Orange Peel and Tomato Decomposition as an Aid in the Retting of *Linum usitatissimum* for Fiber and Textile Use

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Abstract

The bast fibers of *Linum usitatissimum,* flax, have been used for rope, yarn, and fabric since as early as 36,000 BC (CLEC). The complicated system of processing *Linum usitatissimum* has been done since then, and the most complex link in the chain of processing happens during retting when the fibers are freed from the outer layer of the stalk via the help of enzymes that break down pectin and other structural elements. Traditional retting is done by dew retting or submerged water retting while the textiles industry has sped these methods up by using crimped enzyme retting where the flax is pounded to slightly physically break up the flax, sprayed with water and lab produced enzymes (Akin et al. 2001). These lab producing enzymes are predominantly composed of pectinase (Sharma and Van Sumere 1992) which is an enzyme found in decomposing tomato and orange scraps (Sandhya and Kurup). This experiment aims to see if tomato and orange peel scraps could aid in the retting of flax by 1) speeding up traditional retting (dew and water retting) that is done by home or small scale processors in a way that does not require commercial enzymes which are not available to the average consumer, and 2) being used in a crimped enzyme retting system that mimics industrial retting to see if these food scraps could be potentially used at an industrial scale.

Specific Aims

The most complicated link in the chain of processing *Linum usitatissimum,* flax for fiber is retting. Retting is the process of allowing the stalks of the linen to break down and separate the fibers from the stalk and is traditionally done by dew retting, the stalks of flax are spread out on a plot of grass left out for days, and water retting, the stalks are submerged in water for days. It was found that the process in which the flax is being broken down is because of enzymes that break down the pectin and other structural elements that bind the fiber to the stalk; the main enzyme that is found in this process is pectinase which breaks down pectin (Sharma and Van Sumere 1992).

Industrial scale flax processing uses commercially prepared enzymes to speed up the retting process in either dew or water retting. Recently, to make this process even more efficient, the textile industry has adopted Crimped Enzyme Retting where the flax is pounded to slightly physically break up the flax, sprayed with water and lab produced enzymes (Akin et al. 2001).

The lab produced enzymes that are used for all three retting methods are predominantly composed of pectinase (Sharma and Van Sumere 1992) which is an enzyme found in decomposing tomato and orange scraps (Sandhya and Kurup). This

experiment aims to see if tomato and orange peel scraps could aid in the retting of flax by 1) speeding up traditional retting (dew and water retting) that is done by home or small scale processors in a way that does not require commercial enzymes which are not available to the average consumer, and 2) being used in a crimped enzyme retting system that mimics industrial retting to see if these food scraps could be potentially used at an industrial scale.

By testing the three retting methods with orange scrap solution, tomato scrap solution, and a mixture of the two, it is the hope that in all three cases the retting is sped up by the enzymes found in these solutions as opposed to the control treatments. The fibers that come out of each trial will also be tested for strength This will prove that the enzymes are beneficial in all retting processes.

Background and Significance

With a strength of five times that of cotton and low irrigation needs, there is no wonder that linen is one of the dominant fibers in the world of sustainable textiles (CLEC 2015). After flax is grown, rippled (seed pods separated from the plant), and threshed (seed separation and collection), the flax must be retted, that is, undergo a microbial process to loosen fibers from non-fibrous material. According to most small-scale flax farmers retting is “the most important, difficult, and mysterious part of the entire flax process” (Zinzendorf 2011). Traditional retting is done by dew retting and water retting. Dew retting is when the stalks of flax are spread out on a plot of grass that has a good potential for dew production the mold and fungi from the ground and flax to break it down and separate the fibers from the stalks; this can take as long as six weeks to complete (Zinzendorf 2011) Water retting is a method in which water is used to break down the flax by submerging the stalks; this typically takes less time.

Large scale linen producers use a hastened retting method with commercially produced enzyme blends which are predominantly made up of pectinase and in both water and dew retting along with crimped retting -- a relatively new method in which flax stems are “crimped” by being pounded to slightly physically break up the flax to disrupt the outer layers and soaked or sprayed with enzymatic solutions (Akin et al. 2001).

