result on this pot is a deeper blue than on the first. Dyeing done on September 8, and 150°F redone on September 16.
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

TEMPERATURE VARIANCES
(Temperatures Not Maintained)

150°F

WOOL

150°F
(Re-done)

SILK

200°F

FLAX

COTTON
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

AFTERBATH WHEN TEMPERATURE WAS NOT MAINTAINED

The results of this afterbath are comparable to the results of the 150°F afterbath where original temperature was maintained. I conclude that 150 F water was used on both to extract dye in the first place, and so the amount of dye left to use in the leaves must be about the same. The wool is a light color and the silk shows some, but the cotton and flax show little to no color at all.
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

AFTERBATH WHEN TEMPERATURE WAS NOT MAINTAINED

150°F

WOOL

SILK

FLAX

COTTON
I have always heard that you are not able to get color from woad if you used hard water to dye with. This made me wonder about the effects of other waters. The four waters that I used are commercial distilled water with no salt, North Saskatchewan River water collected at the Drayton Valley bridge, hard water from a well, and hard water from a well with calgon powder added. Calgon is supposed to give softening qualities and I wondered if this would make a difference.

After adding the waters to the leaves at 200°F changes are immediate and very different. The calgon water is a deep emerald green and blue scummy bubbles are on top in places. The hard water pot is an emerald green and the commercial and river water pots are a pale emerald green. In 30 minutes the calgon pot has remained the same with the thin bluish scum on top, the hard water has developed a pinkish scum on top, and the other two have turned a light sherry color with no scum. On straining the leaves I find that the leaves from the calgon pot are reduced nearly to mush.

Because I could not believe that color could be had from hard water I redid it with hard water from another well. The results were the same all the way through, with the exception of the color of the wool. So now the question concerning mineral content of these two well waters comes up and is this why there could be the difference in color on the wool? Possibly one has more iron content than the other.

The colors from the dyes using different waters showed success all the way through on all fibers. I am surprised and pleased to find this as I had thought it not possible.

This dyeing was done on September 9 and the redone pot on September 16.
METHODS OF GROWING AND DYING WITH WOAD ON HANDSPUN YARNS

WATER VARIANCES

- COMMERCIAL WATER
- RIVER WATER
- HARD WATER
- HARD WATER #2
- HARD WATER WITH CALGON

WOOL

SILK

FLAX

COTTON
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

AFTERBATHS ON WATER VARIANCES

After simmering for 60 minutes all baths are a pinkish sherry color with the exception of the calgon bath which is dark green. When alum is added the calgon bath forms yellow bubbles and all go cloudy, with the hard water and hard water with calgon being the cloudiest.

The hard water from a different well redone has a green tinge to the bath. Its resulting colors on wool and silk are the most noticeable but I do not know why. My conclusion is that the particular well has some mineral that the other one did not, possibly iron.
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

WATER VARIANCES
AFTERBATHS

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METHODS OF GROWING AND DYING WITH WOAD ON HANDSPUN YARNS

RECIPE VARIANCES

1. Rit Color Remover. Use as with the original recipe and instructions but substitute 1 Tablespoon instead of the spectralite. Proceed as usual.

2. Washing Soda. Pick and tear up the fresh leaves. Cover with warm water in which 2 Tablespoons of washing soda have been dissolved. Cover the container very tightly and leave in a warm place for twenty four hours at a temperature of 95-110°F. The next day remove and squeeze the woad leaves and add 2 cups of bran to the dyebath. Add the clean wet wool and return to the warmth to ferment. In twenty four hours remove and air the wool for ten minutes, replace the wool and keep it warm. Air each day, outdoors, as the smell will increase. Very little color will be taken up after the fifth or sixth day.

3. Urine. Pick and tear up the fresh leaves. Scald them with nearly boiling soft water. Let sit for 45 minutes then strain. Add 1 Tablespoon washing soda and whisk for five minutes to aerate it well. Have a plastic gallon container 1/4 filled with stale urine to which 1/3 cup of bran has been added. Add the woad solution and clean wet wool and screw the lid on. Set the carton in full sunshine for at least two weeks so that it is kept at nearly 125°F for several days. After fermenting, air the wool twice daily until it is as dark as required.

