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Date: 7-18-2019
Adventures down the silken rabbit-hole road

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August, 2017
**ABSTRACT**

Silk is a highly prized and sought after fiber. It is extremely strong, soft, warm, and lustrous. These are the exact qualities that drive the market and causes silk to fetch such high prices. A feasibility study of growing your own silk at home was done to explore the cost and time involved as a means to reduce the price of silk; therefore, making silk more affordable and accessible to every hand spinner willing to venture down the silken rabbit-hole road. The study also accesses the viability of home processed silk as opposed to commercial processing operations as an additional weight factor for growing it yourself for a better quality fiber. Our findings were amazingly positives ones but the amount of work involved and time spent did not outweigh the cost, in my opinion, that could be saved by growing your own silk at home. The study was subject to individual income variables between person to person that played a significant role in the mind of each individual willing to spend money over effort and time. Therefore, each individual could argue our results based on work ethic and time versus income.
# Table of Contents

Abstract .................................................................................................................. 2
Introduction ............................................................................................................. 5
Materials and Methods .......................................................................................... 11
Samples ................................................................................................................... 14
Results .................................................................................................................... 119
Conclusion .............................................................................................................. 121
Figure: 1-A silkworm eggs ...................................................................................... 123
Figure: 1-B Silkworm incubator ............................................................................. 123
Figure: 1-C Kegos hatching ................................................................................... 123
Figure: 1-D Medium size tulle .............................................................................. 123
Figure: 1-E Non-slip rug padding .......................................................................... 123
Figure: 1-F Stack of trays with silkworm ............................................................... 124
Figure: 1-G Stack or trays with silkworms showing plastic cover ....................... 124
Figure: 1-H Silkworm Condo’s ............................................................................. 124
Figure: I Silkworm Condo’s .................................................................................. 124
Figure: 1-J Tent/Blaze fibers and cut cocoons ....................................................... 124
Figure: 1-K Homemade Mawata frame ................................................................. 124
Figure: 1-L Handmade Mawata ............................................................................ 125
Figure: 1-O Silk mawata cut into strips ................................................................. 125
Figure 1-P Mawata strips cut into squares ......................................................... 125
Figure: 1-Q Mawata squares carded .................................................................... 123
Figure: 1-M Silk reeling setup .............................................................................. 125
Figure: 1-N Silk reeling bobbin and electric winder ........................................... 125
Appendix .................................................................................................................. 126
Glossary ................................................................................................................... 127
INTRODUCTION

From nearly the beginning of man there has always been a need for wearable garments, and productive tools for making them. According to Genesis 3-7, (Rainbow Study Bible, 1992, p6) once Adam and Eve’s eyes became open to the knowledge of good and evil, they “knew” they were naked. They then fasted themselves aprons sewn together of fig leaves to ease their conscious minds of their nakedness (Rainbow Study Bible, 1992, Genesis 3-7, p.6). Though mention was not made to the actual type of thread they used to sew these leaves together, the knowledge gained must have abled them to sew, and therefore, can be concluded, they must have learned to make thread of some kind, as well. Shortly after...the Lord God also made coats of skins, to cloth them as well, according to Genesis 3-21 (Rainbow Study Bible, Genesis 3-21, 1992, p.7). Living in the utopic environment protected by God where no clothing or provisions were previously needed, there was therefore no thought placed on them. Things all changed from the day they took of the forbidden fruit and began to eat...the gate to the utopic “Garden of Eden” was then closed.

“Therefore the Lord God sent him forth from the garden of Eden, to till the ground from whence he was taken. So he drove out the man; and he placed at the east of the garden of Eden Cherubims, and a flaming sword which turned every way, to keep the way of the tree of life” (Rainbow Study Bible, 1992, Genesis 3: 23-24, p.7).

They then instantly became subject to the elements of the earth and a need to simply survive was created. All focus was then directed toward making tools for protection from the elements and procuring food to sustain life, which brought a new focus on fibers as a tool to ease the everyday labors of life.
Hot, cold, sun, rain, wind, dirt, insects, and many other factors drove man to search out ways to win a war against the environmental conditions causing him stress, pain, fatigue, hunger, and all the ailments we wish to avoid and the joys we wish to welcome and promote today. Great amounts of energy were placed on looking for ways to make clothing for warmth from the cold, and shade from the heat. Ropes were created for pulling, nets for catching food to ease hunger, tents for cover and protection, dressings to help wounds heal, filters for clean fresh water, and bags to carry produce. The needs were great and the crude inventions were surely all but comfortable. In the beginning, pure necessity would have been the driving force of all the new inventions designed to help ease the harsh conditions faced. But, as time lapsed and basic necessities became met, man would have looked for ways to improve upon their inventions that would add comfort and style in addition to function. From the fig leaf, to the animal skins, to today's modern day luxuries, man has certainly come a long way. Though many luxuries have been achieved, like, tents to homes, rocks to wheels, camp fire to gas stove, and horseback to cars, our focus in this study is on the improvement made and production gained by the invention of the silk industry and the founding of the silk fiber. We may never know what the thread Adam and Eve used to sew those first fig leaf aprons together was, but one thing that must have existed from the beginning of creation would have been the silk worm and its pupa, nestled within a purse-like 'pot of gold' cocoon made of silk fiber.

Silk is a fiber that was discovered way before 2600 BC, we know this because the silk industry was already well underway at this time, records show that Shangtun, China, was paying tribute to a north-Indian power in silk by 2200 BC and therefore had been processing it for many past years. These records, however, according to Robson and Ekarius (2011), are likely going to change due to the recent advancement in DNA analysis and the use of perishable arts in the
What we do know is that the secret of silk production was slow to travel and only did due to smuggling of the information out of the country to other areas such as one Chinese princess did by hiding the silkworm eggs in her headdress, and how two monks also did this by stashing them in their walking stick, crime punishable by death (Bush, 1993). According to ThoughtCo.com, it was Emperor Huang Di (Wu-di or Huang Ti), the Yellow Emperor’s wife Xilingshi (Lei-tzu or Si Ling-chi) that actually discovered silk. It is said that she was in her garden picking some cocoons from a mulberry tree and somehow accidentally dropped one into her hot cup of tea at some point and then realized, as she picked it up, that it unwound as one long continuous thread. Her husband then took those discoveries and built a nearly 2,000 year monopoly on silk production before its secrets escaped across the land and into other countries. Knowing that silk originated in China and that Emperor Huang Di is credited as the founder of the Chinese nation, ruling from 2698 BC to 2599 BC, according to Margaret River Silk Road.com, it would be safe to say, once putting all of these pieces of the puzzle together, that silk would have been founded during this timeframe if it was in fact discovered by Huang Di’s wife, Lei-tzu, to which she put this extraordinary fiber to good use by weaving it into a ceremonial robe for the Emperor (Thought.com, ND). One can only imagine that magical moment when Lei-tzu first found out a silk cocoon that had been submerged into hot liquid would become a single continuous thread and that also, once the liquid silk had melted and let loose of a single continuously wound thread, that it could be used for an innumerable amount of products. So, what all is it that makes silk such a desirable fiber to man? Its luster, good moisture absorption, warmth, elasticity, strength, and durability, of course!

To retain silks maximum luster it should be combed, the spun fibers need to be balanced, and the degumming temperatures must remain at or below 180 degrees. When washing silk you
must also be sure to never use greater than a two percent solution of soda ash, due to its alkaline
damaging effects on the protein silk fibers. This solution must also be washed out right away.
Never use chlorine bleach to wash silk either as it will dissolve the silk. Do not place the silk
under ultraviolet rays. Ultraviolet rays tend to destroy the silk fibers and are one reason not to
use this method to stifle the cocoons to be reeled but rather heat or freeze them instead (Olds,
2013).

Silk can absorb nearly 30% of its dry weight without feeling wet. This quality would
have been an extraordinary benefit when trying to keep from getting damp during the cold winter
months, or even for storage of perishable items that could develop mold or mildew and quickly
become ruined. Silk is highly resistant to molds and mildew but perspiration will discolor and
weaken the silk fiber. The wool moths tend to stay away from silk but silverfish and carpet
beetles will eat it at times. Today, this quality of moisture absorption is prized in the dyeing of
the fibers, as the moisture absorption takes up the dye readily for vibrant and consistent colors
(Olds, 2013).

The elasticity of silk is also quite good but it still has less elasticity than wool. It can
stretch between 10 to 20% of its length when dry but if stretched farther than that it will not
return back to its original length. When wet it can stretch approximately 30 to 35% its length.
This quality silk has to stretch is utilized in the fabric industry for warps when weaving. It can
also add elasticity to non-elastic fibers such as alpaca and cotton. Silk is warmer than wool, is the
lightest yet strongest fiber, and is very durable. All these facts on silk can be confirmed by the
olds college level three workbook (Olds, 2013).

As a spinner, many are obsessed with trying their hand at producing a barrage of fibers to
help offset the cost of the commercially bought and processed ones. Their love of animals has
Silk Feasibility Study

one raising sheep, angora goats, rabbits, alpacas, Llamas and more. The plant world also has a host of fibers to produce as well, like, cotton, flax, nettle, ramie, and bamboo. With the animals, come harsh winters, muddy springs, feeding chores, mucking stalls, medications, vaccinations, some large feed bills, and home birthing that is sometimes meet with heartache. The plant fibers help to avoid many of these harsh conditions. No messy stalls, routine feedings, shots or vaccinations, but best of all... no three am wellness checks. Simply order the seeds, till the ground, wait for God to make it rain, and watch them grow. All the production of the plant fiber is fairly easy, but the processing gets beyond a bit stinky. The retting/rotting in small ponds of stagnant water creates a stink on the hands like no other. The molds growing on the plants as they break down the outer core of the plant, this doesn’t appeal to one’s health much at all either. And the plants don’t have quite what it takes to fill the heart with that loving lively nature the animals do. And so... I introduced you to silk!

Silk is such a beautiful, soft, lustrous, and strong fiber, but wow is it ever expensive. So began a need for exploration in how it is made. The liquid silk, called sericin, is what holds together the two threads, called brines, that make up a single filament of silk, called a bave, once it exits the spinneret (Gaddum, 1979). Alden Amos informs us that nearly 25% of silks weight in the raw stage is sericin (Alden, 2001). This sericin requires hot temperatures just below the boiling point to liquefy it again and release the brave from its figure eight solid structure and allow it to become one single continuous thread. The cocoon is the waste product after the silkworm has metamorphed into a moth and left the security from within, to procure a mate, deposit eggs or sperm, and then die shortly thereafter (Sylvia, 1982). The female moth can lay between 250-500 eggs after fertilization, depending on her vigor, which is influenced by the conditions during rearing. The eggs either hatch a few weeks after being laid, if they are
polyvoltine, or they will hibernate until they are exposed to a long cold winter period, if they are monovoltine (Gaddum, 1979). Once the eggs start to incubate it takes approximately 14-21 days for them to hatch, this does vary and is dependent on how many days they were able to incubate before they began hibernation, if they hibernate at all, which eggs from the polyvoltine moths don’t (Sylvia, 1982). Temperatures can also alter the speed in the hatching.

There are five stages in a silkworm’s lifecycle, called instar (Wormspit, N.D.). The egg stage is stage one of the life cycle. Stage two begins after the larva, also known as a Kigo, hatches (Kite, 1997). At birth the kego is approximately 3mm long with hair and is black in color. After the third, fourth, and during the fifth instar the silkworm will eat 80% of what it ate during the entire larva stages one through four and will weigh 10,000 times more than when hatched (Sylvia, 1982). During this stage the silkworm stops eating and starts winding its cocoon. The cocoon is nearly one mile long and takes approximately two days to complete (Sylvia, 1982). After about seven days the pupa must be killed so that it will not emerge and destroy the single continuous thread. This is done either by heating or freezing the cocoon. If the pupa is not killed it will hatch and immediately mate and the female will shortly after start laying eggs. Usually several cocoons are allowed to hatch to replace the eggs that were previously used to make the silk. So began this feasibility study to determine if home reared silk could offset the high cost of store-bought silk without losing the quality of a commercially made product.
Materials and Methods

Silkworm eggs/seeds were ordered from Mulberyfarms.com, approximately 2,000 of them, see Figure 1-A for silkworm eggs. After arrival the eggs were placed in incubators made of a plastic box with a Pyrex pan inside, see Figure 1-B. Water was placed in the bottom of the plastic box in order to keep the correct moisture and prevent the eggs from drying out. The boxes were placed in a warm dark closet at approximately 80 degrees until the first few kegos were seen hatching, see Figure 1-C. The temperature was regulated by using an electric heater and the humidity was regulated with a room humidifier. A digital humidity detector/meter was used to monitor the humidity. Every morning when it was time for the kegos to hatch they were placed in a lighted area to help entice all the eggs to hatch at the same time. Once the eggs hatched, small diced up segments of mulberry leaves were placed on top of the eggs. After approximately two days of feeding, a sheet of tulle fabric was placed over the worms and more food segments were added to the top of the fabric. It is of great importance to make sure the holes in the fabric are larger than the worms so they can easily crawl through the fabric and reach the new food. After one or two more feedings the kegos should have come to the top and can be lifted to a clean area for this procedure to be repeated. The leftover food and silkworm manure, called frass, can then be easily discarded. As the silkworms grow it is necessary to increase the size of the holes in the fabric by switching the type of fabric used, see Figure 1-D. This insures that none will get trapped in the holes as they grow and are crawling through the fabric to reach the new food. Small size tulle was used first and then a large size before finally switching to non-slip rug padding, see Figure 1-E. The worms were housed on cookie sheet trays and stacked on a baker’s rack that was covered with plastic to retain moisture and help the leaves from drying out too fast, see Figures 1-F and G.
The worms were fed local mulberry leaves from birth until cocooning. Some of the leaves were fed fresh and others were stored in a refrigerator for a few days. The stored leaves were allowed to reach room temperature before feeding to the worms to prevent them from getting sick, due to the cold temperature of the leaves. The worms were fed every four hours during the 24 hour period. They were also kept under continuous light in order to provide more time for eating. When the worms were ready to start cocooning, condos were built using paper towel rolls which were cut into approximately two-inch sections and then folded square and hot glued on top of one another, see Figures 1-H and I for some pictures of a condo with some cocoons in them. The cocoons were left in the condos for seven days and then removed and placed in the freezer to stifle them.

Several methods were utilized to produce silk from the cocoons. First the tent fibers, also known as blaze, were removed from all the cocoons and carded to make rolags and worsted sausages to spin. Second, the cocoons were cut open on one end to remove the pupa and were degummed and turned into Mawata. Procedures described by Kolander were followed for opening the cocoons and the degumming solution and procedures are outlined by Old’s (Kolander, 1985, p.71) (Olds, 2013, p. D-18). See Figure 1-J for some cut open cocoons. The Mawata frame can be made following instructions in the level three Old’s College workbook on page B-14. (Olds, 2013, p. B-14) See Figures 1-K and L for a picture of a Mawata frame and finished Mawata. The cocoons were also used for reeling to make thread such as tram and organzine. For exact procedures followed, refer to -Six Slick Silks- by Michael Cook for making the organzine (Cook, 2012).

The cocoons were heated in temperatures just below boiling for thirty minutes and then reeled using a homemade silk reel which was made by following the instructions outlined at
www.wormspit.com (Wormspit, ND). See Figure 1-M for a picture of the silk reeling system. Approximately 25 cocoons were reeled at a time for a durable enough fiber to re-reel without breakage. Once all the silk was on the bobbin the silk was then re-reeled onto smaller silk bobbins using an electric bobbin winder. See Figure 1-N for a picture of the silk reeling bobbin and electric silk bobbin winder. A span of approximately 25' was left between the bobbins to allow for drying time before the silk thread was wound onto the second bobbin. This procedure was repeated three more times on three more silk bobbins in order to make four filaments to spin into tram and then into organzine. Once the four filaments were reeled onto four separate bobbins they were paced on a lazy kate and spun together to add twist into the fibers. Exact procedures are listed in the sample section under sample#9 Figure 1-D organzine. I made two bobbins of this thread which is called tram. Once the two bobbins of tram were complete I placed them onto a Lazy Kate and spun them again to neutralize the energy in the thread and make the final organzine yarn. The organzine was placed in a heated degumming solution for 30 minutes and then rinsed in warm water and set by slightly snapping it between the wrists before it was hung to dry. The recipe for the degumming solution can be found in the samples section under organzine.

