# Black Powder six ways, using a hobbyist mill.

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## Introduction:

Recently, I was asked to evaluate a sample of dogwood (cornus florida) charcoal that I was given, for use in making black powder. I decided to use it to answer some of my own questions about production methods, with my newer, smaller hobbyist mill. The mill runs on 12 volts, is very small, and portable. It's made by Pyro-Gear in the UK, and sold in the USA by Woody's. The way I typically test black powder for lift is to first press it into test pucks of +1.7g/cc density, corn it, and grade it. Then, known weights of powders of specific grades are used to test the flight times of standard baseballs, shot from a 3" (76mm) fiberglass mortar. This way, processing methods and powder grades can be compared to each other with a reasonable degree of accuracy, suitable for general practical application.

According to Ned Gorski of Fireworking.com, a total baseball flight time of 7.5 seconds will lift a 3" ball shell to a suitable display height. I chose 10 gram quantities of powder for each of my tests. The powders were contained in condiment cups inserted in larger cups to center them and hold them upright. A long piece of thin black match with a visco leader was used for ignition. For each powder test, 3 flights were timed with a stopwatch, and averaged to give the result.

## Milling and screen-mixing details:

I am an advocate of making black powder with the components milled singly and then screen-mixed twice through 40 mesh. I decided to see how these kinds of powders would fare when milled in small quantities with a small diameter 4" (104mm) ID mill jar. These powders were compared to a batch of powder milled as a complete mixture. Due to the potential explosion hazard, the complete mixture was milled in a remote, safe location. A *similar* set of tests was previously done with a much larger mill with a much larger (Rebel 17) mill jar. Those results would not be directly comparable to the results of this series of tests, for various reasons. For this series, a charge of 6.6 pounds (3 kilograms) of 1/2" diameter 302 stainless steel spheres was used as the milling media. This filled the jar just over half full.

**Potassium nitrate:** For all tests, the starting material was Norwegian technical grade, milled in 250 gram batches for 2 hours, and screened through 40 mesh (American sieve size). Only the potassium nitrate that passed 40 mesh was used.

**Sulfur:** For all tests, 99% sulfur in the form of lenticular-shaped 'prills' was used. This is a deviation from all my previous testing, which used rubbermaker's sulfur. That source has dried up, and I was forced to go this route to get sulfur of reasonable purity. When one attempts to mill or screen sulfur by itself, the extreme 'clinginess' due to static charges will become apparent. To combat this problem, 2 short bursts of Static Guard spray were applied directly to the sulfur in the mill jar before closing. The sulfur was milled in 200 gram batches for 2 hours. Only the sulfur that passed 100 mesh (American sieve size) was used for these tests.

**Charcoal:** The dogwood (cornus florida) was provided to me by a member of Fireworking.com. The 'green' limbs were cut, split, and force-dried for 3 days by the donor before charring. I don't consider the exact details, beyond this brief description, to be important to this investigation. This series of tests was performed to answer some questions I had, and this charcoal happened to be the one donated for testing. 2 birds, one stone. For all tests, only charcoal passing 12 mesh (American sieve size) was used.

**The test batches:** 5 batches of powder were prepared, with 1 batch being split into 2 smaller batches, for a total of 6 test batches.

**1)** The -12 mesh charcoal was milled as a 100 gram batch for 2 hours. A 300 gram batch of 75-15-10 screen-mixed powder was prepared by mixing 45 grams of the product with 30 grams of the milled sulfur, and 225 grams of the milled potassium nitrate, and running the mixture twice through a 40 mesh screen.

**2)** The -12 mesh charcoal was milled for 4 hours, and a 300 gram batch of powder was prepared, as above.

**3, 4, 5)** The charcoal was milled for 6 hours, and prepared as above. An additional batch of charcoal was also milled for 6 hours, and a second identical batch of powder was prepared. The second batch was split into 2 smaller batches for further testing (more on that later).

**6)** A 300 gram batch of 75-15-10 was milled (remotely) as a complete mixture for 3 hours. The same -12 mesh charcoal, milled sulfur, and milled potassium nitrate were used as starting materials.