It is known that the enzyme that is doing to most work of freeing the fibers is pectinase which aids in breaking down the pectin which holds the fibers together (Sharma and Van Sumere 1992). In “Screening and Isolation of Pectinase from Fruit and Vegetable Wastes” it was found that composting orange peels and tomatoes produced the most pectinase-producing molds and fungi (Sandhya and Kurup). This could be crucial to a naturally occurring alternative to commercial enzyme retting techniques.

This experiment aims to see if the molds and fungi found in tomato and orange peel scraps could aid in the retting of flax by 1) speeding up traditional retting (dew and

water retting) that is done by home or small scale processors in a way that does not require commercial enzymes which are not available to the average consumer, and 2) being used in a crimped enzyme retting system that mimics industrial retting to see if these food scraps could be potentially used at an industrial scale.

Experimental Design

Set up:

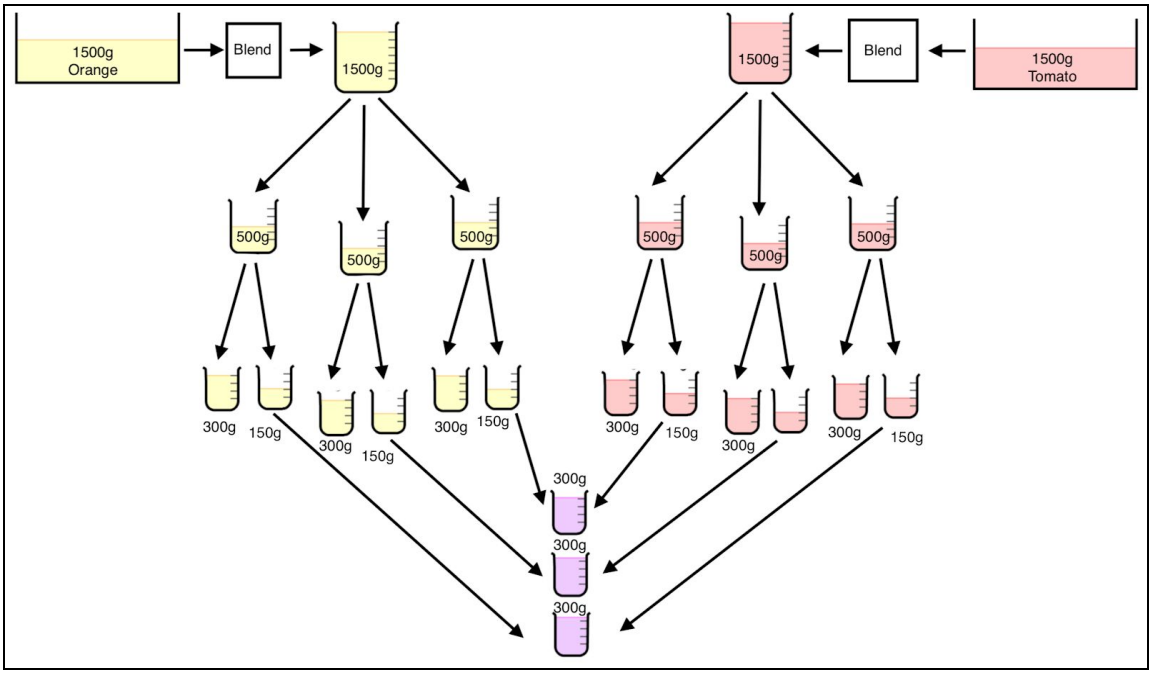
1. *Growth and Preparation of Fungi and Enzymes*

    1500g of tomato flesh and skin (which has been cut up to mimic food waste) and 1500g of orange peels and flesh (which are separated to mimic food waste) will each be placed into uncovered shallow containers and left in a climate controlled room representing the average home with the temperature kept between 68 and 78 degrees (USDE 2016) -- and the humidity kept between 55% and 65% (Metzger and Norton 2014). These will be left to sit for 10 days for decomposition to begin and fungi to form.