Figure 1-O is an image of first cutting the mawata into long strips, Figure 1-P is the image of what the mawata looks like after cutting into one inch squares. The squares were then placed on hand carders and carded until they were open and evenly aligned on the hand carders as shown in Figure 1-Q. For worsted yarn the fibers were rolled off using the sausage method and for woollen spinning the fibers were rolled into rolags. The fibers were then spun into samples.
Silk Feasibility Study

Samples

Sample: 1

100% Silk Tent fibers Spun woollen

Hand carded into rolags

Spun woollen using supported long-draw technique

Spun “Z”  Plied “S”  3 ply yarn  4.7 TPI
20 WPI  2.0 g  10 yds  34° angle of twist

Count:  \[ \frac{10 \text{ yds} \times 454 \text{ g}}{2.0 \text{ g}} \times 3 \text{ ply} = 8.10 \approx 8s/3 \]

YPP:  \[ 8s \times 840 \text{FW#} = 2,240 \text{ ypp} \]

TEX:  \[ \frac{2.0 \text{ g} \times 1,000}{9 \text{ m}} = 111.11 \approx \text{R111 TEX3} \]

NM:  \[ \frac{9 \text{ m}}{2.0 \text{ g}} = 4.5 \text{ m/g} \]

YPP:  \[ \frac{9 \text{ m} \times 454 \times 1.09 \text{ yds}}{2.0 \text{ g}} = 2,227 \text{ ypp} \]

Suitable end use: scarves, baby blankets, or making ribbon

The outer fibers from a silk cocoon were removed. These fibers are also known as blaze, flossing, strippings, keba, or kibisu fibers. They are coarser than the fiber used to make the inside of the cocoon but are still fine enough to make a next-to-the-skin soft garment. The fibers were hand carded into rolags and then spun woollen using the supported long draw method of spinning. The singles were spun in the clockwise “z” direction at approximately six twists per inch and then plied in the opposite counter-clockwise “s” direction for an approximate five twist per inch, for a three-ply balanced yarn. Equations for finding twist per inch can be found in appendix 1-C. A Kromski Sonata spinning wheel was used with a 18:1 ratio to achieve the maximum twist while using the minimal number of treadles to still remain comfortable while spinning. The woollen style spinning gives the yarn a more matte finish due to the fibers.
orienting in many different directions, thus scattering the light more, so light hits the eye. This disorganized arrangement of fibers does help retain heat better by trapping air in-between the spaces the network of fibers from woollen spinning creates. Other factors contributing to this particular sample’s matte finish is due to a slight overheating beyond the safe $180^\circ$ temperature. Mismeasurement of the washing soda added to the degumming solution which slightly degraded the silk’s outer surface due to a too high pH which was caused by too much base being added to the solution as described by Sara Lamb (Lamb, 2014, p.58). The matte finish would have its benefits though... some silk fibers are very slick and tend to slide around on a surface, with a matte finish the fibers would better stay in place. Some suitable end uses for this fiber would be for scarves, baby blankets, or making ribbon.

The fibers were simmered at approximately $180^\circ$ for 30 minutes and then rinsed in warm well water to gradually reduce the heat. The yarn was then rinsed in warm water and greatly agitated to help set the fibers, balance, and full the yarn. A final rinse was used with a slightly acidic solution to help bring the pH back to neutral. The exact recipe for the 10% acid rinse used can be found in Appendix 31-A. The fibers were then wrung out to remove excess water and snapped between the wrists after being whacked several times on a clean dry towel to help set and full the yarn before it was hung to air dry.
Sample #1: Figure: 1-A is a woven sample swatch of this yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH again, and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix 1-A.

Figure: 1-B is a sample of the raw tent/blaze fibers.

Figure 1-C is a sample of the yarn spun using the sample from Figure 1-B.

Figure 1-D is a knitted sample swatch of the yarn. The sample was washed and set the same as the sample in Figure: 1-A.
Silk Feasibility Study

**Sample: 2**

100% Silk tent fibers Worsted

Hand carded into worsted sausages

Spun worsted using inchworm technique

<table>
<thead>
<tr>
<th>Spun “Z”</th>
<th>Plied “S”</th>
<th>3ply yarn</th>
<th>4 TPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 WPI</td>
<td>2.0 g</td>
<td>10 yds</td>
<td>32° angle of twist</td>
</tr>
</tbody>
</table>

**Count:**

\[
10 \text{ yds} \times \frac{454 \text{ g}}{2.0 \text{ g}} \times 3 \text{ ply} = 8.10 \approx 8s/3
\]

**YPP:**

\[
\frac{8s \times 840 \text{ FW#}}{3 \text{ ply}} = 2,240 \text{ ypp}
\]

**TEX:**

\[
\frac{2.0 \text{ g} \times 1,000}{9 \text{ m}} = 222.22 \approx \text{R222 TEX3}
\]

**NM:**

\[
\frac{9 \text{ m}}{2.0 \text{ g}} = 4.5 \text{ m/g}
\]

**YPP:**

\[
\frac{9 \text{ m} \times 454 \times 1.09 \text{ yds}}{2.0 \text{ g}} = 2,227 \text{ ypp}
\]

Suitable end use: doilies, curtains, scarves, or a long robe

The outer fibers from a silk cocoon were removed. These fibers are also known as blaze, flossing, strippings, keba, or kibisu fibers. They are coarser than the fiber used to make the inside of the cocoon but are still fine enough to make a next-to-the-skin soft garment as well. The fibers were hand carded into worsted sausages and then spun using the worsted method of spinning using the inchworm technique with an approximate two-inch draft. The worsted style spinning gives the yarn a more lustrous finish due to the fibers orienting in the same direction and thus scattering the light in the same direction, so more light hits the eye. This organized arrangement of fibers loses its heat trapping ability because there is no air space between the parallel alignment of fiber which the worsted spinning creates. The singles were spun in the clockwise “z” direction at approximately five twists per inch and then plied in the opposite counterclockwise “s” direction for an approximate four twists per inch for a three-ply balanced yarn.
Equations for finding twist per inch can be found in Appendix 1-C. A Kromski Sonata spinning wheel was used with an 18:1 ratio to achieve the maximum twist while using the minimal number of treadles and still remain comfortable while spinning. I do feel this sample could have had more of a gloss finish but a couple factors may have contributed to this particular sample’s more matte finish. That being due to a slight overheating beyond the safe 180° temperature and also a mismeasurement of the washing soda added to the degumming solution which slightly degraded the silk fibers in the too high of a pH solution as described by Sara Lamb (Lamb, 2014, p. 58). The matte finish would have its benefits as well. Some silk fibers are very slick and tend to slide around on a surface. With a matte finish the fibers would better stay in place. A suitable end use for this fiber would be for doilies, curtains, scarves, or a long robe.

The fibers were simmered at approximately 180° for 30 minutes and then rinsed in warm well water to gradually reduce the heat. The yarn was then rinsed in warm water; no agitation was used to help prevent disruption of the parallel fibers. A final rinse was used with a slightly acidic solution to help bring the pH back to neutral. For the exact recipe for the 10% acid rinse used see Appendix 1-A. The fibers were then wrung out to remove excess water and snapped between the wrists and then hung to air dry.
Silk Feasibility Study

Sample #2: Figure 1-A is a woven sample swatch of this yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in Appendix 1-A.

Figure 1-B is a sample of the raw tent/blaze fibers.

Figure 1-C is a sample of the yarn spun using the sample from Figure 1-B.

Figure 1-D is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in Figure 1-A.
Sample 3

100% Silk Woollen

Hand carded into rolags
Spun woollen using supported long-draw technique

<table>
<thead>
<tr>
<th>Spun “Z”</th>
<th>Plied “S”</th>
<th>2 ply yarn</th>
<th>6 TPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 WPI</td>
<td>4.0 g</td>
<td>10 yds</td>
<td>30° angle of twist</td>
</tr>
</tbody>
</table>

Count: \[
\frac{10 \text{ yds} \times 454 \text{ g}}{4.0 \text{ g}} \times 2 \text{ ply} = 2.70 \approx 3s/2
\]

YPP: \[
3s \times \frac{840 \text{ FW#}}{2 \text{ ply}} = 1,260 \text{ ypp}
\]

TEX: \[
\frac{4.0 \text{ g} \times 1,000}{9 \text{ m}} = 444.44 \approx R444 \text{ TEX2}
\]

NM: \[
\frac{9 \text{ m}}{4.0 \text{ g}} = 2.25 \text{ m/g}
\]

YPP: \[
\frac{9 \text{ m} \times 454 \times 1.09 \text{ yds}}{4.0 \text{ g}} = 1,113 \text{ ypp}
\]

Suitable end use: pillow slips, bed covers, or woven fabrics

The yarn was spun yarn using commercially prepared silk top. The fiber was hand carded into rolags and spun woollen using the supported long-draw method of spinning. The singles were spun in the clockwise “z” direction at approximately eight twists per inch and then plied counter-clockwise “s” direction at approximately six twists per inch for a balanced two ply yarn. Equations for finding twist per inch can be found in appendix 1-C. A Kromski Sonata spinning wheel was used with a 12:1 ratio to achieve the maximum twist while using the minimal number of treadles to still remain comfortable while spinning. The yarn was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH and greatly agitated to help set the fibers, balance, and full the yarn. An exact recipe for the washing solution can be found in Appendix 1-B. A final rinse was used with a slightly acidic solution to help bring the pH back to neutral. For the exact recipe of the 10% acid rinse used see Appendix 1-A. The
fibers were then wrung out to remove excess water and snapped between the wrists after being whacked several times on a clean dry towel to help set and full the yarn before it was hung to air dry.

**Sample #3: Figure: 1-A** is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and 2 percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe of the 10% acid rinse can be found in appendix 1-A.

**Figure: 1-B** is a sample of a commercially prepared silk fiber. This sample is combed Bombyx top.

**Figure 1-C** is a sample of the yarn spun using the sample from **Figure 1-B**.

**Figure 1-D** is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in **Figure: 1-A**.

The woollen spinning technique gave this yarn great loft for maximum heat retention. Some of the luster is lost using this spinning technique but it still does have ample shine. The feel is soft and the fiber is not too slick. The drape is good and this yarn would make excellent pillow slips, bed covers, or woven fabrics.
Hand carded into sausages
Spun worsted using inchworm technique
Spun “Z”  Plied “S”  2 ply yarn  6.3 TPI
18 WPI  3.2 g  10 yds  25° angle of twist

Count: \[ \frac{10 \text{ yds} \times 454 \text{ g} \times 2 \text{ ply}}{3.2 \text{ g}} = \frac{3.37}{840 \text{ FW#}} \approx 4s/2 \]
YPP: \[ \frac{4s \times 840 \text{ FW#}}{2 \text{ ply}} = 1,680 \text{ ypp} \]
TEX: \[ \frac{3.2 \text{ g} \times 1,000}{9 \text{ m}} = 355.55 \approx \text{ R356 TEX2} \]
NM: \[ \frac{9 \text{ m}}{3.2 \text{ g}} = 2.8 \text{ m/g} \]
YPP: \[ \frac{9 \text{ m} \times 454 \times 1.09 \text{ yds}}{3.2 \text{ g}} = 1,392 \text{ ypp} \]

Suitable end use: woven dinner napkins, knit a wedding garter, or perhaps a pair of gloves

This yarn was spun using commercially prepared silk top, hand carded into worsted sausages, and spun worsted method of spinning using the inchworm technique with an approximate two-inch draft length. The singles were spun in the clockwise “z” direction at approximately eight twists per inch and then plied counter-clockwise “s” direction at approximately six twists per inch for a balanced two ply yarn. Equations for finding twist per inch can be found in appendix 1-C. A Kromski Sonata spinning wheel was used with a 12:1 ratio to achieve the maximum twist while using the minimal number of treadles and still remain comfortable while spinning. The yarn was then washed in warm soapy water using dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. No agitation was used to help prevent disruption of the parallel fibers. A final rinse was used with a slightly acidic solution to help bring the pH back to neutral. For the exact recipe of the 10% acid rinse used see Appendix 1-A. The fibers were then
wrung out to remove excess water and snapped between the wrists to help set the yarn before it was hung to air dry.

The worsted spinning technique created a very lustrous yarn with excellent drape. My choice for this yarn would be to weave some dinner napkins, knit a wedding garter, or perhaps a pair of gloves.

Sample #4: Figure: 1-A is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix 1-A.

Figure: 1-B is a sample of a commercially prepared silk fiber. This sample is combed Bombyx top.

Figure 1Cc is a sample of the yarn spun using the sample from Figure 1-B.

Figure 1-D is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in Figure: 1-A.
Sample #4

Figure 1-A

Figure 1-B

Figure 1-C

Figure 1-D
Silk Feasibility Study

Sample: 5

100% Silk from Mawata (Hankies) Worsted

Hand carded into sausages
Spun worsted using the inchworm technique
Spun “Z”  Plied “S”  3 ply yarn  5.5 TPI
18 WPI  2.6 g  10 yds  48° angle of twist

Count:  10 yds x 454 g x 3 ply = 6.23 ≈ 6s/3  
         2.6 g  840 FW#  
YPP:  6s x 840FW# = 1,680 ypp  
                3 ply  
TEX:  2.6 g x 1,000 = 288.88 ≈ R289 TEX3  
                9 m  
NM:  9 m = 3.46 m/g  
         2.6 g  
YPP:  9 m x 454 x 1.09 yds = 1,713 ypp  
         2.6 g

Suitable end use: upholstery, string to tie bundles together, or to crochet Barbie or doll clothing

The cocoons were first turned into Mawata by following procedures outlined in Olds College Level three workbook (Olds, 2013, p.14). They were soaked in a hot but not boiling Orvis paste solution made of ¼ cup of paste and ¼ cup of washing soda to one gallon water. The cocoons were placed on the end of a fork handle before placing them in the water which made them stay submerged and easier to remove from the hot water without losing the opening. This makes it easier to stretch the cocoon over the frame after it has softened. The cocoons were worked open with the fingers from the opening where the silk moth had emerged and the fork handle was inserted. The cocoon was then stretched over a mawata frame. The frame was constructed following the methods described in paragraph three of the Level Three Olds College workbook (Olds, 2013, p.14). Once several cocoons were placed on the frame they were rinsed in cool tap/well water with a spray nozzle. Finally, they were removed from the frame and placed
on a towel to dry. Once the mawata were dry, they were pulled apart and stretched into fine lengths of fiber and spun on a Kromski Sanata wheel using a 18:1 ratio for maximum twist with minimum treadle that best suits the spinner’s comforts. The fibers were kept parallel by using the worsted spinning technique with approximately a two inch draft length. The singles were spun in the clockwise “z” direction at approximately seven twists per inch and then plied counterclockwise “s” direction at approximately five and a half twists per inch for a balanced three-ply yarn.

The yarn was then simmered at approximately 180° for 30 minutes and then rinsed in warm well water without agitation to gradually reduce the heat and to help preserve the fiber alignment of the yarn. A final rinse was used with a slightly acidic solution to help bring the pH back to neutral. To see the exact recipe for the 10% acid rinse used, see Appendix 1-A. The fiber were then wrung out to remove excess water and snapped between the wrists to help set the yarn before it was hung to air dry. Spinning from a mawata worsted style can be difficult to keep from getting glubs, clumps, or pills in the yarn. You have to expect more texture and less luster to result. The tighter twist in this yarn gives it great durability. A choice end use for this fiber would be for upholstery, string to tie bundles together, or to crochet Barbie or doll clothing.
Sample #5: Figure: 1-A is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and 2% washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix A.

Figure: 1-B Is a sample of the hand made mawata.

Figure 1-C is a sample of the yarn spun using the sample from Figure 1-B.

Figure 1-D is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in Figure: 1-A.