It should be noted at this time that this investigation is a casual study on what results are to be expected from a black powder used as lift, made with *this* charcoal, and prepared various ways. Sure, there is some value in comparing the results, but it would certainly be inappropriate to consider these results as any kind of unequivocal statement about dogwood charcoal in general, single component milling, or 3 component milling. As will be seen by the end of this article, black powder suitable for use as lift was produced with every batch tested.

The reader should easily see what would need to be done to use each of the powders to advantage in their application, and what they might need to do if they wanted to boost performance.

## Pucking, corning, and grading the powders:

The final powders were all prepared by moistening each batch with water, screening twice through a 20 mesh screen, with hand-mixing. Each batch was allowed to 'temper', to allow the moisture to distribute as evenly as possible throughout the mass. Test pucks were made using a test puck die that has a 'stop' on the plunger head, so that pucks of consistent thickness (and therefore, density) are produced. Obviously, the weight of powder and water need to be carefully calculated to produce pucks of the desired density (+1.7g/cc). The nominal test puck size is 1/2" thick and 2" in diameter (12.7mm X 50.8mm).

In the past, the amount of water used to prepare my test batches for pucking has been 8%, additional. This amount was derived from an article on Passfire, where the author used 10% additional water weight to press his pucks. The article concerned the preparation of black powder in a multi-puck die of larger diameter than my small, single puck die. The water helps to consolidate the powder, but it also serves to lubricate the walls, as it is partially squeezed out during pressing. Using 8% water was what I felt to be a moderate compromise. For consistency, I've stuck with it for all my pucked powders for testing. Indeed, I've stuck with it for most of this testing too. I'll admit, I have no love for the messiness involved with using this much water.

Recently, a member of Fireworking.com suggested that the ideal amount of water used for pucking might be just one drop more than it takes to consolidate the powder. This amount of water (whatever it is), would effectively displace any air in the mass to allow perfect consolidation, without making a mess or removing any oxidizer in dissolved form. At the same time, a suggestion was made that 2% water is an amount that some operators use to make pucks, though they were certainly not comparable in density or durability to commercial powder.

My opinion was that such a small amount of water would not allow a puck to be compressed to the same density as I am able to achieve, *without increasing the pressing force.* I wondered what force would be required to achieve a density of +1.7g/cc with varying amounts of water to dampen. I also wondered what the performances of the powders would be, and if more fines would be produced during the corning process. To answer these questions, I used the extra batch of powder referred to under batches **3, 4, 5)**. I moistened appropriate amounts of powder with 4% and 2% water, to produce pucks that would have the same weight after drying (and therefore, the same density). An attempt was also made to consolidate the powder with no additional water.

When pressing with 4% water, I was able to achieve my puck thickness (and thus, density) at the same force I used to press the same powder with 8% water. The press gauge read 4 tons, and my P to F gauge read 3 1/2 tons. The disparity in readings is a minor point that I feel obligated to include, for no particular reason. The press gauge was used for all pucks. With 4% water, not a drop was expressed. The damp powder was pleasant to handle. The puck was well-formed, and perfectly clean to handle as well. The dwell time was not (ever) measured, but seemed consistent with my 'normal' times.

The next batch was pressed with only 2% water. Surprisingly (to me), the powder pressed to the same density in the same time *at the same pressure* as the pucks using 8% and 4% water. The powder was a little dusty to handle, but produced pucks that had a satiny sheen I'd never seen previously. At this point, I was wondering if moisture was needed at all!

Finally, I took the same amount of dry powder that was used (before moistening) for the other pucks, and attempted to press a puck. The powder steadfastly resisted consolidation, and appeared unmoved by leaving it to dwell under pressure. The force was increased to 5, 6, and finally 7 tons on the press gauge. The dwell time was probably up around half an hour, instead of my usual (estimated) 5 minutes. I'm sure that there ~~is~~ might be an amount of force that would do the job of consolidating the dry powder to the same density as the other pucks, but I didn't want to risk damaging my equipment by going any further. I aborted, and attempted to eject the 'puck'. It crumbled upon ejection, and was discarded.

