Rhubarb Research Project Summary

Before expanding production and investing in a processing plant, several major production and extraction questions need to be answered in determining the optimum rhubarb for a supreme juicing product?

1. What is the most efficient method of extracting the juice?
2. Which varieties of rhubarb give the most juice per acre?
3. Are their noticeable differences in the qualities of juice between different rhubarb varieties, extraction, storage and processing methods?

In addition to the above horticultural questions, before the rhubarb juice can be more widely marketed an approved Hazard Analysis Critical Control Points (HACCP) plan must be in place. The HACCP plan covers every aspect of the rhubarb juicing process from the production field to how the bottled rhubarb juice will be stored prior to distribution. The plan must be approved by Alaska DEC before the bottled rhubarb can be sold.
This project addressed the needs of this rapidly expanding section of the specialty crop industry. In order to meet the market demand, the questions outlined in this project must be answered.

Project Approach

- Consulting with people interested in growing rhubarb for juicing and with parties interested in selling juice at the farmers market
- Create and deliver a presentation at the 2015 SARE Conference
- Maintaining the new collection of rhubarb varieties at the UAF Matanuska Experiment Farm
- Refining the press and preparing it for powder coating
- Identifying a Process Authority that was willing to work on this project
- Making rhubarb juice for sampling by the Process Authority
- Incorporating the Critical Points identified in the Process Letter into the HACCP plans
- Revising the three HACCP plans that we hope to get approved

    1) Making frozen rhubarb chunks for sale and for use in the bladder press
    2) Using the Bladder press with commercially available frozen rhubarb chunks
    3) Using the mechanical press on freshly pulped rhubarb

- Working with DEC to establish the Standard Operating Procedures and the HACCP steps in the process

Goal 1 – Identify and purchase an appropriate vegetable shredder to pulp the rhubarb and fabricate a hydraulic press to squeeze the juice from the pulp. Using a factorial design compare the shredding versus freezing pre-treatments and the bladder press versus hydraulic press for extraction efficiency. Comparisons will be made on three rhubarb varieties.

Goals 2 & 3 – Using the MEF rhubarb collection measure the yields of the top 10 producing varieties under different harvest protocols. After measuring the fresh petioles extract the juice to determine the juicing implications associated with each harvest strategy. Determine the pH and brix level of the extracted juice treatments. Freeze the juice treatments and determine the pH and brix levels after 6 months of frozen storage to see how stable the frozen juice is.

Goal 4 – Working with the USDA FDA and the Alaska DEC food safety specialists develop a HACCP plan that will allow the Alaska Rhubarb Company to produce a safe and high-quality product. The plan will cover all aspects of rhubarb production, juicing, bottling and storage.

Goals and Outcomes Achieved

Objective 1: Determining the optimal rhubarb variety and harvest strategy for Alaska rhubarb.
In consultation with Drs. David Ianson and Danny Barney, both former curators of the National rhubarb germplasm collection housed at the Matanuska Experiment Farm in Palmer, ten varieties of rhubarb were chosen for the evaluation. Both curators had evaluated the collection for horticultural characteristics and were in good positions to advise which varieties had high juicing potential. The 10 varieties and their respective yields in the 2013 and 2014 growing seasons are given in Table 1 below. The harvest strategy used by Alaska's commercial rhubarb growers varies depending on the intended marketing plan. For sales in the farmers market the estimated amount that can be sold is harvested the day before market. The harvested plants are often 'high graded' with only the best stalks being picked with all other left remaining on the plant. This same process is repeated each week for market with picking pressure being spread out over the whole field. When the field is picked for juicing many more of the petioles (or stalks) are removed with some growers stripping all stalks from the plants. In the initial project proposal we were interested in determining if the juicing potential of the entire plant was similar or if the acidity varied throughout the season. Ultimately, the juice growers thought that while these biological nuances may be interesting the information was of no use to them. The juice growers were only interested in two criteria: Long-term survival of the crown and yield. The cost of harvest did not allow the luxury of separating the petioles from a potentially premium location on the plant from the other petioles. Efficient harvest mixed all marketable petioles in the harvest bin and left the unmarketable petioles on the ground. Likewise, the nuance of a slight change in brix as the plant matured was insignificant to the juice growers compared to the possibility of getting a larger yield of juiceable petioles or the need to harvest the rhubarb when time fit into the farm's management scheme rather than at some optimal time. Realistically, in the single pass heavy harvest strategy used by most growers for the juice market the crew will pull some immature stalks, some perfectly mature stalks, and a few slightly over mature stalks. Most consumers consider them all too acidic to drink directly and the rhubarb juice will be modified with another juice prior to consumption. The pH of the varieties ranged from 2.5 to 3.3 but, similar to stalk color, this trait is not stable from year to year. Interestingly, although the home gardeners are very interested in stalk color, the juicers didn't really care about the trait. One of them commented that a drop or two of black current juice when the rhubarb juice is added to the sweeter juice of choice (lemonade, pear juice, apple juice etc.) adds all the red color they need.