This method of spinning the cocoons and turning them into mawata creates a textured yarn. Pulling the mawata apart into long thin fibers can be hard on the hands if you are not careful. The fibers are very strong and can actually cut the skin.
Silk Feasibility Study

**Sample: 6**

100% Silk from Mawata (Hankies) Woollen

<table>
<thead>
<tr>
<th>Spun “Z”</th>
<th>Plied “S”</th>
<th>3 ply yarn</th>
<th>4 TPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 WPI</td>
<td>2.0 g</td>
<td>10 yds</td>
<td>36° angle of twist</td>
</tr>
</tbody>
</table>

Count:  
10 yds × 454 g × 3 ply = 8.10 ≈ 8s/3  
2.0 g 840 FW#

YPP:  
8s × 840FW# = 2,240 ypp

TEX:  
2.0 g × 1,000 = 111.11 ≈ R111 TEX3

NM:  
9 m = 4.5 m/g

YPP:  
9 m × 454 × 1.09 yds = 2,227 ypp

Suitable end use: My first choice for this fiber would be woven blankets. Scarves, baby clothing, women’s lingerie, and handkerchiefs would be a few other spectacular choices for this yarn.

The cocoons were first turned into Mawata by following procedures outlined in Olds College Level three workb (Olds, 2013, p. 14). The cocoons were soaked in a hot but not boiling Orvis paste solution made of ¼ cup of paste and ¼ cup of washing soda to one gallon water. The cocoons were placed on the end of a fork handle before placing them in the water which made them stay submerged and easier to remove from the hot water without losing the opening. This also makes it easier to stretch the cocoon over the frame after it has softened. The cocoons were worked open with the fingers from the opening where the silk moth had emerged and the fork handle was inserted. The cocoon was then stretched over a mawata frame. The frame was constructed following the methods described by Olds (Olds, 2013, p. 14). Once several cocoons were placed on the frame they were rinsed in cool tap/well water with a spray nozzle. Finally, they were removed from the frame and placed on a towel to dry.

Once the mawata were dry, they were pulled apart and stretched into fine lengths of fiber and
Silk Feasibility Study

spun using the woollen spinning method. The technique used was simply to pull the mawata apart with both hands into long lines of fiber until they were the thickness desired and then let to reel onto the bobbin. A Kromski Sanata wheel was used with a 18:1 ratio for maximum twist with minimum treadle that best suits the spinner’s comforts. The singles were spun in the clockwise “z” direction at approximately five twists per inch and then plied counter-clockwise “s” direction at approximately four twists per inch for a balanced three-ply yarn. The yarn was then simmered at approximately 180° for 30 minutes and then rinsed in warm well water to gradually reduce the heat. Gentle agitation was used to set and help full the yarn. A final rinse was used with a slightly acidic solution in order to help bring the pH back to neutral. To see the exact recipe for the 10% acid rinse used, see Appendix 1-A. The fiber were then wrung out to remove excess water and snapped between the wrists and whacked several times on a dry towel to further set and full the yarn before it was hung to air dry.
Sample #6: **Figure: 1-A** is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix 1-A.

**Figure: 1-B** is a sample of the handmade mawata.

**Figure 1-C** is a sample of the yarn spun using the sample from Figure 1-B.

**Figure 1-D** is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in Figure 1-A.

The silk mawata spun woollen produced an exceptionally soft and delightfully textured yarn to look at. The woollen technique also produced a lofty effect for wonderful heat retaining properties. My first choice for this fiber would be woven blankets, scarves, baby clothing, women's lingerie, and handkerchiefs would be a few other spectacular choices for this yarn.
**Sample: 7**

**100% Silk from cut Hankies Worsted**

<table>
<thead>
<tr>
<th>Spun &quot;Z&quot;</th>
<th>Plied “S”</th>
<th>3 ply yarn</th>
<th>7 TPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 WPI</td>
<td>2.6 g</td>
<td>10 yds</td>
<td>60° angle of twist</td>
</tr>
</tbody>
</table>

Count: \(10 \text{ yds} \times 454 \text{ g} \times 3 \text{ ply} = 6.23 \approx 6s/3\)  
2.6 g \(840 \text{ FW#}\)  
YPP: \(6s \times 840\text{FW#} = 1,680 \text{ ypp}\)  
3 ply  
TEX: \(2.6 \text{ g} \times 1,000 = 288.88 \approx R289\text{TEX}\)  
9 m  
NM: \(9 \text{ m} = 3.46 \text{ m/g}\)  
2.6 g  
YPP: \(9 \text{ m} \times 454 \times 1.09 \text{ yds} = 1,713 \text{ ypp}\)  
2.6 g

**Suitable end use:** sweaters, netting for catching things, or bags

The cocoons were first turned into Mawata by following procedures outlined by Olds (Olds, 2013, p.14). The cocoons were soaked in a hot but not boiling Orvis paste solution made of \(\frac{1}{4}\) cup of paste and \(\frac{1}{4}\) cup of washing soda to one gallon water. The cocoons were placed on the end of a fork handle before placing them in the water which made them stay submerged and easier to remove from the hot water without losing the opening. This also makes it easier to stretch the cocoon over the frame after it has softened. The cocoons were worked open with the fingers from the opening where the silk moth had emerged and the fork handle was inserted. The cocoon was then stretched over a mawata frame. The frame was constructed following the methods described by Olds (Olds, 2013, p.14). Once several cocoons were placed on the frame they were rinsed in cool tap/well water with a spray nozzle. Finally, they were removed from the frame and placed on a towel to dry.

After the mawata were dry they were cut into half-inch squares with a pair of ordinary hand...
scissors. The small cut pieces were then placed on hand carders and carded until the fibers broke loose and became single fibers. Once the fibers were carded until smooth they were rolled into worsted sausages and spun worsted using the inchworm technique with approximately a one inch draft. A Kromski Sanata wheel was used with a 18:1 ratio for maximum twist with minimum treadle that best suits the spinner’s comforts. The singles were spun in the clockwise “z” direction at approximately nine twists per inch and then plied counter-clockwise “s” direction at approximately seven twists per inch for a balanced three-ply yarn. The yarn was then simmered at approximately 180° for 30 minutes and then rinsed in warm well water without agitation to gradually reduce the heat and to help preserve the fiber alignment of the yarn. A final rinse was used with a slightly acidic solution to help bring the pH back to neutral. To see the exact recipe for the 10% acid rinse used, see Appendix 1-A. The fiber were then wrung out to remove excess water and snapped between the wrists before it was hung to air dry.
Sample #7: Figure: 1-A is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix 1-A.

Figure: 1-B is a sample of the handmade cuttings made from mawata.

Figure: 1-C is a sample of the hand carded cut mawata.

Figure 1-D is a sample of the yarn spun using the sample from Figure 1-C.

Figure 1-E is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in Figure: 1-A.

The yarn produced from the cut and carded mawata was very similar to that of the commercial silk top that was spun worsted. The work involved was exceedingly greater but the end product was very much the same. The yarn has ample luster, good drape, very strong, and soft as well. I would consider using this yarn to make sweaters, netting for catching things, or bags for carrying heavy weight items in.
Sample #7

Figure 1-A

Figure 1-B

Figure 1-C

Figure 1-D

Figure 1-E
Hand carded into rolags  
Spun woollen using supported long-draw technique

<table>
<thead>
<tr>
<th>Spun “Z”</th>
<th>Plied “S”</th>
<th>3 ply yarn</th>
<th>6 TPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 WPI</td>
<td>3.0 g</td>
<td>10 yds</td>
<td>39° angle of twist</td>
</tr>
</tbody>
</table>

**Count:**  
\[
10 \text{ yds} \times 454 \text{ g} \times 3 \text{ ply} = 5.40 \approx 5s/3
\]
\[
3.0 \text{ g} \times 840 \text{ FW#}
\]

**YPP:**  
\[
5s \times 840 \text{ FW#} = 1,400 \text{ ypp}
\]
\[
3 \text{ ply}
\]

**TEX:**  
\[
3.0 \text{ g} \times 1,000 = 333.33 \approx R333 \text{ TEX}
\]
\[
9 \text{ m}
\]

**NM:**  
\[
9 \text{ m} = 3.0 \text{ m/g}
\]
\[
3.0 \text{ g}
\]

**YPP:**  
\[
9 \text{ m} \times 454 \times 1.09 \text{ yds} = 1,485 \text{ ypp}
\]
\[
3.0 \text{ g}
\]

Suitable end use: Gauze pads, filters, cheese cloth, hair nets, and stockings

The cocoons were first turned into Mawata by following procedures outlined by Olds (Olds, 2013, p.14). The cocoons were soaked in a hot but not boiling Orvis paste solution made of ¼ cup of paste and ¼ cup of washing soda to one gallon water. The cocoons were placed on the end of a fork handle before placing them in the water which made them stay submerged and easier to remove from the hot water without losing the opening which makes it easier to stretch the cocoon over the frame after it has softened. The cocoons were worked open with the fingers from the opening where the silk moth had emerged and the fork handle was inserted. The cocoon was then stretched over a mawata frame. The frame was constructed following the methods described by Olds (Olds, 2013, p.14). Once several cocoons were placed on the frame they were rinsed in cool tap/well water with a spray nozzle. Finally, they were removed from the frame and placed on a towel to dry.
After the mawata were dry they were cut into half-inch squares with a pair of ordinary hand scissors. The small cut pieces were then placed on hand carders and carded until the fibers broke loose and became single fibers. Once the fibers were carded until smooth they were rolled into rolags and spun woollen using the supported long draw spinning technique. A Kromski Sanata wheel was used with a 18:1 ratio for maximum twist with minimum treadle that best suits the spinner’s comforts. The singles were spun in the clockwise in the “z” direction at approximately eight twists per inch and then plied counter-clockwise “s” direction at approximately six twists per inch for a balanced three-ply yarn. The yarn was then simmered at approximately 180° for 30 minutes and then rinsed in warm well water to gradually reduce the heat. Gentle agitation was used to set and help full the yarn. A final rinse was used with a slightly acidic solution to help bring the pH back to neutral. To see the exact recipe for the 10% acid rinse used, see Appendix 1-A. The fiber were then wrung out to remove excess water and snapped between the wrists and whacked several times on a dry towel to further set and full the yarn before it was hung to air dry.
Silk Feasibility Study

**Sample #8: Figure: 1-A** is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix 1-A.

**Figure: 1-B** is a sample of the handmade cuttings made from mawata.

**Figure: 1-C** is a sample of the hand carded cut mawata.

**Figure 1-D** is a sample of the yarn spun using the sample from **Figure 1-C**.

**Figure 1-E** is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in **Figure: 1-A**.

This sample yarn is not a lustrous as the commercial equivalent but seems to be a loftier yarn and could possibly have better heat retaining properties than the commercial silk carded and spun the same way. Some perfect end uses for this yarn would be hair nets, stockings, cheese cloth, filters, and gauze pads.
Sample: 9

Hand reeled and spun into tram
Tram spun/thrown worsted using inchworm technique

<table>
<thead>
<tr>
<th>Spun “S” Plied “Z”</th>
<th>2 ply yarn</th>
<th>23.5 TPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 WPI</td>
<td>0.5 g</td>
<td>10 yds</td>
</tr>
</tbody>
</table>

Count: $10\text{ yds} \times 454\text{ g} \times 2\text{ ply} = 21.61 \approx 22s/2$

$0.5\text{ g} \\ 840\text{ FW#}$

YPP: $22s \times 840\text{FW#} = 9,240 \text{ ypp}$

TEX: $0.5\text{ g} \times 1,000 = 555.55 \approx R556 \text{TEX2}$

NM: $9\text{ m} = 18.0 \text{ m/g}$

YPP: $9\text{ m} \times 454 \times 1.09 \text{ yds} = 8,907 \text{ ypp}$

Suitable end use: surgical thread, gauze, fishing nets, or parachutes

An in-depth explanation of how the silk was reeled from the cocoons can be found in the materials and methods section of this paper. Please also see Michel Cook’s paper titled Six Slick Silks for more in-depth information on how to reel silk, make tram, and organzine. Here is a brief description of how the yarn was spun (Cook, 2012) The cocoons were reeled onto four different bobbins using a homemade silk reel made ourselves by following instructions on Cook’s website www.wormspit.com (Wormspit, ND). At this stage the reeled silk is called filament. A Lendrum wheel was used with a 40:1 ratio using the very very fast flyer for maximum twist with minimum treadle that best suits the spinner’s comforts. The filament from the four bobbins was then spun together or more correctly, thrown, in the counter-clockwise “s” direction at approximately 35 twists per inch. The four thrown filaments, now called tram, were thrown onto two bobbins after spinning. The two bobbins of tram were then plied in the counter-
Silk Feasibility Study

clockwise "z" direction at approximately 23.5 twists per inch for a high twist organzine yarn.
The organzine was simmered at approximately 180° for 30 minutes and then rinsed in warm well
water without agitation to gradually reduce the heat and to help preserve the fiber alignment of
the yarn. A final rinse was used with a slightly acidic solution to help bring the pH back to
neutral. To see the exact recipe for the 10% acid rinse used, see Appendix 1-A. The fiber were
then wrung out to remove excess water and snapped between the wrists before it was hung to air
dry.

**Sample #9: Figure: 1-A** is a woven sample swatch of the yarn. The sample was woven using a
zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two
percent washing soda to help increase the pH. An exact recipe for the washing solution can be
found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the
pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix
1-A.

**Figure: 1-B** is a sample of the hand reeled silk filament.

**Figure: 1-C** is a sample of a cocoon that is scored in order to lay flat.

**Figure: 1-D** is a sample of tram.

**Figure 1-E** is a sample of the organzine made using the tram from **Figure 1-C**.

**Figure 1-F** is a knitted sample swatch of this thread. This sample was washed and set the same
as the sample in **Figure: 1-A**.

The organzine is a highly lustrous, strong, and warm fiber, when tightly woven it can be
used for parachutes, surgical thread, gauze, or fishing net is also another possibility.
Silk Feasibility Study

Sample: 10

100% Silk Bouclé

Spun worsted using inchworm technique
Core Spun “Z” looping yarn Spun “S” Plied “Z”
Basted yarn spun “Z” Basted “S” 3 ply yarn TPI: NA
12 WPI 7.0 g 10 yds Angle of twist: NA

Count: \[\frac{10 \text{ yds} \times 454 \text{ g}}{3 \text{ ply}} = 2.31 \approx \frac{2s}{3}\]
\[\frac{7.0 \text{ g}}{840 \text{ FW#}}\]

YPP: \[2s \times 840 \text{ FW#} = 560 \text{ ypp}\]

3 ply

TEX: \[\frac{7.0 \text{ g} \times 1,000}{9 \text{ m}} = 777.77 \approx 778 \text{ TEX}3\]

NM: \[\frac{9 \text{ m}}{7.0 \text{ g}} = 1.29 \text{ m/g}\]

YPP: \[\frac{9 \text{ m} \times 454 \times 1.09 \text{ yds}}{7.0 \text{ g}} = 636 \text{ ypp}\]

Suitable end use: Scarves, thrum mittens, jacket liner

The bouclé was made using the organzine in sample: 9 Figure 1-E of this paper. The organzine was used as the core and basting thread. A Kromski Sanata wheel was used with a 18:1 ratio for maximum twist with minimum treadle that best suits the spinner’s comforts. The bouclé was constructed following instructions by Sarah Anderson (Anderson, 2013, p133-135).

The yarn was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The yarn was also greatly agitated during washing to help set the fibers, balance, and full the yarn. A final rinse was used with a slightly acidic solution to help bring the pH back to neutral. For the exact recipe of the 10% acid rinse used see Appendix 1-A. The fibers were then wrung out to remove excess water and snapped between the wrists after being whacked several times on a clean dry towel to help set and full the yarn before it was hung to air dry.
Sample #10: Figure 1-A is a woven sample swatch of the yarn. The sample was woven using a zoom loom. Silk organzine was used as the warp and the Bouclé was used as the weft. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix 1-A.

Figure 1-B is a sample of the yarn spun using the samples from Figure 1-C.

Figure 1-C is a sample of the organzine which was used as the warp, the core, and basting thread. Also pictured is the raw silk top that was spun and used to make the loops in the Bouclé.