## Corning and grading:

All powders were corned by first placing the pucks inside an 18" (45cm) plastic pipe, which sat on an LDPE 'test cap'. The test caps are soft and pliable, so they resist damage by the corning process. With the apparatus sitting on an I-beam, a baseball bat fitted on the end with an aluminum meat hammer head was brought down on the pucks with a few good whacks. All powders were screened to remove -4 mesh (American sieve size) material, and the larger chunks poured back into the 'corning pipe'. The process was repeated over and over, until all powders passed 4 mesh. All powders were then shaken on 12 mesh. The powder that rested on the 12 mesh was called 2FA. The powder that passed 12 mesh was the shaken on a 16 mesh screen. The 12-16 mesh powder that rested on the screen was called 1Fg. These are the 2 grades of powder that were tested for this article.

To save making this report any more cumbersome and complicated than it already is, I'm not going to individually state the quantities of all the 2FA, 1Fg, and -16 mesh 'fines'. It should be sufficient to say that for all powders, the amounts of 2FA were all 'around' 2/3 of the batch weights, the 1Fg amounts were much less, and the fines roughly matched the 1Fg in quantity.

## The results:

All powders were tested with 10.0 gram charges as measured by triple beam balance, with standard baseballs weighing approximately 145 grams. All results are total flight times, measured with a standard mechanical stopwatch, averaged, and rounded to 1 decimal point.

**1) Screen-mixed powder, charcoal milled for 2 hours, 8% water to dampen:** average of 3 flights per grade: **2FA= 5.9 seconds 1Fg= 7.8 seconds**

**2) Screen-mixed powder, charcoal milled for 4 hours, 8% water to dampen:** average of 3 flights per grade: **2FA= 6.1 seconds 1Fg= 8.1 seconds**

**3) Screen-mixed powder, charcoal milled for 6 hours, 8% water to dampen:** average of 3 flights per grade: **2FA= 6.5 seconds 1Fg= 8.5 seconds**

**4) Screen-mixed powder, charcoal milled for 6 hours, 4% water to dampen:** average of 3 flights for 2FA, average of 2 flights for 1Fg:

**2FA= 6.8 seconds 1Fg= 7.8 seconds**

**5) Screen-mixed powder, charcoal milled for 6 hours, 2%water to dampen:** average of 3 flights for 2FA, average of 2 flights for 1Fg:

**2FA= 6.6 seconds 1Fg= 8.1 seconds**

**6) 75-15-10, (300 grams) milled as a complete mixture with milled potassium nitrate, milled sulfur, and -12 mesh charcoal:** average of 3 flights per grade:

**2FA= 6.6 seconds 1Fg= 8.7 seconds**

## Observations:

All powders fell short of expectations (7.5 seconds flight time) when tested as 2FA grades. All powders met (or exceeded) expectations when tested as 1Fg grades. Mill times with such a small mill are generally much higher than with larger mills. It's reasonable to expect that longer mill times with this mill would increase flight times, if desired. Obviously, the choice of charcoal has a great impact on black powder performance. It's reasonable to expect that using a different charcoal could influence the flight times greatly, up or down. At the end of the day, it's been shown that this charcoal can be used to make perfectly good black powder with a variety of processing methods, with a mill that is small, fully portable, and can be operated on battery current.

It was educational for me to learn that using 8% water (for single pucks) is over-kill, and unnecessarily messy. It was surprising to learn that using as little as 2% water could give good consolidation, good performance, and produce no more fines than if more water was used. Even more surprising was that no increase in pressing force or time was needed to get just as good consolidation as using a much greater amount of water.

These results were not presented graphically for two reasons. First, I lack the necessary skills, to put it bluntly. Second, and more importantly: there are inherent limitations in accuracy, using the testing method chosen. That's not to say that I know of a better method- I don't. Comparing results of these tests (that vary in fractions of a second, in many instances) should be done in a general way. It's been conclusively proven that this charcoal and this mill can produce good black powder, and that a cleaner process that uses less water can be used. It's up to the reader to apply this information in a way that may benefit their process. Even the weakest powder in the group could be used for lift, as 2FA grade. Simply increasing the amount of powder by a few grams is all that's necessary.