Horticultural Commentary:
The crowns in the field were planted in 2010 and were lightly harvested in 2012 so they were ready for a full harvest in 2013. The yields of some varieties in 2013 were incredible with a number of varieties (Sutton, Crimson Wine and German Wine #2) averaging over 30 lbs per plant. The marketable stalks could be sold at a premium price at the farmers market with plenty of lower quality stalks going to the juice bin. Unfortunately, after the fantastic 2013 harvest the rains stopped and a construction project delayed the installation of the irrigation system. By mid-August many of the plants were yellowing and senescing prematurely. Late summer irrigation was inadequate to make up for the drought and the subsequent 2014 harvest showed the consequence of poor bud formation during the previous drought. Sutton's total yield fell from 31.4 lbs to 10.2 lbs while Crimson Wine's and German Wine #2's yields fell from 33.4 and 32.4 to 4.0 and 3.4 lbs respectively. The dramatic lesson presented is that adequate watering, either through rainfall or irrigation is crucial for the next year's crop. Surprisingly, fertility was not as big an influence as expected. Although it is known that rhubarb production rewards appropriate fertilizer application these plots had not been fertilized since they were established. They were

essentially coasting on their initial fertility level. Since the plots were scheduled for destruction in 2015 the decision was made to not fertilize them but normal production fields are usually fertilized at rates about 120 lbs N/ac, 80 lbs P/ac and 100 lbs K/ac. If one prepares the soil well, maintains fertility and irrigates when needed rhubarb is incredibly productive in Southcentral Alaska.

Table 1 Seasonal Yields of Marketable Stalks and Total Stalks

	Lbs. Marketable Stalks		Lbs. Total Stalks	
Variety	2013	2014	2013	2014
Sutton	11.4	9.1	31.4	10.2
The Sutton	13.2	7.2	19.9	7.9
Sutton Seedless	10.5	8.0	16.6	8.3
Crimson Wine	13.7	3.6	33.4	4.0
German Wine #2	19.6	3.1	32.4	3.4
Crimson Delicious	10.7	5.1	23.4	5.9
Timperly Early	1.5	3.7	1.7	4.1
Goliath	6.4	2.2	14.7	2.4
Crimson Cherry	8.8	2.0	16.1	2.2
Strawberry	3.4	2.0	5.5	2.2

Pounds per plant (Average of 5 plants)

Objective 2: Developing a mechanical press to process fresh rhubarb pulp: Bladder Pressing thawed rhubarb chunks

The previous strategy for pressing rhubarb relies on a bladder press which uses garden hose pressure to inflate a rubber bladder which then squeezes the rhubarb against the stainless-steel mesh sidewall. Unfortunately, the bladder press is designed for soft fruits and the rhubarb must be frozen and thawed for the press to be effective. The process of freezing the rhubarb causes ice crystals to puncture the cell walls and once thawed the previously hard rhubarb petiole is now soft enough for the bladder press to effectively squeeze the juice out. Numerous runs have shown the efficiency level of the bladder press to be very close to 10 pounds of fresh rhubarb, frozen and then thawed yields 1 gallon of rhubarb juice. The bladder press is quite effective on larger loads. A pressing cycle with 16 gallons of thawed chunks takes about 30 minutes to fill, press, allow the juice to drain out, release the press pressure and clean the pulp out and prepare for the next load of thawed chunks.