Figure 1-D is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in Figure 1-A.

The bouclé is super lusterous, soft, and lofty. The yarn would be a good choice to thrum the inside of some mittens or to make a woven jacket liner. The yarn would work well for a decorative boarder on sweaters or to knit scarves.

The 100% silk was very hard to work with when making the bouclé due to its luster. The slickness of the fibers made the looping strands bunch up at the orifice of the spinning wheel. It was advised to me by Sara herself to be sure and use something other than silk as the core yarn in order to better keep the loops in place.
Sample: 11  

100% Silk bobbin cuttings with added noils

Hand carded into rolags and planked three times
Spun woollen using supported long-draw technique
Spun “Z”  Plied “S”  2 ply yarn  4 TPI
20 WPI  2.5 g  10 yds  31° angle of twist

Count:  
\[
\begin{align*}
10 \text{ yds} \times 454 \text{ g} \times 2 \text{ ply} &= 6.5 \approx 7s/2 \\
2.5 \text{ g} &= 560 \text{ FW#} \\
7s \times 560\text{FW#} &= 1,960 \text{ ypp} \\
2 \text{ ply} &= 277.7 \approx \text{R278 TEX2} \\
9 \text{ m} &= 3.6 \text{ m/g} \\
2.5 \text{ g} &= 9 \text{ m} \\
9 \text{ m} \times 454 \times 1.09 \text{ yds} &= 1,781 \text{ ypp} \\
2.5 \text{ g} &= 2.5 \text{ g}
\end{align*}
\]

YPP:  

Suitable end use: sweater, table runner, scarves, woven blanket

The art yarn in this sample was created using the cuttings off of a silk bobbin. The bobbin had tram on it and was removed by slicing down the bobbin and cutting all the threads. This resulted in approximately two-inch threads of many reeled silk filaments. The filaments were placed onto a pair of hand carders and carded to open up the tram into individual fibers. Once the fibers were pulled apart several tufts of silk noils were added for color and texture and carded slightly more. Care was taken not to hand card the fibers too much as a more artsy look is created without a homogenous blend. Many of the short tram fibers remained in tacked and further added texture and character to the yarn. The fiber was hand carded into rolags and spun woollen using the supported long-draw method of spinning. The singles were spun in the clockwise “z” direction at approximately five twists per inch and then plied counter-clockwise in the “s” direction at approximately four twists per inch for a balanced two ply yarn. Equations for finding
twist per inch can be found in appendix 1-C. A Kromski Sonata spinning wheel was used with a 12:1 ratio to achieve the maximum twist while using the minimal number of treadles to still remain comfortable while spinning. The yarn was then rinsed in warm water and greatly agitated to help set the fibers, balance, and full the yarn. A final rinse was used with a slightly acidic solution to help bring the pH back to neutral. For the exact recipe of the 10% acid rinse used see Appendix 1-A. The fibers were then wrung out to remove excess water and snapped between the wrists after being whacked several times on a clean dry towel to help set and full the yarn before it was hung to air dry.

**Sample #11: Figure: 1-A** is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix 1-A.

**Figure 1-B** is a sample of the yarn spun using the samples from **Figure 1-C**.

**Figure: 1-C** is a sample of the tram and silk noils that were used to make the yarn

**Figure 1-D** is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in **Figure: 1A**.

The yarn turned out better than expected. The noils add color, texture, and a lovely woollen look and feel for great heat retaining qualities. The bobbin cuttings created a really nice visual texture in the yarn as well. This yarn could be used for a sweater, table runner, scarf, or a woven blanket.
Sample #11

Figure: 1-A

Figure: 1-B

Figure: 1-C

Figure: 1-D
Silk Feasibility Study

**Sample: 12**

100% Tussah silk with added silk noils

Hand carded into rolags and planked three times
Spun woollen using supported long-draw technique

<table>
<thead>
<tr>
<th>Spun “Z”</th>
<th>Plied “S”</th>
<th>3 ply yarn</th>
<th>3.6 TPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 WPI</td>
<td>3 g</td>
<td>10 yds</td>
<td>30° angle of twist</td>
</tr>
</tbody>
</table>

Count: $10 \text{ yds} \times 454 \text{ g} \times 3 \text{ ply} = 8.1 \approx 8s/3$

YPP: $8s \times 560 \text{ FW#} = 1,493 \text{ ypp}$

TEX: $3.0 \text{ g} \times 1,000 = 333.3 \approx R333 \text{ TEX3}$

NM: $9 \text{ m} = 3.0 \text{ m/g}$

YPP: $9 \text{ m} \times 454 \times 1.09 \text{ yds} = 1,485 \text{ ypp}$

Suitable end use: woven wall hangings, scarves, shawls, rugs, woven fabrics, or upholstery

The art yarn in this sample was created using tussah silk top and silk noils. The top was placed on the hand cards, carded a few times, and the noils were then placed on top and carded again a few more times. Care was taken not to hand card the fibers too much as a more artsy disorganized look is created without a homogenous blend. The fiber was then rolled into rolags and spun woollen using the supported long-draw method of spinning. The singles were spun in the clockwise “z” direction at approximately five twists per inch and then plied counter-clockwise in the “s” direction at approximately four twists per inch for a balanced three-ply yarn. Equations for finding twist per inch can be found in appendix 1-C. A kromski Sonata spinning wheel was used with an 18:1 ratio to achieve the maximum twist while using the minimal number of treadles to still remain comfortable while spinning. The yarn was then rinsed in warm water and greatly agitated to help set the fibers, balance, and full the yarn. A final rinse
Silk Feasibility Study

was used with a slightly acidic solution to help bring the pH back to neutral. For the exact recipe of the 10% acid rinse used see Appendix 1-A. The fibers were then wrung out to remove excess water and snapped between the wrists after being whacked several times on a clean dry towel to help further set and full the yarn before it was hung to air dry.

The woollen art yarn with silk noils made a beautiful decorative yarn. The silk has strength and durability for hard-wearing fabrics that can be used for upholstery. A colorful rug or wall hanging could be made of this yarn too. The woollen spinning technique also makes it good for any winter garment and silk’s soft feel makes it ideal for next to the skin fabrics.

Sample #12: Figure: 1-A is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix 1-A.

Figure 1-B is a sample of the yarn spun using the samples from Figure 1-C.

Figure: 1-C is a sample of the commercial bombyx silk top and noils used to create this yarn.

Figure 1-D is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in Figure: 1-A.
Hand carded into rolags
Spun woollen using supported long-draw technique
Spun “Z”  Plied “S”  2 ply yarn  4 TPI
16 WPI  4 g  10 yds  24° angle of twist

Count:  
\[
\frac{10 \text{ yds}}{4 \text{ g}} \times \frac{454 \text{ g}}{2 \text{ ply}} = 7.56 \approx 8\text{s/2}
\]

YPP:  
\[
8\text{s} \times \frac{300 \text{ FW#}}{2 \text{ ply}} = 1,200 \text{ ypp}
\]

TEX:  
\[
\frac{4 \text{ g}}{9 \text{ m}} \times \frac{1,000}{1,000} = 444.44 \approx R444 \text{ TEX2}
\]

NM:  
\[
\frac{9 \text{ m}}{4 \text{ g}} = 2.25 \text{ m/g}
\]

YPP:  
\[
\frac{9 \text{ m}}{4 \text{ g}} \times \frac{454 \times 1.09 \text{ yds}}{4 \text{ g}} = 1,113 \text{ ypp}
\]

Suitable end use: hand towels, table clothes, curtains, scarves

The commercial Rayon top was hand carded into roving and spun woollen using the supported long-draw method of spinning. The singles were spun in the clockwise “z” direction at approximately six twists per inch and then plied counter-clockwise in the “s” direction at approximately four twists per inch for a balanced two ply yarn. A Kromski Sonata spinning wheel was used with a 12:1 ratio to achieve the maximum twist while using the minimal number of treadles to still remain comfortable while spinning. The yarn was then washed in warm soapy water using Dawn as the detergent and 2% washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The yarn was greatly agitated to help set the fibers, balance, and full the yarn. A final rinse was used with a slightly acidic solution to help
being whacked several times on a clean dry towel to help set and full the yarn before it was hung to air dry.

**Sample #13: Figure: 1-A** is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix 1-A.

**Figure 1-B** is a sample of the yarn spun using the samples from **Figure 1-C**.

**Figure: 1-C** is a sample of the commercially prepared rayon top.

**Figure 1-D** is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in **Figure: 1-A**.

The rayon produces an exceptionally lustrous fiber that is very soft to the touch and a strong fiber but not as strong as silk. It has good elasticity, is resistant to moths, and bleaches well. I would not recommend this fiber for clothing due to its high flammability, but it would make good towels, table clothes, or curtains.
Silk Feasibility Study

Sample: 14  
50% Rayon / 50% Bombyx Silk Woollen

Hand carded into rolags
Spun woollen using supported long-draw technique

<table>
<thead>
<tr>
<th>Spun “Z”</th>
<th>Plied “S”</th>
<th>2 ply yarn</th>
<th>5 TPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 WPI</td>
<td>4 g</td>
<td>10 yds</td>
<td>40° angle of twist</td>
</tr>
</tbody>
</table>

Count:  
\[
\begin{align*}
10 \text{ yds} &\times 454 \text{ g} \times 2 \text{ ply} = 7.56 \approx 8s/2 \\
4 \text{ g} &\times 300 \text{ FW#} \\
9 \text{ s} &\times 300 \text{ FW#} = 1,350 \text{ ypp} \\
4 \text{ g} &\times 1,000 = 388.88 \approx \text{R444 TEX2} \\
9 \text{ m} &
\end{align*}
\]

YPP:  
\[
\begin{align*}
2 \text{ ply} \\
9 \text{ m} &\times 454 \times 1.09 \text{ yds} = 1,113 \text{ ypp} \\
4 \text{ g} &
\end{align*}
\]

Suitable end use: sweaters, blankets, skirt, or towels

The silk and rayon fibers were both commercially prepared top fibers. They were weighed and then hand carded to make a homogeneous blend. The fibers were planked three times to help increase the evenness of the blend. Once the fibers were carded until smooth they were rolled into rolags and spun woollen using the supported long draw spinning technique. The singles were spun in the clockwise “z” direction at approximately seven and a half twists per inch and then plied counter-clockwise in the “s” direction at approximately five twists per inch for a balanced two ply yarn. Equations for finding twist per inch can be found in appendix 1-C. A Kromski Sonata spinning wheel was used with an 18:1 ratio to achieve the maximum twist while using the minimal number of treadles and still remain comfortable while spinning. The yarn was then washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in
Appendix 1-B. The yarn was greatly agitated to help set the fibers, balance, and full the yarn. A final rinse was used with a slightly acidic solution to help bring the pH back to neutral. For the exact recipe of the 10% acid rinse used see Appendix 1-A. The fibers were then wrung out to remove excess water and snapped between the wrists after being whacked several times on a clean dry towel to help set and full the yarn before it was hung to air dry.

**Sample #14: Figure: 1-A** is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix 1-A.

**Figure 1-A** is a sample of the yarn spun using the samples from **Figure 1-C**.

**Figure: 1-C** Is a sample of the commercially prepared fibers blended woollen

**Figure 1-D** is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in **Figure: 1-A**.

Silk added strength to this blend and reduced the rayon’s tendency to mildew. The two are both good fibers for absorbency and the woollen style spinning creates a lofty yarn with good heat retention. They also both dye well and can make a more uniform color if blended. This blend would make a wonderful sweater, skirt, towels, or blanket.
Sample: 15  
50% Rayon / 50% Bombyx Silk Worsted

Hand carded into sausages  
Spun worsted using inchworm technique

<table>
<thead>
<tr>
<th>Spun “Z”</th>
<th>Plied “S”</th>
<th>2 ply yarn</th>
<th>3.5 TPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 WPI</td>
<td>3.4 g</td>
<td>10 yds</td>
<td>15° angle of twist</td>
</tr>
</tbody>
</table>

Count:  
\[
\text{10 yds} \times \frac{454 \text{ g}}{3.4 \text{ g}} \times 2 \text{ ply} = 4.77 \approx 5s/2 \\
\text{560 FW#} \\
\text{2 ply} \\
\text{3.4 g} \times 1,000 = 377.7 \approx \text{R378 TEX2} \\
\text{9 m} \\
\text{9 m} = 2.65 \text{ m/g} \\
\text{3.4 g} \\
\text{9 m} \times 454 \times 1.9 \text{ yds} = 1,310 \text{ ypp} \\
\text{3.4 g} \\

Suitable end use: over coat, satchels, hair nets, drapery

Commercially prepared fibers of both rayon and silk were used for the blend. The fibers were weighed, planked and hand carded three times for a more homogeneous blend. The fibers were removed from the hand cards by rolling them into worsted sausages and then spun using the worsted method of spinning using the inchworm technique with an approximate two-inch draft. The worsted style spinning gives the yarn a more lustrous finish due to the fibers orienting in the same direction and thus scattering the light in one direction so more light actually hits the eye. This organized arrangement of fibers loses its heat trapping ability because there is no air space between the parallel alignment of the fibers which the worsted spinning creates. The singles were spun in the clockwise “z” direction at approximately five twists per inch and then plied in the opposite counter-clockwise “s” direction for an approximate three and a half twists per inch to create a two ply balanced yarn. Equations for finding twist per inch can be found in appendix 1-
C. A Kromski Sonata spinning wheel was used with a 16:1 ratio to achieve the maximum twist while using the minimal number of treadles and still remain comfortable while spinning. The yarn was then washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. No agitation was used during the wash or rinse to help preserve the fiber alignment. A final rinse was used with a slightly acidic solution to help bring the pH back to neutral. For the exact recipe of the 10% acid rinse used see Appendix 1-A. The fibers were then wrung out to remove excess water to set the yarn before it was hung to air dry.

**Sample #15: Figure: 1-A** is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix 1-A.

**Figure 1-B** is a sample of the yarn spun using the samples from sample 14 Figure 1-A.

**Figure 1-C** is a sample of the two commercially prepared fibers side by side.

**Figure 1-D** is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in **Figure: 1-A**.

The worsted blend of silk and rayon is a lustrous yarn that is super soft with good drape, absorbency, and elasticity. The silk adds some flame retardant to this yarn and therefore would make good clothing for outerwear, upholstery, shawls, hair nets, satchels, and drapery.
Hand carded into sausages
Spun worsted using inchworm technique

Spun “Z” Plied “S” 2 ply yarn 4 TPI
18 WPI 3.8 g 10 yds 31° angle of twist

Count: \(10 \text{ yds} \times \frac{454 \text{ g}}{3.8 \text{ g}} \times \frac{2 \text{ ply}}{560 \text{ FW#}} = 4.26 \approx 4s/2\)

YPP: \(\frac{4s \times 560\text{FW#}}{2 \text{ ply}} = 1,120 \text{ ypp}\)

TEX: \(\frac{3.8 \text{ g} \times 1,000}{9 \text{ m}} = 422 \approx R422 \text{ TEX}2\)

NM: \(\frac{9 \text{ m}}{3.8 \text{ g}} = 2.37 \text{ m/g}\)

YPP: \(\frac{9 \text{ m} \times 454 \times 1.09 \text{ yds}}{3.8 \text{ g}} = 1,172 \text{ ypp}\)

Suitable end use: woven fabric, hand towels, table runners, scarves, straps for handbags

Commercially prepared rayon fiber used to make this yarn. The fibers were hand carded and removed by rolling them into worsted sausages and then spun using the worsted method of spinning using the inchworm technique with an approximate two-inch draft. The worsted style spinning gives the yarn a more lustrous finish due to the fibers orienting in the same direction and thus scattering the light in one direction, so more light actually hits the eye. This organized arrangement of fibers loses its heat trapping ability because there is no air space between the parallel alignment of fiber which the worsted spinning creates. The singles were spun in the clockwise “z” direction at approximately six twists per inch and then plied in the opposite counter-clockwise “s” direction for an approximate four twists per inch to create a two ply balanced yarn. Equations for finding twist per inch can be found in appendix 1-C. A Kromski
Sonata spinning wheel was used with a 16:1 ratio to achieve the maximum twist while using the minimal number of treadles and still remain comfortable while spinning. The yarn was then washed in warm soapy water using dawn as the detergent and two percent washing soda to help increase the pH and greatly agitated to help set the fibers, balance, and full the yarn. An exact recipe for the washing solution can be found in Appendix 1-B. No agitation was used to help prevent disruption of the parallel fibers. A final rinse was used with a slightly acidic solution to help bring the pH back to neutral. For the exact recipe of the 10% acid rinse used see Appendix A. The fibers were then wrung out to remove excess water to help set the yarn before it was hung to air dry.