4. Yeast. Pick and tear up the fresh leaves. Scald, strain, add washing soda and whisk. Add 1/2 cup of bran, 1/2 teaspoon yeast and 1/2 Tablespoon of sugar to feed the yeast. Put the top on and keep in a warm place for about ten days, opening the top once a day to let out the gas. If it isn't gassy enough, the yeast may need more sugar. After ten days the bath should have turned from dark green to milky yellow. When the fiber turns from green to blue in the air, the
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

RECIPE VARIANCES

RIT COLOR REMOVER  WASHING SODA  WASHING SODA #2  URINE  YEAST

WOOL

SILK

FLAX

COTTON
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

yeast has worked satisfactorily. If not, add more yeast and sugar and put back in the warmth for a few more days.

These mini dye vats were prepared with much difficulty. The ancient woadmen are to be commended on their ability to withstand the powerful stench that comes from a fermenting dyepot. I did each of the dyes the first time but was not happy that any color came from them so redid them. The only one that was saved from the trash on the second go around was the washing soda dye, and only because it looked like it may have a little color. All the rest, including the first time, seemed to rot. When the fiber was removed from the pots it was covered with a sort of a slime that I am assuming was bran. It did not all wash off successfully and was left to dry. On carding it was very dusty and still smelled bad. I was surprised to get any color at all from this. I had a hard time to keep the temperature constant enough to call this comparison a success and give it a proper assessment. This dyeing should be done in a hot summer sun, outdoors.

This was dyed on September 10 and November 2.

AFTERBATHS USING DIFFERENT MORDANTS

The alum recipe here is as the usual afterbath recipe that has been used throughout for afterbaths. For the others, substitute either 1/16 teaspoon iron or 1/16 teaspoon tin in place of the alum per ounce of fiber. Add the fiber and simmer for only 15 minutes instead of 60 as in the alum recipe. The iron gives a little darker color while the tin is lighter on both wool and silk. The cotton and flax show little to no color or change from the alum afterbath.
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

AFTERBATHS USING DIFFERENT MORDANTS

IRON          ALUM          TIN

WOOL

SILK

FLAX

COTTON
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

DYEBATHS PREPARED FROM PLANTS GROWN IN VARYING SOILS

This experiment took a little more preparation than any of the others but served to answer my initial question of the pigment obtained on fiber in relation to the soil type the dye plant was originally grown in.

Three small gardens, 2 feet by 3 feet were prepared. Each was dug down about one foot below ground level and different soil types used to fill them. In the first one was peat moss from the muskeg on our farm. In the second one was a mix of black dirt and sand. In the third was straight manure from the sheep pile that had rotted and gone back to dirt.

To the first garden with peat I added 3 cups of aluminum sulphate dissolved in water which gave it a PH of 6.5. The second box of black dirt and sand got nothing, its PH was 7.2. The third box with manure was given a solution of 3 cups of lime dissolved in water and its PH was now 7.8. The PH was checked periodically throughout the summer and more lime and aluminum sulphate was added twice more to keep the PH constant.

The woad seeds were planted and the soil did not seem to make a difference in germination or growth rate. The alkali garden of manure and lime seemed to grow a bit faster than the other two, but not much.

On using the dye, the dyebath from the neutral soil garden is darker than the other two, but after the addition of spectralite, each bath is clear yellow when the fiber is added.

All the dyebaths seemed to give good color equally on all of the fibers but I think the one from the alkali soil is a bit darker on all the fibers.

The dyebaths from this experiment were saved and frozen for a revival experiment later.