2. *Preparation of 12 Treatment Solutions*

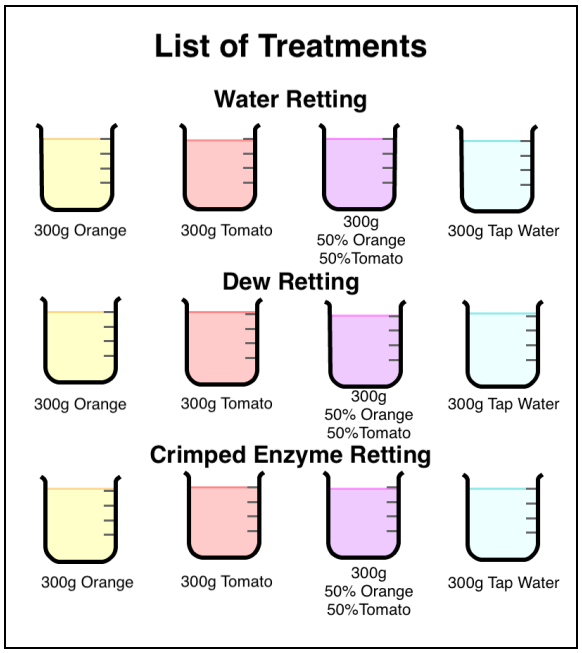
    Once fungi has formed, the entire contents of each container separately is then gently blended as to liquify the substance but not to disrupt the fungi too much. The solutions are then separated into labeled beakers each containing 500g of liquid. Each beaker represents the allotted substance per retting treatment. All 3 beakers are each separated into 2 new beakers: one containing 300g and one containing 150g. There are now 3 beakers of 300g of tomato, 3 beakers of 300g of orange, 3 beakers of 150g of tomato, and 3 beakers of 150g of orange. Each 150g of tomato is added to 150g of orange resulting in 3 beakers of mixed tomato and orange resulting in 300g (see figure 1).

Figure 1



Three beakers will also be filled with 300g of tap water. Now, each retting system (water retting, dew retting, and crimped enzyme retting) will each have the following: 300g orange solution, 300g tomato solution, 300g of a solution of 50% orange solution and 50% tomato solution, and 300g of tap water (see figure 2).

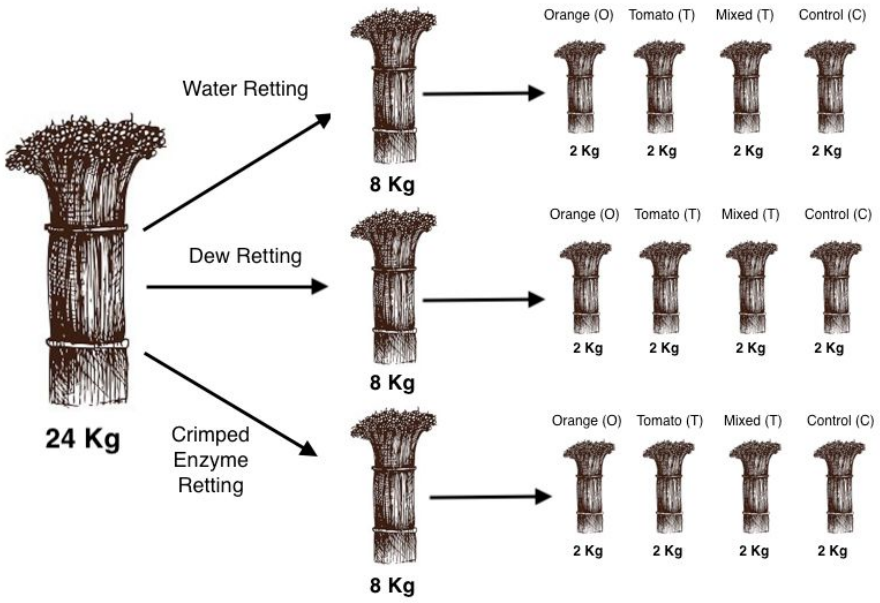
Figure 2



3. *Preparation of Flax*

24 Kg of flax that has been grown, harvested, dried, rippled, and threshed is separated into 3 bundles of 8 Kg each, representing 3 retting treatments: dew retting, water retting, and crimped enzyme retting. Each bundle of 8Kg is then separated into 4 bundles of 2 Kg, representing the sub-treatments: orange solution (O), tomato solution (T), 50% orange and 50% tomato solution (M), and control (C) (see figure 3).