Sample #16: Figure 1-A is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix 1-A.

Figure 1-B is a sample of the yarn spun using the fibers from sample 14 Figure 1-C.

Figure 1-C is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in Figure 1-A.

The rayon produces an exceptionally lustrous yarn that is very soft to the touch and a strong but not as strong as silk. It has good elasticity and is resistant to moths and bleaches well. I would not recommend this fiber for clothing due to its high flammability but it would make good towels, table clothes, straps for handbags, or curtains.
Hand carded into rolags  
Spun woollen using supported long-draw technique  

Spun “Z”  |  Plied “S”  |  2 ply yarn  |  2.6 TPI  
10 WPI  |  10.4 g  |  10 yds  |  28° angle of twist  

Count: \( \frac{10 \text{ yds} \times 454 \text{ g}}{10.4 \text{ g}} \times 2 \text{ ply} = 2.9 \approx \frac{3}{2} \)  
YPP: \( 3s \times 300 \text{ FW#} = 450 \text{ ypp} \)  
TEX: \( 10.4 \text{ g} \times 1,000 = 1155.55 \approx \frac{R1156 \text{ TEX}}{9 \text{ m}} \)  
NM: \( 9 \text{ m} = .87 \text{ m/g} \)  
YPP: \( \frac{9 \text{ m}}{10.4 \text{ g}} \times 454 \times 1.09 \text{ yds} = 428 \text{ ypp} \)  

Suitable end use: scrubber pads, horse blankets, and rugs

Commercial roving was hand carded into rolags and spun woollen using the supported long-draw method of spinning. The singles were spun in the clockwise “Z” direction at approximately four twists per inch and then plied in the counter-clockwise “S” direction at approximately three twists per inch for a balanced two ply yarn. A kromski Sonata spinning wheel was used with a 6.5:1 ratio to achieve the maximum twist while using the minimal number of treadles to still remain comfortable while spinning. Equations for finding twist per inch can be found in appendix 1-C. The yarn was then washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH and greatly agitated to help set the fibers, balance, and full the yarn. An exact recipe for the washing solution can be found in Appendix 1-B. A final rinse was used with a slightly acidic solution to help bring the pH back to neutral. For the exact recipe of the 10% acid rinse used see Appendix 1-A. The fibers were then
wrung out to remove excess water and snapped between the wrists after being whacked several times on a clean dry towel to help set and full the yarn before it was hung to air dry.

**Sample #17: Figure: 1-A** is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix 1-A.

**Figure 1-B** is a sample of the yarn spun using the fibers from **Figure 1-C**.

**Figure: 1-C** Is a sample of the commercially processed roving.

**Figure 1-D** is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in **Figure: 1-A**.

Woollen spun camel hair makes a very hard wearing yarn. It is inelastic and strong. The woven or knit samples would make wonderful animal blankets or saddle pads. The woollen fiber alignment would make excellent filters for separating partials from liquids. The fibers were easy to spin and the long staple length made it nice for drafting using the long-draw method. The fibers are very coarse to the touch and would not be suitable for next to the skin garments but could be knit into a scrubber pad for exfoliating the skin, for cleaning, use it for rugs or even horse blankets.
Hand carded into rolags
Spun woollen using supported long-draw technique

Spun "Z"  Plied "S"  2 ply yarn  2.5 TPI
15 WPI   4.3 g     10 yds    27° angle of twist

Count:  
10 yds x 454 g x 2 ply = 7.03 ≈ 7s/2
4.3 g     300 FW#

YPP: 
7s x 300FW# = 1,050 ypp
2 ply

TEX: 
4.3 g x 1,000 = 477 ≈ R477 TEX2
9 m

NM: 
9 m = 2.09 m/g
4.3 g

YPP: 
9 m x 454 x 1.09 yds = 1,805 ypp
4.3 g

Suitable end use: Picnic blanket, basket liner, ropes, straps

The silk and camel fibers were both commercially prepared fibers. They were weighed and then hand carded to make a homogeneous blend. The fibers were planked and carded three times to help increase the evenness of the blend. Once the fibers were carded until smooth, they were rolled into rolags, and spun woollen using the supported long draw spinning technique. The singles were spun in the clockwise "z" direction at approximately four twists per inch and then plied counter-clockwise in the "s" direction at approximately two and a half twists per inch for a balanced two ply yarn. A Kromski Sonata spinning wheel was used with a 12:1 ratio to achieve the maximum twist while using the minimal number of treadles and still remain comfortable while spinning. Equations for finding twist per inch can be found in appendix 1-C. The yarn was then washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B.
The yarn was greatly agitated to help set the fibers, balance, and full the yarn. A final rinse was used with a slightly acidic solution in order to help bring the pH back to neutral. For the exact recipe of the 10% acid rinse used see Appendix 1-A. The fibers were then wrung out in order to remove excess water and snapped between the wrists after being whacked several times on a clean dry towel to help set and full the yarn before it was hung to air dry.

**Sample #18 Figure: 1-A** is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix 1-A.

**Figure 1-B** is a sample of the yarn spun using the samples from **Figure 1-C**.

**Figure: 1-C** Is a sample of the commercially prepared fibers blended together woollen

**Figure 1-D** is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in **Figure: 1-A**.

The silk gave the blend a feel dramatically softer and increased the drape and shine. This yarn by no means is next to the skin soft but has a much better feel than the 100% woollen camel hair. It is still a very hard wearing fiber that can be used for a picnic blanket or a basket liner. It could be used to make ropes or straps for pulling as well.
Hand carded into sausages  
Spun worsted using inchworm technique  

<table>
<thead>
<tr>
<th>Spun “Z”</th>
<th>Plied “S”</th>
<th>2 ply yarn</th>
<th>3.5 TPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 WPI</td>
<td>3.8 g</td>
<td>10 yds</td>
<td>22° angle of twist</td>
</tr>
</tbody>
</table>

Count: \[
\frac{10 \text{ yds} \times 454 \text{ g}}{3.8 \text{ g}} \times 2 \text{ ply} = 4.266 \approx 4s/2
\]

YPP: \[
4s \times 560 \text{FW#} = 1,120 \text{ ypp}
\]

TEX: \[
\frac{3.8 \text{ g} \times 1,000}{9 \text{ m}} = 422 \approx \text{R422 TEX2}
\]

NM: \[
\frac{9 \text{ m}}{3.8 \text{ g}} = 2.4 \text{ m/g}
\]

YPP: \[
\frac{9 \text{ m} \times 454 \times 1.9 \text{ yds}}{3.8 \text{ g}} = 1,172 \text{ ypp}
\]

Suitable end use: Jacket or work pants with a soft lining, conveyor belting, straps for pulling

Commercially prepared fibers of both the camel and bombyx silk top were used for this blend. The fibers were weighed, hand carded, and planked three times for a more homogeneous blend. The fibers were removed from the hand cards by rolling them into worsted sausages and then spun using the worsted method of spinning using the inchworm technique with an approximate two-inch draft. The worsted style spinning gives the yarn a more lustrous finish due to the fibers orienting in the same direction and thus scattering the light in one direction so more light actually hits the eye. This organized arrangement of fibers loses its heat trapping ability because there is no air space between the parallel fibers which the worsted spinning creates. The singles were spun in the clockwise “z” direction at approximately five twists per inch and then plied in the opposite counter-clockwise “s” direction for an approximate three and a half twists per inch to create a two ply balanced yarn. Equations for finding twist per inch can be found in
appendix 1-C. A Kromski Sonata spinning wheel was used with a 12:1 ratio to achieve the maximum twist while using the minimal number of treadles and still remain comfortable while spinning. The yarn was then washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. No agitation was used to help prevent disruption of the parallel fibers. A final rinse was used with a slightly acidic solution to help bring the pH back to neutral. For the exact recipe of the 10% acid rinse used see Appendix 1-A. The fibers were then wrung out to remove excess water and snapped between the wrists to help set the yarn before it was hung to air dry.
Sample #19: Figure: 1-A is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix 1-A.

Figure 1-B is a sample of the yarn spun using the same blend as sample 18 Figure 1-C, but with a worsted prep.

Figure 1-C is a sample of the two commercially prepared fibers next to each other unblended.

Figure 1-D is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in Figure: 1-A.

The blend is extremely strong. The silk increased the luster and drape of the camel hair. This would be a nice blend to use for a jacket or work pants with a soft lining, or could be used to make belting for a conveyor if need, also.
Sample #19

Figure: 1-A

Silk → Camel

Figure: 1-C

Figure: 1-B

Figure: 1-D
Hand carded into sausages
Spun worsted using inchworm technique
Spun “Z”  Plied “S”  2 ply yarn  3 TPI
11 WPI  8.4 g  10 yds  32° angle of twist

Count:  \(\frac{10 \text{ yds} \times 454 \text{ g}}{8.4 \text{ g}} \times 2 \text{ ply} = 1.9 \approx 2s/2\)

YPP:  \(2s \times 560 \text{FW#} = 560 \text{ ypp}\)

TEX:  \(8.4 \text{ g} \times 1,000 = 933 \approx R933 \text{ TEX2}\)

NM:  \(\frac{9 \text{ m}}{8.4 \text{ g}} = 1.07 \text{ m/g}\)

YPP:  \(9 \text{ m} \times 454 \times 1.09 \text{ yds} = 530 \text{ ypp}\)

Suitable end use: surface scrubbers, harnesses, saddle pads, or reins

The yarn was spun using commercially prepared roving. The fibers were hand carded and removed from the cards by rolling them into worsted sausages and then spun using the worsted method of spinning using the inchworm technique, with an approximate two-inch draft. The worsted style spinning gives the yarn a more smooth and shiny finish due to the fibers orienting in the same direction and thus scattering the light in one direction so more light hits the eye. This organized arrangement of fibers loses its heat trapping ability because there is no air space between the parallel fibers, which the worsted spinning creates. The singles were spun in the clockwise “z” direction at approximately four and a half twists per inch and then plied in the opposite counter-clockwise “s” direction for an approximate three twists per inch to create a two ply balanced yarn. Equations for finding twist per inch can be found in appendix 1-C. A Kromski Sonata spinning wheel was used with a 6.5:1 ratio to achieve the maximum twist while using the
minimal number of treadles and still remain comfortable while spinning. The yarn was then
washed in warm soapy water using Dawn as the detergent and two percent washing soda to help
increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. No
agitation was used in order to help prevent disruption of the parallel fibers. A final rinse was
used with a slightly acidic solution to help bring the pH back to neutral. For the exact recipe of
the 10% acid rinse used see Appendix 1-A. The fibers were then wrung out to remove excess
water and snapped between the wrists to help set the yarn before it was hung to air dry.

Sample #20: Figure: 1-A is a woven sample swatch of the yarn. The sample was woven using a
zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two
percent washing soda to help increase the pH. An exact recipe for the washing solution can be
found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the
pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix
1-A.

Figure 1-B is a sample of the yarn spun using camel fiber with a worsted prep.

Figure: 1-C is a knitted sample swatch of this yarn. This sample was washed and set the same as
the sample in Figure: 1-A.

This yarn is a very durable yarn that is inelastic and coarse to the touch. It is a strong
fiber that would be hard wearing for harness, saddle pads, reins, hot pads, or surface scrubbers.
Silk Feasibility Study

Sample: 21  

Hand carded into rolags
Spun woollen using supported long-draw technique

<table>
<thead>
<tr>
<th></th>
<th>Spun “Z”</th>
<th>Plied “S”</th>
<th>2ply yarn</th>
<th>5.3 TPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 WPI</td>
<td>8 g</td>
<td>10 yds</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>27° angle of twist</td>
</tr>
</tbody>
</table>

Count:

\[
\text{YPP: } \frac{10 \text{ yds} \times 454 \text{ g} \times 2 \text{ ply}}{8.0 \text{ g} \times 300 \text{ FW#}} = 3.78 \approx 4s/2
\]

YPP:

\[
\frac{4s \times 300\text{FW#}}{2 \text{ ply}} = 600 \text{ ypp}
\]

TEX:

\[
\frac{8.0 \text{ g} \times 1,000}{9 \text{ m}} = 888.8 \approx \text{R888 TEX2}
\]

NM:

\[
\frac{9 \text{ m}}{8.0 \text{ g}} = 1.13 \text{ m/g}
\]

YPP:

\[
\frac{9 \text{ m} \times 454 \times 1.09 \text{ yds}}{8.0 \text{ g}} = 557 \text{ ypp}
\]

Suitable end use: towels, filters, ropes, and scrubber sponges

Commercial hemp roving was hand carded into rolags and spun woollen using the supported long-draw method of spinning. The singles were spun in the clockwise “z” direction at approximately seven and a half twists per inch and then plied in the counter-clockwise “s” direction at approximately five twists per inch for a balanced two ply yarn. Equations for finding twist per inch can be found in appendix 1-C. A Kromski Sonata spinning wheel was used with a 6.5:1 ratio to achieve the maximum twist while using the minimal number of treadles to still remain comfortable while spinning. The yarn was then washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH as hemp cannot tolerate acidic conditions (Gaustad, 2014). An exact recipe for the washing solution can be found in Appendix 1-B. The fibers were then wrung out to remove excess water and snapped between the wrists after being whacked several times on a clean dry towel to help set and full the yarn before

81
it was hung to air dry. Hemp fiber spun woollen is a soft fiber that can be worn next to the skin. It also gets softer and softer with each washing. Hemp is three times stronger than cotton and is very durable and absorbent. It dyes well and is resistant to mold, mildew, and rot. The woollen prep makes it a more lofty yarn. The fiber alignment from woollen spinning makes it perfect for filtering liquids as well. Towels, filters, ropes and sponges are perfect choices for this yarn.

Sample #21: Figure: 1-A is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH as hemp cannot tolerate acid. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed in regular well water and blocked for drying.

Figure 1-B is a sample of the yarn spun using the samples from Figure 1-C.

Figure: 1-C is a sample of the commercially processed roving.

Figure 1-D is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in Figure: 1-A.
Sample #21

Figure: 1-A

Figure: 1-B

Figure: 1-C

Figure: 1-D
Sample: 22  

50% Hemp / 50% Tussah Silk Woollen

Hand carded into rolags  
Spun woollen using supported long-draw technique

<table>
<thead>
<tr>
<th>Plied “S”</th>
<th>2ply yarn</th>
<th>5 TPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3 g</td>
<td>10 yds</td>
<td>22º angle of twist</td>
</tr>
</tbody>
</table>

Count:  
\[
\text{10 yds} \times \frac{454 \text{ g}}{\text{2 ply}} = \frac{9.17}{300 \text{ FW#}} \approx 9s/2
\]
\[
\text{9s} \times \frac{300 \text{ FW#}}{2 \text{ ply}} = 1,350 \text{ ypp}
\]

TEX:  
\[
\frac{3.3 \text{ g} \times 1,000}{9 \text{ m}} = 366.66 \approx \text{R367 TEX2}
\]

NM:  
\[
\frac{9 \text{ m}}{3.3 \text{ g}} = 2.7 \text{ m/g}
\]

YPP:  
\[
\frac{9 \text{ m} \times 454 \times 1.09 \text{ yds}}{3.3 \text{ g}} = 1,350 \text{ ypp}
\]

Suitable end use: clothing, towels, bed pads, and wash clothes

The silk and camel fibers were both commercially prepared fibers. They were weighed and then hand carded to make a homogeneous blend. The fibers were planked and carded three times to help increase the evenness of the blend. Once the fibers were carded until smooth they were rolled into rolags and spun woollen using the supported long draw spinning technique. The singles were spun in the clockwise “z” direction at approximately seven and a half twists per inch and then plied counter-clockwise in the “s” direction at approximately five twists per inch for a balanced two ply yarn. Equations for finding twist per inch can be found in appendix 1-C. A Kromski Sonata spinning wheel was used with a 12:1 ratio to achieve the maximum twist while using the minimal number of treadles to still remain comfortable while spinning. The yarn was then washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH as hemp cannot tolerate acidic conditions. An exact recipe for the
washing solution can be found in Appendix 1-B. The fibers were then wrung out to remove excess water and snapped between the wrists to help set the yarn before it was hung to air dry. The silk adds luster, strength, and softness to this blend. Both fibers are good absorbers and dye well. The silk adds drape and warmth to the blend, also. The blend makes an exceptionally strong yarn that is breathable, absorbent, soft and warm. The possibilities for this yarn are endless but the best choice would be clothing, towels, bed pads, and wash clothes.