This dyeing was done on September 16.
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

DYE BATHS PREPARED FROM PLANTS
GROWN IN VARYING SOILS

ACIDIC SOIL  NEUTRAL SOIL  ALKALI SOIL

WOOL

SILK

FLAX

COTTON
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

AFTERBATHS PREPARED FROM PLANTS GROWN IN VARYING SOILS

This afterbath was done with an alum mordant and was prepared as the others. All resulting fiber from this afterbath looks to be extremely close in color.

My conclusion on this experiment is that woad is happy to grow in a range of different soil types and gives an equally good dye from them all.
METHODS OF GROWING AND DYING WITH WOAD ON HANDSPUN YARNS

AFTERBATHS PREPARED FROM PLANTS GROWN IN VARYING SOILS

<table>
<thead>
<tr>
<th>SOIL</th>
<th>Wool</th>
<th>Silk</th>
<th>Flax</th>
<th>Cotton</th>
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</tr>
<tr>
<td>Alkaline</td>
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</table>
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

FRESH LEAVES WITH MORDANT VARIANCE

One question that kept popping to mind was, 'What if the woad leaves were prepared for dye as any other leaves were prepared for dye, instead of dyeing in a vat?' And so leaves were torn for preparation and simmered for 60 minutes in rain water, then strained.

One pot received no mordant.

The second pot was alum and the same recipe was used that has been used for afterbaths.

The third pot received 1/16 teaspoon tin per ounce of fiber and simmered with the fiber for 15 minutes.

The fourth pot received 1/2 teaspoon copper sulphate per ounce of fiber and simmered with the fiber for 15 minutes.

The fifth pot received 1/16 teaspoon of iron per ounce of fiber and simmered with the fiber for 15 minutes.

The sixth pot received 1/16 ounce of chrome per ounce of fiber and simmered with the fiber for 45 minutes.

The fibers were left to cool in the dyepots overnight, then rinsed and dried.

I was surprised by the results of this experiment, of the range of color that was obtained by using the different mordants. I find the colors pleasing on all of the fibers and can see where woad might be used as more than just a vat dye.

This was dyed on September 16.
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

FRESH LEAVES WITH MORDANT VARIANCE

<table>
<thead>
<tr>
<th>NO MORDANT</th>
<th>ALUM</th>
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<th>IRON</th>
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<tr>
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<tr>
<td>FLAX</td>
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<tr>
<td>COTTON</td>
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</tbody>
</table>
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

AFTER FROST DYE PLANT USE
VARIANCE IN LEAF SOAKING TIME

Does frost on the plant affect its dye capabilities? If so, how about the length of time the plant matter soaks when it is initially being scalded?

We are having an unusually mild fall this year. A snowfall in late October left when the weather warmed again and the ground is bare. The thermometer dips to below freezing each night and hovers around 0°C to +5°C during the day. The woad in the garden is still green and is not limp as some plants are when touched with frost. These leaves were picked four days after our first heavy killing frost.

The leaves were soaked in 200°F water for 15 minutes, 30 minutes, 45 minutes and lastly for 60 minutes. The leaves were strained and the procedure went as normal. The tea in the baths are darker the longer the leaves have soaked.

I am quite surprised and pleased with finding that the frost did not seem to affect the dye quality of the woad plant. The fiber seems to be all comparable but does darken slightly with the length of time the leaves were soaked. This is some of the best color obtained all summer from this woad.

This bath is kept unfrozen for revival later.

This dyeing was carried out on October 11.
Methods of growing and dyeing with Woad on handspun yarns

After frost dye plant use
(Variance in leaf soaking time)

15 Min.  30 Min.  45 Min.  60 Min.

Wool
Silk
Flax
Cotton
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

AFTER FROST DYE PLANT USE
VARIANCE IN LEAF SOAKING TIME
AFTERTHROUGH

This afterbath was carried out as always, simmering the leaves for 60 minutes. But the bath that had originally been soaked for the longest, 60 minutes is the darkest of them all. This surprises me, as I had thought it would be the lightest. The wool in this dyepot also seems to be the darkest, but the rest of the colors are very close in value in all fibers.
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