The bladder press procedure works fine but the bottleneck to the process is the freezing and thawing steps. There are two strategies to the freezing step. One is to harvest the marketable rhubarb and sell it to a vegetable processor in Anchorage receiving wholesale prices for the fresh rhubarb. The processor will chop, package, freeze and store the rhubarb. We can purchase the frozen chopped rhubarb as any other customer could at their regular bulk rates. There are two advantages to this strategy. One is that the processor has huge freezer capacities, well beyond what a farm could afford to have. This allows them to store significant amounts of frozen rhubarb for the period of time between harvest and when the juicers start to make the juice. The other advantage comes into play when the juicer want to have a DEC inspected product which they can wholesale to non-end users. The vegetable processing facility is inspected by DEC and they have a Hazzard Analysis Critical Control Point (HACCP) Plan in place. Their HACCP certification comes with the frozen chunks to become a portion of our HACCP Plan for the final juice product.

Mechanically Pressing pulped rhubarb

In this method rhubarb is pulped and poured on to special dacron press cloths to a depth of about 2" and the remainder of cloth is folded on top of the pulp (somewhat like diapering a baby). This layer of pulp within the press cloth is called a 'cheese'. A plastic spacer is placed on the cheese and a new cheese is built on top of the previous one. This process is repeated until you have a stack of cheeses up to the heigt of the press opening. A jack forces the press plate against the cheeses extruding the juices out into the catch tray while the press cloth holds the pulp in.

The Cuisinart food processor was upgraded to a RoboCoupe continuous flow food processor. This unit does not deposit the cut pieces into a bowl or hopper but rather flings them out a side chute into an adjacent container of your choice. The RoboCoupe is able to slice the petioles about as fast as I can put them into the feed chute. As noted above it was able to turn 10 lbs. of petioles into 1/8" slices in under 2 minutes.

Recognizing that it was the long fibers that fouled up the grinder's auger we tried a meat grinder to pulp the rhubarb slices. The short fibers of the slices were much easier on the grinder than the chunks originally tried but still about every 2 lbs. of slices the pulp stopped coming out the discharge chute and the auger had to be pulled out and cleaned. Luckily, with the shorter fibers the auger easily came out and the fibers were easy to clean out. Much of the 28 minutes that it took pulping the 10 lbs. of rhubarb slices were actually the time it took to pull the unit apart 5 times and clean it out. Cleaning difficulties aside, the pulp that came out was just perfect for pressing. The pulp was broken down enough that we had good amount of liquids released from the cells and not too fine that large amounts of fine particles came along with the juice.

In the current process the pulping step is the bottleneck. With the numerous times we have to clean out the auger it brings out total processing time to around 2 gal per hour from field stalk into juice. We still search for effective ways to pulp the rhubarb. There are numerous examples of homemade fruit pulpers on the internet but most of them would not pass OSHA inspection much less DEC inspection. Apple pulpers are readily available but apples don't have the levels of fibers that rhubarb does and it is not likely that these pulpers would work for us. What I think would be almost perfect for us is a leaf chipper. The blades are capable of turning sticks into sawdust and the screens are adjustable in size. When I mentioned that to the equipment salesperson their comment was unless it was made of stainless steel it not going to pass DEC inspection so keep dreaming. When visiting a food processing pilot plant at Oregon State University I was shown a continuous flow vegetable juicer that looked like it would solve our troubles. If only the cost wasn't $25,000…

The meat grinder following the slicer is showing potential. There may be a way to modify the auger to better deal with the fibers. An alternative is to increase the size of the strainer at the end of the auger to allow material to pass through easier. It would be quicker to coarse grind and the regrind with a finer strainer than to have to clean out the auger every 2 lbs. Another avenue for us to test out is to try a larger grater blade for the RoboCoupe. Possibly a larger grater opening would cut the fibers more effectively than the small grater blade that we initially got.