Sample #22: Figure: 1-A is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH as hemp cannot tolerate acidic conditions. An exact recipe for the washing solution can be found in Appendix 1-B The sample was then rinsed in regular well water and blocked for drying.

Figure 1-B is a sample of the yarn spun using the fibers from sample 23 Figure 1-C

Figure: 1-C Is a sample of the commercially prepared fibers side by side unblended

Figure 1-D is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in Figure: 1-A
Sample #22

Figure: 1-A

Figure: 1-C

Silk → Hemp

Figure: 1-B

Figure: 1-D
Sample: 23

50% Hemp / 50% Tussah Silk Worsted

Hand carded into sausages
Spun worsted using inchworm technique

<table>
<thead>
<tr>
<th>Spun “Z”</th>
<th>Plied “S”</th>
<th>2ply yarn</th>
<th>3 TPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 WPI</td>
<td>3.0 g</td>
<td>10 yds</td>
<td>21° angle of twist</td>
</tr>
</tbody>
</table>

Count:

\[
10 \text{ yds} \times 454 \text{ g} \times 2 \text{ ply} = 5.4 \approx 5s/2
\]

\[
3.0 \text{ g} \times 300 \text{ FW#}
\]

YPP:

\[
5s \times 560\text{FW#} = 1,400 \text{ ypp}
\]

TEX:

\[
3.0 \text{ g} \times 1,000 = 333.33 \approx R333 \text{TEX2}
\]

NM:

\[
9 \text{ m} = 2.73 \text{ m/g}
\]

\[
3.0 \text{ g}
\]

YPP:

\[
9 \text{ m} \times 454 \times 1.09 \text{ yds} = 1,485 \text{ ypp}
\]

Suitable end use: baby garments, towels, cloth diapers, and sweaters

Commercially prepared hemp and silk fibers were used for the blend. The fibers were weighed, hand carded, and planked three times for a more homogeneous blend. The fibers were removed from the hand cards by rolling them into worsted sausages and then spun using the worsted method of spinning using the inchworm technique with an approximate two-inch draft. The worsted style spinning gives the yarn a more lustrous finish due to the fibers orienting in the same direction and thus scattering the light in one direction so more light hits the eye. This organized arrangement of fibers loses its heat trapping ability because there is no air space between the parallel alignment of fiber which the worsted spinning creates. The singles were spun in the clockwise “z” direction at approximately four and a half twists per inch and then plied in the opposite counter-clockwise “s” direction for an approximate three twists per inch to create a two ply balanced yarn. Equations for finding twist per inch can be found in appendix 1-
C. A Kromski Sonata spinning wheel was used with a 12:1 ratio to achieve the maximum twist while using the minimal number of treadles to still remain comfortable while spinning. The yarn was then washed in warm soapy water using Dawn as the detergent and 2% washing soda to help increase the pH as hemp cannot tolerate acidic conditions. An exact recipe for the washing solution can be found in Appendix 1-B. No agitation was used to help prevent disruption of the parallel fibers. The fibers were then wrung out to remove excess water and snapped between the wrists to help set the yarn before it was hung to air dry. The more this yarn is washed the softer it gets. Baby garments, towels and cloth diapers would be some of the choices to use this yarn for, due to its softness, absorbency, and resistance to mold, mildew, and rot. It is breathable so won’t cause skin irritations or rashes and is antimicrobial to help reduce bacterial infections. The silk adds some elasticity and makes the garment light weight and cool to wear.

**Sample #23: Figure: 1-A** is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH as hemp cannot tolerate acidic conditions. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed in regular well water and blocked for drying.

**Figure 1-B** is a sample of the yarn spun using the fibers from **Figure** 1-C but with a worsted prep.

**Figure 1-C** is a sample of the two commercially prepared fibers carded woollen.

**Figure 1-D** is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in **Figure: 1-A**.
Silk Feasibility Study

Sample: 24

Hand carded into sausages
Spun worsted using inchworm technique
Spun “Z” Plied “S” 2ply yarn 6.3 TPI
15 WPI 5.8 g 10 yds 32° angle of twist

Count: 10 yds x 454 g x 2 ply = 2.79 ≈ 3s/2
5.8 g 560 FW#

YPP: 3s x 560FW# = 840 ypp
2 ply

TEX: 5.8 g x 1,000 = 644.4 ≈ R644 TEX2
9 m

NM: 9 m = 1.55 m/g
5.8 g

YPP: 9 m x 454 x 1.09 yds = 768 ypp
5.8 g

Suitable end use: paper towel, sacks for storing food, fences, ropes, and curtains

Commercially prepared roving was used to spin this yarn. The fibers were hand carded and rolled into worsted sausages and then spun using the worsted method of spinning using the inchworm technique with an approximate two-inch draft. The worsted style spinning gives the yarn a more shiny finish due to the fibers orienting in the same direction and thus scattering the light in one direction so more light hits the eye. This organized arrangement of fibers loses its heat trapping ability because there is no air space between the parallel alignment of fibers which the worsted spinning creates. The singles were spun in the clockwise “z” direction at approximately nine twists per inch and then plied in the opposite counter-clockwise “s” direction for an approximate six twists per inch to create a two ply balanced yarn. Equations for finding twist per inch can be found in appendix 1-C. A Kromski Sonata spinning wheel was used with a 16:1 ratio to achieve the maximum twist while using the minimal number of treadles to still
remain comfortable while spinning. The yarn was then washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH as hemp cannot tolerate acidic conditions. An exact recipe for the washing solution can be found in Appendix 1-B. No agitation was used to help prevent disruption of the parallel fibers. The fibers were then wrung out to remove excess water and snapped between the wrists to help set the yarn before it was hung to air dry.

Hemp spun worsted makes a spectacularly strong fiber with little drape and elasticity. It is absorbent and soft so could be used for reusable toilet paper in a survival situation due to its antimicrobial properties. It also resists molds and mildew so would be easy to store in less desirable conditions. Hemp is very durable and could be used to make ropes or even fences because it is resistant to ultraviolet rays. Curtains would also make an excellent choice as well. Bags and nets for catching things are other possible options, too.

Sample#24: Figure: 1-A is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH as hemp cannot tolerate acidic conditions. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed in regular well water and blocked for drying.

Figure 1-B is a sample of the yarn spun using the hemp fiber with a worsted prep.

Figure: 1-C is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in Figure: 1-A.
Sample #24

Figure: 1-A

Figure: 1-B

Figure: 1-C
Sample: 25

Hand carded into rolags
Spun woollen using supported long-draw technique

<table>
<thead>
<tr>
<th>Spun “Z”</th>
<th>Plied “S”</th>
<th>2 ply yarn</th>
<th>6.5 TPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 WPI</td>
<td>5 g</td>
<td>10 yds</td>
<td>47° angle of twist</td>
</tr>
</tbody>
</table>

Count:
\[
\text{10 yds} \times 454 \text{ g} \times 2 \text{ ply} = 6.05 \approx 6s/2
\]
\[
\frac{5.0 \text{ g}}{300 \text{ FW#}}
\]

YPP:
\[
6s \times 300\text{FW#} = 900 \text{ ypp}
\]

TEX:
\[
\frac{5.0 \text{ g}}{9 \text{ m}} \times 1,000 = 555.5 \approx R556 \text{ TEX2}
\]

NM:
\[
\frac{9 \text{ m}}{5.0 \text{ g}} = 1.8 \text{ m/g}
\]

YPP:
\[
9 \text{ m} \times 454 \times 1.09 \text{ yds} = 891 \text{ ypp}
\]

Suitable end use: baby clothing, draft stoppers, socks, baby soakers

Commercially prepared Merino fiber was hand carded into rolags and spun woollen using the supported long-draw method of spinning. The singles were spun in the clockwise “Z” direction at approximately ten twists per inch and then plied in the counter-clockwise “S” direction at approximately six and a half twists per inch for a balanced two ply yarn. Equations for finding twist per inch can be found in appendix 1-C. A Kromski Sonata spinning wheel was used with a 6.5:1 ratio to achieve the maximum twist while using the minimal number of treadles to still remain comfortable while spinning. The yarn was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH and greatly agitated to help set the fibers, balance, and full the yarn. An exact recipe for the washing solution can be found in Appendix 1-B. A final rinse was used with a slightly acidic solution to help bring the
pH back to neutral. For the exact recipe of the 10% acid rinse used see Appendix 1-A. The fibers were then wrung out to remove excess water and snapped between the wrists after being whacked several times on a clean dry towel to help set and full the yarn before it was hung to air dry.

Merino spun woollen is a very warm and soft fine fiber. Merino has great elasticity and can absorb 30% its weight in moisture without feeling wet. Its flame retardant properties make it perfect for baby clothing. Its soft feel would make wonderful wash clothes and the elasticity would work wonders in socks. It is extremely insulating and woven fabrics could be used to stop drafts from windows or under doors.

**Sample#25: Figure: 1-A** is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix 1-A.

**Figure 1-B** is a sample of the yarn spun using the samples from **Figure 1-C** but spun woollen.

**Figure: 1-C** Is a sample of the commercially processed roving.

**Figure 1-D** is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in **Figure: 1-A**.
Silk Feasibility Study

### Sample: 26

**50% Merino / 50% Bombyx Silk Woollen**

Hand carded into rolags  
Spun woollen using supported long-draw technique  

<table>
<thead>
<tr>
<th>Spun “Z”</th>
<th>Plied “S”</th>
<th>2ply yarn</th>
<th>5 TPI</th>
<th>13 WPI</th>
<th>2.6 g</th>
<th>10 yds</th>
<th>45° angle of twist</th>
</tr>
</thead>
</table>

Count:  

\[ 10 \text{ yds} \times 454 \text{ g} \times 2 \text{ ply} = 11.64 \approx 12s/2 \]
\[ 2.6 \text{ g} \times 300 \text{ FW#} \]

YPP:  

\[ 12s \times 300\text{FW#} = 1,800 \text{ ypp} \]
\[ 2 \text{ ply} \]

TEX:  

\[ 2.6 \text{ g} \times 1,000 = 288.8 \approx \text{R289 TEX2} \]
\[ 9 \text{ m} \]

NM:  

\[ \frac{9 \text{ m}}{2.6 \text{ g}} = 3.46 \text{ m/g} \]

YPP:  

\[ \frac{9 \text{ m} \times 454 \times 1.09 \text{ yds}}{2.6 \text{ g}} = 1,713 \text{ ypp} \]

Suitable end use: blankets, scarves, shawls, hats, or mittens

The silk and merino fibers were both commercially prepared fibers. They were weighed and then hand carded to make a homogeneous blend. The fibers were planked and carded three times to help increase the evenness of the blend. Once the fibers were carded until smooth they were rolled into rolags and spun woollen using the supported long draw spinning technique. The singles were spun in the clockwise “z” direction at approximately seven and a half twists per inch and then plied counter-clockwise in the “s” direction at approximately five twists per inch for a balanced two ply yarn. Equations for finding twist per inch can be found in appendix 1-C. A Kromski Sonata spinning wheel was used with a 12:1 ratio to achieve the maximum twist while using the minimal number of treadles to still remain comfortable while spinning. The yarn was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH and greatly agitated to help set the fibers, balance, and full the yarn. An
exact recipe for the washing solution can be found in Appendix 1-B. A final rinse was used with a slightly acidic solution to help bring the pH back to neutral. For the exact recipe of the 10% acid rinse used see Appendix 1-A. The fibers were then wrung out to remove excess water and snapped between the wrists after being whacked several times on a clean dry towel to help set and full the yarn before it was hung to air dry.

The silk merino blend was chosen as a sample described by, Clara Parkes, to show how silk adds luster, drape, and strength to the already warm and soft merino (Parks, 2009). It’s absorbent and soft, adds moth resistance to the blend and helps resist felting. This blend is shiny, soft, strong, and durable. It would make very warm and soft blankets, scarves, shawls, hats or mittens... just an exceptional all round yarn for knitting, weaving, or crochet items.

**Sample #26:** *Figure: 1-A* is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix 1-A.

*Figure 1-B* is a sample of the yarn spun using the blend shown in sample 27 *Figure 1-C.*

*Figure: 1-C* is a sample of the commercially prepared merino roving and silk top, side by side.

*Figure 1-D* is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in *Figure: 1-A.*
Sample: 27  

50% Merino / 50% Bombyx Silk Worsted

Hand carded into sausages  
Spun worsted using inchworm technique

Spun “Z”  
Plied “S”  
2ply yarn  
5 TPI

15 WPI  
2.4 g  
10 yds  
46° angle of twist

Count:  
\[
\frac{10 \text{ yds} \times 454 \text{ g} \times 2 \text{ ply}}{2.4 \text{ g}} = 6.755 \approx 7s/2
\]

YPP:  
\[
7s \times 560 \text{FW#} = 1,960 \text{ ypp}
\]

TEX:  
\[
\frac{2.4 \text{ g} \times 1,000}{9 \text{ m}} = 266.66 \approx \text{R267 TEX2}
\]

NM:  
\[
\frac{9 \text{ m}}{2.4 \text{ g}} = 3.75 \text{ m/g}
\]

YPP:  
\[
\frac{9 \text{ m} \times 454 \times 1.09 \text{ yds}}{2.4 \text{ g}} = 1,856 \text{ ypp}
\]

Suitable end use: baby garments, cloves, hats, socks, anything where stitch definition is required

Commercially prepared fiber of both the merino and silk were used for the blend. The fibers were weighed, hand carded, and planked three times for a more homogeneous blend. The fibers were removed from the hand cards by rolling them into worsted sausages and then spun using the worsted method of spinning using the inchworm technique with an approximate two-inch draft length. The worsted style spinning gives the yarn a more lustrous finish due to the fibers orienting in the same direction and thus scattering the light in one direction so more light actually hits the eye. This organized arrangement of fibers loses its heat trapping ability because there is no air space between the parallel alignment of fiber which the worsted spinning creates.

The singles were spun in the clockwise “z” direction at approximately seven and a half twists per inch and then plied in the opposite counter-clockwise “s” direction for an approximate five twists per inch to create a two ply balanced yarn. Equations for finding twist per inch can be found in
appendix 1-C. A Kromski Sonata spinning wheel was used with a 12:1 ratio to achieve the maximum twist while using the minimal number of treadles and still remain comfortable while spinning. The yarn was then washed in warm soapy water using dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. No agitation was used to help prevent disruption of the parallel fibers. A final rinse was used with a slightly acidic solution to help bring the pH back to neutral. For the exact recipe of the 10% acid rinse used see Appendix 1-A. The fibers were then wrung out to remove excess water and snapped between the wrists to help set the yarn before it was hung to air dry.

This worsted spun blend is soft and shiny. The merino adds elasticity, strength, durability, absorbency, and drape to the already soft, strong, elastic, and drapey silk. Silk enhances the merino’s shine and makes it more smooth and drapey. The ideal products for this yarn would be knitted items where stitch definition is required. It could also be used for woven fabrics, clothing, or bedding. Any baby items would also be welcome choices, as well.
Sample #27: Figure 1-A is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix 1-A.

Figure 1-B is a sample of the yarn spun using the same fibers from sample 25 Figure 1-C but were hand carded worsted.

Figure 1-C is a sample of the merino and silk fibers carded woollen.