AFTER FROST DYE PLANT USE
(VARIANCE IN LEAF SOAKING TIME)
AFTERTBATH

15 Min.  30 Min.  45 Min.  60 Min.

WOOL

SILK

FLAX

COTTON
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

AFTER FROST DYE PLANT USE
VARIANCE IN FIBER SOAKING TIME

Winter is coming tonight. Finally. It is New Year's Eve and we have had a very long Indian Summer. The woad has had frost a lot by now, not heavy frost or steady, but it has been freezing every night for the last two months. Some days temperature temperatures remain at or below the freezing point and some are warmer. The woad is in very good condition for any plant that should survive an Alberta winter. It is still green. A few leaves are dark, almost black green. They are limp, not crisp as a leaf gets when it is frozen. Will they make dye? And if so, will it make a difference to the depth of color as to how long the fiber is in the bath?

Dyeing is as normal. The fiber stayed in the first bath for 45 minutes and was aired. The fiber stayed in the second bath for 45 minutes and was aired for 10 minutes, then returned to the bath for 15 minutes. The fiber stayed in the third bath for 45 minutes, aired for 10 minutes, returned to the bath for 15 minutes, aired for 10 minutes and returned to the bath for another 15 minutes.

The overall color is very washed looking with the blue being almost lost on the wool, while the flax still picked up some blue dye. I was surprised by the pink-violet of the silk. The additional dippings did not seem to make a lot of difference, although the last one is a bit darker. Perhaps this part of the experiment would have shown more difference had the plant retained more of its dyeing capabilities.

This dyeing was carried out on January 1.
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

AFTER FROST DYE PLANT USE

(VARIANCE IN FIBER SOAKING TIME)

WOOL

SILK

FLAX

COTTON

45 Min.

45 Min. + 15 Min.

45 Min. + 15 Min.
I was very happy to see that as an afterbath dye, one could still get color from the woad as late into the year as January 1, even though the blue seems to have faded. This is indeed a good dye plant! The color from this dye is very comparable to the colors from the other afterbaths here.
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

AFTER FROST DYE PLANT USE
AFTERTBATH JAN. 1

WOOL

SILK

FLAX

COTTON
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

SECOND YEAR PLANTS

In the spring the woad plants came up so fast, even before the rest of the garden was planted. By May 31 they were from 4 1/2 feet to 5 feet tall. To prevent an overabundance of seed and the likelihood of some seed escaping, I cut them all down and decided to see what other parts of the plant had for dye. I was also curious about second year leaves.

The bath from the stems has very little color, the root has some but not much. The flower give the bath a brighter orangy pink and the leaves were as the flower but a little darker. This changed with the addition of spectralite.

None of the dye pots gave much color to any of the fibers, except for the leaves which gave very pale colors to most, with the flax picking up the most blue.

This was dyed on May 31.
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

SECOND YEAR PLANTS

<table>
<thead>
<tr>
<th></th>
<th>FLOWERS</th>
<th>STEMS</th>
<th>LEAVES</th>
<th>ROOTS</th>
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<tbody>
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<tr>
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</tbody>
</table>
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

SECOND YEAR PLANTS
AFTERBATHS

This dyebath is perhaps the one I did not expect. The range of colors in the afterbath with alum mordant was unbelievable. I was maybe the most excited to get yellow from the flowers. The leaves too gave almost as good a dye from second year plants as the first year afterbaths had.
METHODS OF GROWING AND DYING WITH WOAD ON HANDSPUN YARNS

SECOND YEAR PLANTS
AFTERBATHS

FLOWERS  STEMS  LEAVES  ROOTS

WOOL

SILK

FLAX

COTTON
I wondered if the woad leaves could be stored in a conventional method, such as freezing or drying them for storage. Equal amounts were picked and put away, one to the freezer and the other dried in the sun, was ziplocked and kept for another dye day.