Figure 3

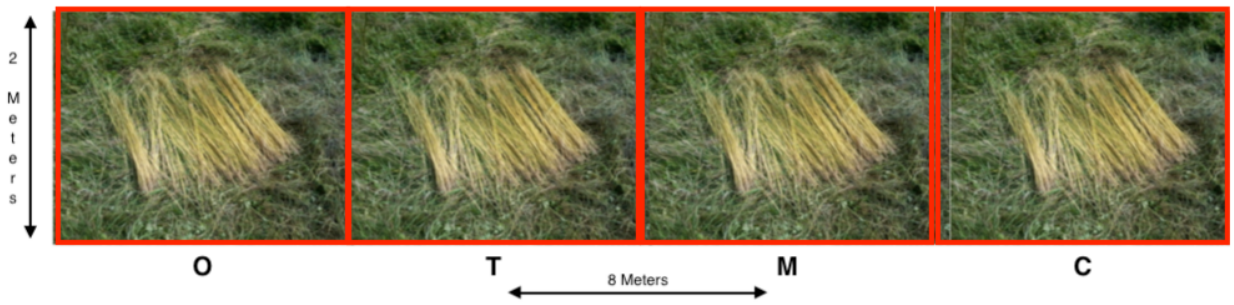


Retting Systems:

Dew retting

A 2 Meter by 8 Meter plot of grass that has a high potential for dew production is roped off by laying rope on the ground. This plot is then separated into 4 2 by 2 Meter adjoining squares (see figure 4). A 2 Kg bundle of flax is spread out in a single layer onto and individual section. This is repeated 3 more times. Each plot is then labeled O, T, M, or C. Each treatment will then be covered by the corresponding solution with a spoon.

Figure 4



Water Retting

4 40 gallon tubs (such as Rubbermaid ®) are placed side outside and filled ½ way to the top with tap temperature hose water. Each tub is labeled either O, T, M, or C. 4 2 Kg bundles are separated and each tub receives 1 opened up bundle (see figure 5). Each barrel is then labeled and given a specific treatment O, T, M, or C. Each tub then receives the corresponding solution poured on top of the flax.

Figure 5

Crimped enzyme retting.

4 2Kg bundles are separated and spread out in a single layer onto a plywood plot and hit with a wooden mallet to start the decomposing process. This is the “crimping” part of crimped enzyme retting. A 2 Meter by 8 Meter plot of grass that has a high potential for dew production is roped off by laying rope on the ground. This plot is then separated into 4 2 by 2 Meter adjoining squares (see figure 4). A 2 Kg bundle of crimped flax is spread out in a single layer onto and individual section. This is repeated 3 more times. Each plot is then labeled O, T, M, or C. Each treatment will then be covered by the corresponding solution with a spoon.

Monitoring, Finishing, and Testing

Monitoring

What makes retting difficult is that the timing of the retting changes each time depending on many variables such as quality and toughness of the flax, temperature, humidity, availability of dew, and much more. Many flax processors refer to processing flax as an art rather than a science since it takes a skilled retter to make the call on what is just the right amount of decomposition is to free but not rot the fibers.

Each treatment should be checked on daily until the right amount of decomposition has been attained (the fibers should be separating from the stalks, but not decomposing themselves). When each process has run its course and the right amount of decomposition has been met, the flax is rinsed and dried by the sun.

Finishing

Each treatment will then be separately dressed following the traditional methods (as the machines that typically dress flax can not handle such a small batch): breaking (breaks up the straw into short segments) scutching (removes most of the the straw from the fiber) and heckling (pulling the fiber through various sizes of heckling combs which separate the coarser tow fibers from the fine line fibers. This fiber is then spun into a 2 ply balanced yarn. The process is repeated until all treatments are in the form of yarn.

Testing

Observations of the fibers are done based on the final yarns. Thy will be judged based on color, softness, micron count (thickness of individual fibers), and tensile strength. The tensile strength will be tested by hanging different weights from 1M of yarn until it breaks.

If the fibers that were retted with the aid of enzymes are at the same grade or better than the control fibers, and the retting was faster than the control, the experiment will be considered successful.

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