Figure 1-D is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in Figure 1-A.
Hand carded into sausages
Spun worsted using inchworm technique

- Spun “Z”
  - 13 WPI
  - 3.7 g
  - 2 ply yarn
  - 6.3 TPI
  - 2 ply yarn
  - 50° angle of twist

- Count:
  - 10 yds \times 454 \text{ g} \times 2 \text{ ply} = 4.38 \approx 4s/2
  - 3.7 \text{ g}

- YPP:
  - 4s \times 560FW\# = 1,120 ypp
  - 2 ply

- TEX:
  - 3.7 \text{ g} \times 1,000 = 411.1 \approx R411 TEX2
  - 9 m

- NM:
  - \frac{9 \text{ m}}{3.7 \text{ g}} = 2.43 \text{ m/g}

- YPP:
  - \frac{9 \text{ m} \times 454 \times 1.09 \text{ yds}}{3.7 \text{ g}} = 1,204 \text{ ypp}

Suitable end use: winter garments, baby items, scarves, hats, blankets, and gloves

Commercially prepared merino roving was hand carded into worsted sausages and then spun using the worsted method of spinning using the inchworm technique with an approximate two-inch draft. The worsted style spinning gives the yarn a more lustrous finish due to the fibers orienting in the same direction and thus scattering the light in one direction so more light actually hits the eye. This organized arrangement of fibers loses its heat trapping ability because there is no air space between the parallel alignment of fiber which the worsted spinning creates. The merino wool, however, is a great insulator in itself so this isn’t that great of a detrimental factor. The singles were spun in the clockwise “z” direction at approximately nine and a half twists per inch and then plied in the opposite counter-clockwise “s” direction for an approximate six twists per inch to create a two ply balanced yarn. Equations for finding twist per inch can be found in appendix 1-C. A Kromski Sonata spinning wheel was used with a 6.5:1 ratio to achieve the
maximum twist while using the minimal number of treadles and still remain comfortable while spinning. The yarn was then washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. No agitation was used in order to help prevent disruption of the parallel fibers. A final rinse was used with a slightly acidic solution to help bring the pH back to neutral. For the exact recipe of the 10% acid rinse used see Appendix 1-A. The fibers were then wrung out to remove excess water and snapped between the wrists to help set the yarn before it was hung to air dry.

Worsted is the perfect method for spinning fine woollens according to Olds (Olds, 2013). This would keep piling of the fine fibers to a minimum and the wool fibers themselves would offer plenty heat retention without being spun woollen. This fiber has good drape, elasticity, resilience and durability. As always, the best choices for merino are next to the skin clothing, baby garments, winter clothing, scarves, blankets, socks, and hats.

**Sample #28: Figure: 1-A** is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix 1-A.

**Figure 1-B** is a sample of the yarn spun using merino wool fiber with a worsted prep.

**Figure: 1-C** is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in **Figure: 1-A**.
Hand carded into rolags
Spun woollen using supported long-draw technique

<table>
<thead>
<tr>
<th>Spun “Z”</th>
<th>Plied “S”</th>
<th>3ply yarn</th>
<th>4 TPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 WPI</td>
<td>3.0 g</td>
<td>10 yds</td>
<td>28° angle of twist</td>
</tr>
</tbody>
</table>

Count: \[\frac{10 \text{ yds} \times 454 \text{ g} \times 3 \text{ ply}}{3.0 \text{ g} \times 300 \text{ FW#}} = 15.13 \approx 15\text{s/3}\]

YPP: \[15\text{s} \times 300\text{FW#} = 1,500 \text{ ypp}\]

TEX: \[\frac{3.0 \text{ g} \times 1,000}{9 \text{ m}} = 333.33 \approx R333 \text{ TEX3}\]

NM: \[\frac{9 \text{ m}}{3.0 \text{ g}} = 3.0 \frac{\text{ m}}{\text{g}}\]

YPP: \[\frac{9 \text{ m} \times 454 \times 1.09 \text{ yds}}{3.0 \text{ g}} = 1,485 \text{ ypp}\]

Suitable end use: thermal under wears, baby garments, hats, jacket liners, and lingerie

The raw angora fiber was hand carded into rolags and spun woollen using the supported long-draw method of spinning. The singles were spun in the clockwise “z” direction at approximately five twists per inch and then plied in the counter-clockwise “s” direction at approximately four twists per inch for a balanced three-ply yarn. Equations for finding twist per inch can be found in appendix 1-C. A Kromski Sonata spinning wheel was used with an 18:1 ratio to achieve the maximum twist while using the minimal number of treadles to still remain comfortable while spinning. The yarn was washed in warm soapy water using dawn as the detergent and two percent washing soda to help increase the pH and greatly agitated to help set the fibers, balance, and full the yarn. An exact recipe for the washing solution can be found in Appendix 1-B. A final rinse was used with a slightly acidic solution to help bring the pH back to neutral. For the exact recipe of the 10% acid rinse used see Appendix 1-A. The fibers were then
wrung out to remove excess water and snapped between the wrists after being whacked several times on a clean dry towel to help set and full the yarn before it was hung to air dry.

Woollen angora yarn is remarkably soft. It has great heat retaining ability and a lovely halo. It dyes well and is water-repellent. This yarn would produce next to the skin softness for underwear’s, baby garments, hats, jacket liners, and lingerie.

Sample #29: Figure: 1-A is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix 1-A.

Figure 1-B is a sample of the yarn spun using the samples from Figure 1-C carded woollen.

Figure 1-C is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in Figure: 1-A.
Sample: 30  50% Angora / 50% Bombyx Silk Woollen

Hand carded into rolags
Spun woollen using supported long-draw technique

<table>
<thead>
<tr>
<th>Spun “Z”</th>
<th>Plied “S”</th>
<th>3 ply yarn</th>
<th>4 TPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 WPI</td>
<td>3.5 g</td>
<td>10 yds</td>
<td>35° angle of twist</td>
</tr>
</tbody>
</table>

Count: \[10 \text{ yds} \times \frac{454 \text{ g}}{3 \text{ ply}} = 12.97 \approx 13s/3\]

YPP: \[13s \times 300 \text{FW#} = 1,300 \text{ ypp}\]

TEX: \[\frac{3.5 \text{ g} \times 1,000}{9 \text{ m}} = 388.88 \approx \text{R389 TEX}3\]

NM: \[\frac{9 \text{ m}}{3.5 \text{ g}} = 2.57 \text{ m/g}\]

YPP: \[\frac{9 \text{ m} \times 454 \times 1.09 \text{ yds}}{3.5 \text{ g}} = 1,071 \text{ ypp}\]

Suitable end use: winter garments, lingerie, baby items, sweaters

The fibers used were commercially prepared bombyx top and raw angora. They were weighed, hand carded, and planked three times to help increase the evenness of the blend. Once the fibers were carded until homogenous they were rolled into rolags and spun woollen using the supported long draw spinning technique. The singles were spun in the clockwise “z” direction at approximately five twists per inch and then plied counter-clockwise in the “s” direction at approximately four twists per inch for a balanced three ply yarn. Equations for finding twist per inch can be found in appendix 1-C. A Kromski Sonata spinning wheel was used with an 18:1 ratio to achieve the maximum twist while using the minimal number of treadles to still remain comfortable while spinning. The yarn was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH and greatly agitated to help set the fibers, balance, and full the yarn. An exact recipe for the washing solution can be found in
Appendix 1-B. A final rinse was used with a slightly acidic solution to help bring the pH back to neutral. For the exact recipe of the 10% acid rinse used see Appendix 1-A. The fibers were then wrung out to remove excess water and snapped between the wrists after being whacked several times on a clean dry towel to help set and full the yarn before it was hung to air dry.

The silk angora creates a blend that offers softness to the touch, strength, and heat retention. The woollen style spinning techniques gives loft to the yarn and creates a beautiful halo. The silk adds elasticity and strength to the blend and the angora adds character, warmth, and water resistance. This blend would be a good choice for thermal under garments, winter scarves, hats, and gloves. Blankets and baby items would also be good choices.

**Sample #30: Figure: 1-A** is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix 1-A.

**Figure 1-B** is a sample of the yarn spun using the fibers from sample 31 **Figure 1-C**.

**Figure: 1-C** is a sample of the raw angora fiber.

**Figure 1-D** is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in **Figure: 1-A**.
Sample: 31  

50% Angora / 50% Bombyx Silk Worsted

Hand carded into sausages  
Spun worsted using inchworm technique  
Spun “Z”  
Plied “S”  
3 ply yarn  
4 TPI  
17 WPI  
4.0 g  
10 yds  
40° angle of twist  

Count:  
10 yds x 454 g x 3 ply = 6.08 ≈ 6s/3  
4.0 g  
560 FW#  

YPP:  
6s x 560FW# = 1,120 ypp  
3 ply  

TEX:  
4.0 g x 1,000 = 444.44 ≈ R444 TEX3  
9 m  

NM:  
9 m = 2.25 m/g  
4.0 g  

YPP:  
9 m x 454 x 1.09 yds = 1,113 ypp  
4.0 g  

Suitable end use: Bras, lingerie, scarves, robes, baby garments

Commercially prepared bombyx silk top and raw angora fibers were used for the blend.  
The fibers were weighed, hand carded, and planked three times for a more homogeneous blend.  
The fibers were removed from the hand cards by rolling them into worsted sausages and then  
spun using the worsted method of spinning using the inchworm technique with an approximate  
two-inch draft. The worsted style spinning gives the yarn a more lustrous finish due to the fibers  
orienting in the same direction and thus scattering the light in one direction so more light actually  
hits the eye. This organized arrangement of fibers loses its heat trapping ability because there is  
o air space between the parallel alignment of fiber which the worsted spinning creates. The  
singles were spun in the clockwise “Z” direction at approximately five twists per inch and then  
plied in the opposite counter-clockwise “S” direction for an approximate four twists per inch to  
create a three-ply balanced yarn. Equations for finding twist per inch can be found in appendix 1-C. A Kromski Sonata spinning wheel was used with an 18:1 ratio to achieve the maximum twist.
while using the minimal number of treadles and still remain comfortable while spinning. The yarn was then washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. No agitation was used in order to help prevent disruption of the parallel fibers. A final rinse was used with a slightly acidic solution to help bring the pH back to neutral. For the exact recipe of the 10% acid rinse used see Appendix 1-A. The fibers were then wrung out to remove excess water and snapped between the wrists to help set the yarn before it was hung to air dry.

The worsted spinning technique adds luster to this blend. It reduced the halo caused by the angora and created a smoother yarn with greater stitch definition. The silk adds shine, elasticity, and strength to the blend while the angora adds softness, halo, and water resistance. This super soft yarn can be used for robes, scarves, sweaters, bras, baby garments, or underwear.
**Sample #31: Figure: 1-A** is a woven sample swatch of the yarn. The sample was woven using a zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two percent washing soda to help increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix 1-A.

**Figure 1-B** is a sample of the yarn spun using the blended fibers in sample 30 **Figure 1-C** but carded worsted.

**Figure 1-C** is a sample of the angora and silk fibers carded woollen.

**Figure 1-D** is a knitted sample swatch of this yarn. This sample was washed and set the same as the sample in **Figure: 1-A**.
Sample: 32

Hand carded into sausages
Spun worsted using inchworm technique

Spun “Z” Plied “S” 3 ply yarn 3 TPI
19 WPI 3.3 g 10 yds 27° angle of twist

Count: $\frac{10 \text{ yds} \times 454 \text{ g} \times 3 \text{ ply}}{3.3 \text{ g}} = 7.37 \approx 7s/3$

YPP: $\frac{7s \times 560 \text{ FW#}}{3 \text{ ply}} = 1,307 \text{ ypp}$

TEX: $\frac{3.3 \text{ g} \times 1,000}{9 \text{ m}} = 366.6 \approx 367 \text{ TEX}$

NM: $\frac{9 \text{ m}}{3.3 \text{ g}} = 2.73 \text{ m/g}$

YPP: $\frac{9 \text{ m} \times 454 \times 1.09 \text{ yds}}{3.3 \text{ g}} = 1,350 \text{ ypp}$

Suitable end use: pants, woven fabrics, bed sheets, socks, and winter garments

Raw angora fibers were used to spin this sample yarn. The fibers were hand carded and then removed by rolling them into worsted sausages and spun using the worsted method of spinning with the inchworm technique at an approximate one inch draft. The worsted style spinning gives the yarn a more lustrous finish due to the fibers orienting in the same direction and thus scattering the light in one direction so more light hits the eye. This organized arrangement of fibers loses its heat trapping ability because there is no air space between the parallel alignment of the fibers which the worsted spinning creates. The singles were spun in the clockwise “z” direction at approximately four twists per inch and then plied in the opposite counter-clockwise “s” direction for an approximate three twists per inch to create a three-ply balanced yarn. Equations for finding twist per inch can be found in appendix 1-C. A Kromski Sonata spinning wheel was used with an 18:1 ratio to achieve the maximum twist while using the
minimal number of treadles and still remain comfortable while spinning. The yarn was then
washed in warm soapy water using Dawn as the detergent and two percent washing soda to help
increase the pH. An exact recipe for the washing solution can be found in Appendix 1-B. No
agitation was used to help prevent disruption of the parallel fibers. A final rinse was used with a
slightly acidic solution to help bring the pH back to neutral. For the exact recipe of the 10% acid
rinse used see Appendix 1-A. The fibers were then wrung out to remove excess water and
snapped between the wrists to help set the yarn before it was hung to air dry.

The 100% angora has less halo than the woollen spun sample. It is less soft to the touch
with more drape. The fibers were easy to spin worsted using the inchworm style and produced a
more defined stitch for knitting and weaving a pattern. Woven fabrics, bed sheets, socks, pants
and winter garments would be a few examples for uses of this yarn.

**Sample #32: Figure: 1-A** is a woven sample swatch of the yarn. The sample was woven using a
zoom loom. The sample was washed in warm soapy water using Dawn as the detergent and two
percent washing soda to help increase the pH. An exact recipe for the washing solution can be
found in Appendix 1-B. The sample was then rinsed with a 10% acid rinse to help neutralize the
pH and then blocked for drying. An exact recipe for the 10% acid rinse can be found in appendix
1-A.

**Figure 1-B** is a sample of the yarn spun using raw angora fiber with a worsted prep.

**Figure 1-C** is a sample of the raw angora fiber and commercial bombyx silk fibers side by side
uncarded.

**Figure: 1-D** is a knitted sample swatch of this yarn. This sample was washed and set the same as
the sample in **Figure: 1-A**.
Results.

When comparing commercially prepared silk fibers to those reared at home, according to H. T. Gaddum and Company, there is no finer fiber than those reeled by hand (Gaddum, 1979). Machines simply cannot and do not compare in quality (Gaddum, 1979). The silk needs a trained eye to watch over it at all times. So, if it’s maximum quality you are looking for, in reeled silk, it simply must be done at home by hand. If quantity is your goal, then turning to machines is your best bet.

The tent fibers were easily removed, carded, and spun by hand but with time your fingers become sore, so only so many cocoons can be plucked at a time and very little fiber is acquired this way. A special machine would be better suited for this practice that could remove these fibers from the cocoon, much like the cotton gin removes the cotton from the seed.

When making the mawata, the biggest concern and challenge was keeping the chemicals from drying out the hands. Gloves can be worn but it somewhat hinders the ability to feel the silk as you pull it open and try to keep it smooth and even. There is also a concern with the simmering water the cocoons are degummed in, as the chemicals are continuously leached into the air as the simmering water evaporates. Proper ventilation is needed. There was no noticeable difference between the commercial made mawata and mawata made at home by hand.

The yarn from the cut and carded mawata was very time-consuming to make and the cutting and carding procedures were very hard on the wrists and hands. These two procedures would be much better done using machines in a commercial setting with comparable end results between the hand carding worsted sausages and the commercial prepared top. The rovings were both hand carded for the woollen style yarn and produced nearly identical results; therefore, we feel it safe
to say time is the biggest restraint in factoring whether to produce your own silk for spinning or to buy it commercially. All other sample blends for this study were spun using commercially prepared top in order to save the spinner time, from pain in the hands, pain in the wrists, and from possible future medical issues such as carpal tunnel and arthritis from hand carding so much fiber.