I was surprised at the difference in the dyebaths. On the hot water scalding the leaves, the dried leaves turned the bath a reddish brown, while the frozen leaves turned the bath light green. The dried leaf bath is much darker than the other one. With the addition of spectralite the bath from the dried leaves turns a yellowy-orange color, while the frozen leaf bath turns yellow.

Neither method of storing leaves proved to be of any use in order to obtain a blue dye.
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

DYE BATHS PREPARED FROM STORED LEAVES

<table>
<thead>
<tr>
<th>Frozen Leaves</th>
<th>Dried Leaves</th>
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</thead>
<tbody>
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<td>Wool</td>
<td></td>
</tr>
<tr>
<td>Silk</td>
<td></td>
</tr>
<tr>
<td>Flax</td>
<td></td>
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<tr>
<td>Cotton</td>
<td></td>
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</tbody>
</table>
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

DYEBATHS PREPARED FROM STORED LEAVES

AFTERBATHS

The afterbaths on these two dyes were carried out with the usual alum recipe. The colors obtained are very good, especially from the dried leaves. This makes me wonder what could happen with other mordants?
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

DYEBATHS PREPARED FROM STORED LEAVES

AFTERBATHS

FROZEN LEAVES

DRIED LEAVES

WOOL

SILK

FLAX

COTTON
Two dyebaths had been prepared and already used to get a blue dye successfully. They had then been stored, one frozen and one not. It is written that this procedure is alright to do, while still maintaining the ability to retrieve blue dye from the dye bath.

To revive the bath, bring the temperature no higher than 125°F then follow the normal recipe. The color from my dye bath was lost on all the fibers as this did not seem to work the way it should have. On doing further research I find that I should have added 1 teaspoon of sodium metabisulphite as a preservative. This will be one to try again, correctly this time.
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

DYEBATHS PREPARED FROM STORED DYEBATHS

FROZEN STORAGE

UNFROZEN STORAGE

WOOL

SILK

FLAX

COTTON
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

CONCLUSION

The first conclusion that I make after my investigation of woad is that it is a tremendously versatile dye plant. It gave good color with water from different sources, and showed that hard water could be used successfully, but that water from different wells could make a difference in the resulting color on wool. It was shown that woad can be grown in different soil types and give equally good color from each. I learned how important the temperature of the dyepot is, that you should use very hot water to extract the dye from the leaves, but if the dyepot itself is too hot the color is easily lost. By experimenting, I found that woad can give surprising color with different mordants, and that cellulose fibers did not always take the dye as well as the protein fibers in the same dye bath. I was disappointed with the failure of the fermenting vats and shall attempt it again one day, smelly as it is.

I was impressed with the effect the dye had on the fibers. Except in the few instances where noted, eg. where temperatures were maintained high, the dye bath seemed to be kind to the fiber, leaving them soft and with good hand, and a pleasure to work with.

This project answered alot of my questions about woad but also opened up alot more. For instance, just how quickly does the woad plant deplete the soil of its nutrients, and is this apparent by its dye? One would have to set aside a small plot of ground for about 5 years and dye from plants grown on it each year to see what effect the color might have on the fiber. Other ideas arise with the thought of introducing other dye plants used in conjunction with woad, either together or as overdyes. The possibilities of exploration appear to go on and on.

My own research with woad will continue for a very long time as I have too many unanswered questions to let rest.
METHODS OF GROWING AND DYEING WITH WOAD ON HANDSPUN YARNS

USING WOAD DYED YARNS IN A PROJECT

Now that I had all of these wonderful samples of woad dyed yarns of differing fiber types, could they all work together in one project? A pattern was chosen for a vest where it looked like small samples could be used to effectively display each fiber type and the color it held.

I was quite pleased with the resulting garment. The yarn needed to be doubled throughout to reach the gauge required by the pattern, which adds to the character of the knitted cloth. The colors work well together and enhance each other as do the different fibers. For example, the muted blue flax brings out the shimmering of the purple blue silk that it surrounds.

This will be a fun vest to wear and a good display of the colors obtained by one singular plant - woad.
BIBLIOGRAPHY