The blended fibers were all spun using commercial bombyx top. The time it saves, along with the wear on your hands and wrists when using hand cards were well worth the money spent on buying the prepared silk fibers. The results found in the blended yarns showed no distinct difference. The worsted silk from the commercial top was a bit smoother than the hand carded worsted sausages made from the hand cut mawata.
Conclusion

Producing silk had somewhat of an animal raising nature to it. There was still the stall cleaning part and routine feeding chores, but there just wasn’t the muddy, rainy, windy, or cold going outside on those frigid winter nights. The silkworms could be raised in a confined setting in the comfort of the home, where the temperature and humidity can be controlled. The food was also free, so long as, one is willing to go pick them from the trees. Thousands of silkworms could be raised in a room no bigger than most walk-in closets that can be found in homes today. You don’t even have to worry about watering them. Silkworms don’t need water. Home fiber raising woes are gone. The trays were super easy to clean and they were just as easy to feed. The most amazing part is that it only takes 30 days to produce the product, silk cocoons! The processing wasn’t as messy as rolling around on the ground with a sheep or while getting spit on during the shearing procedure by an angry alpaca, either. Within 30 days you can be making reeled silk, silk hankies, and even card some fibers into rolags. Raising the cocoons is the easy part in my opinion.

All these wonderful experiences with raising the fiber itself, were met with woes, though, when it came to the chemicals and the time factor of producing a spinable product. The chemical astringents/degumming agents used to remove the sericin from the silk left the hands dry and cracked after handling just a few cocoons for making hankies which were cut up and carded for rolags. The silk would stick to the cracks in the hands and cause a slight annoying sensation to the neurological system. This could be eliminated by using gloves or by using your silk to spin a few months later after your hands are healed. I didn’t have the time to wait and many are too eager to spin in order for that to work either.
Hand cutting the hankies was very time-consuming using scissors and required very sharp blades. The carding was done using hand cards and was quite a laborious one as well. I suppose if one really wanted to make their own roving, a drum carder would help ease the hands and wrists from the pain of hand carders. All these factors pushed me to believe commercial silk was more the way to go. Raising the silk was a dream. It was the processing that was a full-time job with harsh consequences, in our opinion, except the silk reeling. The reeling was less laborious and you could actually wear gloves while degumming in the harsh chemicals. I also found that if you add the reeled silk from a bobbin to a pair of hand cards and card it long enough, it can make lovely roving. More experimenting would need done on this but it is possible.

I conclude that this study is subject to personal opinion and interests that would weigh on the results whether processing your own silk was an enjoyable enough process for a person to commence or if income makes it easier to just buy the commercially prepared fibers to spin. It is advised that every spinner take an adventure down the silken rabbit hole road to see for themselves whether the silk rearing and processing experience is an enjoyable enough one for the undertaking and processing of one’s own silk. I concluded that it would be much more rewarding if you could raise your own cocoons and then have them processed or sold for money to buy commercial processed bombyx top for spinning, but do your own reeling. The hand reeled fibers, which are a superior product, could also possibly be traded for a lesser quality product such as bombyx top.
Tables and figures:

Figure: 1-A Silkworm eggs.

Figure: 1-B Silkworm incubator

Figure: 1-C Kegos hatching

Figure: 1-D Medium size tulle

Figure: 1-E Non-slip rug padding

Figure: 1-F Stack of trays with silkworm
Figure: 1-G Stack or trays with silkworms showing plastic cover

Figure: 1-H Silkworm Condo’s

Figure: 1-I Silkworm Condo’s

Figure: 1-J Tent/Blaze fibers and cut cocoons

Figure: 1-K
Figure: 1-L Handmade Mawata

Figure 1-P Mawata strips cut into squares.

Figure: 1-Q Mawata squares carded

Figure: 1-M Silk reeling setup

Figure: 1-N Silk reeling bobbin and electric winde
Appendix #1

A: Solution for washing fibers: Olds College Recipe for degumming silk

1 Gallon of water, ¼ cup Orvus, and ¼ cup washing soda.

Sara Lamb’s Recipe to degum grams of fiber but was what I used to wash samples.

1 Gallon of water, ¼ teaspoon of detergent, ¼ teaspoon washing soda.

B: Acid rinse solution for rinsing protein fibers:

Take a gallon of water and pour out 379ml of water and add that much vinegar back to it to make one gallon of a 10% acid rinse solution.

C: Equations for spinning singles Olds College Level 3 page C-18:

For spinning singles: \[ \text{Tpi in singles} = \frac{\text{tpi of plied yarn} \times (\text{number of plies} + 1)}{\text{Number of plies}} \]
**Silk Glossary of terms (Cook, 2012)**

**Bave** - The filament secreted from the silk gland of a silk-producing caterpillar. It is composed of two brins.

**Bead** – The twist on thrown silks. Tightly twisted organzines in particular resemble a string of tiny beads.

**Ell** - A stack of silk caps, usually with a final silk cap opened over the entire stack to close it.

**Bivoltine** - Having two broods or generations per year. Some races of silkworms are bivoltine. Bivoltine caterpillars produce better quality and quantity of silk.

**Blaze** - The fluffy fiber used to anchor a cocoon; it stays on the outside of the cocoon until it is removed. Also called cocoon strippings, keba, kibisu, or flossing.

**Brin** - One half of a silk bave.

**Brood** - A generation of silkworms, from eggs to eggs.

**Cap** - Similar to a mawata or hankie, but stretched over a bent hoop to form a shape similar to a hat or a sack. Made in stacks called bells; sometimes "bell" is used instead of "cap."

**Chawki** - An Indian name for a hatchling silkworm

**Claspers** - Also called anal claspers; the extra-grippy pair of "legs" at the very back of a caterpillar.

**Cocoon** - The protective covering that a silkworm spins around itself before pupation. This is used to make silk thread through spinning or reeling.
**Cocoon strippings** - The fluffy coarse fiber used to anchor a Bombyx mori cocoon; it stays on the outside of the cocoon until it is removed. Also called blaze, keba, or flossing. This fiber is used to produce spun silk, and is often sold to handspinners.

**Cocoonase** - The enzyme used by the moth to soften and partially dissolve the end of the cocoon during eclosion. It is secreted from a gland in the moth's head.

**Continuously brooded** - Having one generation after another without diapause. Samia ricini, the Eri silkmoth, is continuously brooded.

**Croissure** – French term meaning “crossing.” During reeling, a filament of raw silk is twisted around itself to help agglutinate the fibers and remove water. Important for producing quality raw silk.

**Degum** – To remove the sericin (silk gum) from silk fiber. Degumming makes silk softer, shinier, and better able to accept dye. Silk can be degummed in the yarn or in the fabric, depending on the application.

**Denier** - Can be pronounced three different ways; they come out to be about like "DEEnner," "DEENyer" and "den-YAY". A measure of the weight per length of silk, equivalent to one gram per 9,000 meters. One denier is 1/9 of a Tex, and equal to 4,464,492 (yes, that's four million) yards per pound. The original name comes from a small antique French coin worth 1/12 of a sou, which was used to balance scales when measuring silk. A single cocoon's bave measures typically two to three denier, and most Chinese filature (machine reeled) raw silk filament is 21 denier. In the description of a filament silk thread, the first number, sometimes followed by a letter d, is the denier measure of the filament. For example, a 21d10x2 organzine is a doubles (the final two) with each singles being made of ten 21-denier strands. The denier of the thread
would be 420, which is about halfway between sewing thread and buttonhole thread size. Denier is measured in the raw silk, and the number is not adjusted after degumming.

**Diapause** - A period of dormancy. Many silkmoths undergo diapause in the cocoon; some (Bombyx mori and Antheraea yamamai being examples) undergo diapause in the egg. The diapause is typically how a species overwinters. Diapause is often necessary for the organism to develop properly.

**Doupionni** - Silk thread reeled from doupion cocoons, cocoons where two mulberry silkworms have spun one cocoon together. In practice, many inferior-grade single cocoons are included in this reeling. Often contains long patches of shiny reeled thread, punctuated by characteristic slubs. Also refers to the slubby fabric woven with this thread as weft, which is popular for suiting, drapery, and upholstery. Also spelled dupionni, duppioni, doupioni, duopionni. Often incorrectly labeled as raw silk.

**Ecdysis** - Changing the larval skin, molting, shedding. Most caterpillars ecdyse four times (making five instars) before spinning.

**Ecllosion** - The emergence of the moth from the cocoon. I've seen both "eclode" and "eclose" for the verb form. Can also refer to hatching from the egg.

**Domesticated** - Tame and cared for by human beings. Chickens, horses, dogs, cats, and silkworm moths are all domesticated animals.

**Egg** - the female sex cell, which can unite with a male sex cell to produce a new silkworm.

**Fanning** - With mulberry silkworms, brushing the larvae off of the hatched eggs and onto the tray of mulberry leaves.
Silk Feasibility Study

**Fibroin** - One of the two silk proteins; the other is sericin. Fibroin is the protein which makes the long lustrous fibers.

**Filature** - A silk-reeling factory.

**Flacherie** - A gastric disease of silkworms. The worms become listless, limp, and discolored, and almost always die. Best prevention is by keeping rearing areas clean, well ventilated, and not too hot or humid.

**Floss** – A multi-purpose term with regards to silk. Embroidery thread is referred to as floss. Conversely, -floss silk- is often spun silk made from broken cocoons or cocoon strippings. The silk flossing on a cocoon is the rough irregular fibers laid down by the worm when it begins to spin, also called keba, blaze, or cocoon strippings.

**Frass** - Caterpillar poop.

**Grasserie** - A disease of silkworms which causes the infected worm to become swollen and yellow and to leak a milky hemolymph. Caused by a nuclear polyhedrosis virus.

**Habotai** – (also habutae, habutai) – Means “soft as down.” A Japanese fabric woven traditionally from very fine raw silk and then piece degummed. The threads are very loosely twisted, and this fabric is typically very thin and soft.

**Hankie** (also hanky, plural hankies) – A form of silk consisting of single cocoons degummed and stretched over a square frame to attenuate the fibers. Used in spinning silk thread, and in making padding for garments. Sometimes called silk squares: also see -mawata.

**Imago** - An adult insect; with the silkmoths, the imago is the moth.
Instar - A larval stage between two successive molts during this time the silkworm eats and grows. Most caterpillars have five, some have six or more.

Keba - The fluffy fiber used to anchor a Bombyx mori cocoon; it stays on the outside of the cocoon until it is removed. This is so called cocoon strippings, blaze, or flossing.

Kego (or keiko, or kesan) - A Japanese name for a hatchling silkworm.

Larva (plural larvae) - The immature stage of an insect. In moths, the larva is a caterpillar. Most silkmoths spend the vast majority of their life in the larval stage. In cultivated as well as wild silkmoths, the larval stage is the only part of the life cycle that can eat; the adults have no mouths or digestive organs.

Mawata - An attenuated cocoon, also called a silk hankie. Originally from a Japanese verb meaning -to pass around or spread. Mawata silk was first made in Japan from degummed silk cocoons that have been stretched over a frame to make insulating batts for clothing, bedding, etc. Square shapes were most common, however, cocoons were often stretched larger to fit in a sleeve area or length of kimono without having to attach squares. Production of this fiber form in Japan has declined and is kept for domestic use. Square -hankies- available today are processed in China.

Meconium - The reddish or tan liquid that a moth will squirt out of its body, sometimes upon hatching, sometimes when startled. The fluid accumulates during pupation, and is used in pumping out the wings. This is also called urine.

Metamorphosis - Stages are egg, larva, pupa, and adult. The silkworm grows and changes during these stages.
**Molting** - The process of growing a new skin and shedding the old one.

**Mountage** (or mounting) - The frame that silkworms are placed in to spin their cocoons. This is also the act of putting the silkworms in the frame to spin.

**Muscardine** - A fungal disease of silkworms. This disease is particularly virulent and contagious. The larvae die covered with white fuzzy patches.

**Noil** - The bits of silk that can't be reeled or spun into long-fiber thread. These are often very short and clumpy fibers, and are spun into a cotton-like yarn. Also refers to fabric woven from this yarn.

**Organzine** - A filament silk thread made of two or more twisted singles, twisted together in the opposite direction of the original twist. Organzine is the equivalent of a plied yarn, and is the multi-purpose workhorse of the reeled silk threads. Because of the twisting, which can range from fairly loose to very tight, the threads are better able to handle abrasion and less likely to snag. Organzine is used for silk warp in most weaving applications. Tabby fabric woven with organzine as both warp and weft is taffeta. The numbering system for organzine is the denier of the filament first (usually 21 or 40 for bombyx, 35 for tussah, in filature silk) followed by the number of filaments in a ply, followed by the number of plies.

**Pebrine** - A disease of silkworms caused by protozoa. Pebrine nearly wiped out culture of Bombyx mori in Europe. Successful management techniques were developed by Louis Pasteur.

**Pheromone** - A sexual attractant chemical. Female moths release pheromones which are detected by the males using their antennae; males will fly as much as several miles to mate with a scenting female.
**Polyvoltine** - Having more than one generation per year; often depending on climate.

**Pupa** (plural: pupae) - The stage of an insect between larva and adult. This stage is mostly immobile (many can wiggle) and often overwinters. When people talk about eating silkworms, this is the stage they go for, often stir-fried or grilled.

**Raw Silk** - Silk that has been reeled, but still has its sericin (gum) intact. It can be in the form of reeled filament, thrown threads, or fabrics. The term is often used loosely to refer to fabrics made from wild silk, such as tussah, to silk noil or waste silk, to doupionni silk, and to spun silk; however, these are all different things which each have their own specific terms. Raw silk can be woven into fabric, which is often desirable because the sericin protects the thread against abrasion. Some fabrics, such as silk organza, are left with the gum in, which creates a stiff crisp fabric suitable for veils and sheer draperies. Raw silk is typically finished by degumming, which uses either alkali or enzymes to remove some or all of the sericin, leaving the silk soft and lustrous.

**Reel** - (v) To unravel the silk from whole cocoons by winding it onto an apparatus. Reeled silk is the finest and most lustrous form of silk. (n) A tool used to unwind cocoons; in the simplest form, they are similar to tools used to measure skeins, and can often be used interchangeably. Filature reels are large machines; some of them are entirely automated, and require human attention only when they jam or need cleaning.

**Scenting** - Releasing a pheromone to attract a mate. Female moths scent with a special gland in their backsides which releases the pheromone

**Sericin** - A sticky substance produced by a silkworm’s body that holds strands of silk thread together.
Spin - drawing and twisting of various lengths of fiber; also, the activity of a caterpillar making its silk cocoon. Reeled silk is thrown, not spun, because there is no drafting involved.

Spinneret - The organ on a silkworm's chin that secretes the silk. Spiders have them also, but on their backsides.

Spiracle - A hole in the abdomen through which an insect breathes. On a silkmoth caterpillar, they are typically visible as dots down the caterpillar's sides.

Throwing - Twisting a reeled silk filament to make it stronger and more durable. Occasionally spelled throwsting, especially in older texts.

Tram - A heavy, low-twist reeled thread used for weft, brocading, and embroidery. Tram is usually made from multiple filaments twisted together 2 to 5 twists per inch.

True legs - The legs at the front of the caterpillar; these will look like its "hands." These will become the legs of the adult moth, or imago

Univoltine - Having only one brood, or generation, per year.

Wild silk - Silk which is gathered from wild-cocoons. In practice, these moths are frequently semi-domesticated, and raised on plantations. Often used to refer to any non-mulberry silk, such as Tussah, Eri, or Muga.

A note about micron size and silk: I often get asked by people who are accustomed to dealing with animal fibers, what the micron size is for silk. It's a complicated answer. The bave, as secreted by the caterpillar, is typically around 20 microns across in B. mori. There are of course variations for different strains, diet issues, etc. If this were a wool or alpaca fiber, it would be a thick one. The thing is – the bave includes two brins, and is up to 30% by weight of sericin
gum. After degumming, the two brins separate, and the gum is gone. After degumming, the brins are approximately 7 to 8 microns across, which is exceptionally fine.
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