The press:

The press is patterned after a batch method cider press. The frame is fabricated from heavy duty (1/4" wall) 2x3" rectangular tubing and creating it was an iterative process. The press was returned to the fabricator three times to strengthen additional points. The majority of modifications were in strengthening the base. There was so much force from the press arm that the bottom of the juice catching tray was deforming until the base had additional thick wall 2x2" tubing put in for reinforcement. The pressing surface is designed around 15" by 23" food service trays for easy cleaning. The 25" opening between the base and the top press plate allow up to 10 press cloth layers to be run at once. In between the press cloth cheeses are ½" slotted plates made from food grade plastic. These plates have groves cut in the top and bottom surfaces to let the juice easily run out from the middle of the press pile. The cycle

time of this mechanical press is much shorter than the bladder press. It is capable of pressing several hundred pounds of pulp in under 20 minutes. This pulp could either be thawed rhubarb of fresh rhubarb that has been ground into a pulp. Although the press was built stoutly enough to handle a 10-20 ton hydraulic jack to power the press in the future the current pressing force is delivered by a mechanical 'farm jack' (Hi-Low Brand). The mechanical jack was chosen for inspection simplicity since there is no hydraulic fluid to potentially contaminate the juice. Initial trials have shown the 7,000 lb. force generated by the jack to be adequate and the speed is quicker than a hydraulic cylinder using a hand pump.
Juice Pressing numbers: 10.18 lbs. of washed rhubarb were sliced in 2 minutes using the RoboCoupe continuous flow food processor. The resulting slices were then run through a meat grinder to form a pulp and 9.54 lbs of pulp and juice came out. It took 27 minutes and the grinder was pulled apart 5 times to clean out the fibers as part of this time. The half a pound loss was left as slices in the slicer, pulp in the grinder, spilled liquid in the process or wet juices on the trays. So, the pulping step tool about 30 minutes for 10 lbs of rhubarb. The 9.5 lbs. of pulp were put on the press cloth and pressed for 3 minutes. There was 2.75 lbs. of pulp left on the press cloth and the process yielded 3.75 quarts (120 oz) of juice. The bladder press process using frozen rhubarb yields 4 quarts (128 oz) of juice per 10 lbs. of fresh rhubarb so our non-freezing process has an extraction efficiency of almost 94% of the frozen chunk method.
Because of our pulping inefficiencies the frozen chunk method is still more efficient when process time is factored in but the indications are very strong that when we find an efficient method of pulping the fresh rhubarb at a rate of 200 lbs per hour the efficiencies will be in the favor of the pulping-mechanical press method. The ability to efficiently pulp large amounts of fresh rhubarb will help us get around our current freezer bottleneck.

Objective 3: Getting the process certified by DEC for wholesale sales and off-site preparation.
The rhubarb juice is sold as a part of a beverage at fairs and other gatherings. The process falls under the Cottage Industry regulations where the product must be made on the day of sale and the customer must purchase the beverage from the person that made it. While we are currently able to work with these regulations our goal is to develop an inspection protocol to prepare the rhubarb juice in a certified kitchen at one time of year and be able to sell the product at a later date and to other food preparers. Our initial marketing efforts have identified interest in bottled rhubarb juice from both bar tenders and caterers. Having a DEC inspected process would facilitate these sales.
So, that's where the project currently sits at the end of the grant time frame. We have the crucial Process Letter and we have submitted three HACCP plans for evaluation. Once the plans have been accepted, we will work with our DEC inspector on how to set up the process that they can inspect and certify. We will then be able to sell the bottled rhubarb juice to non-end users such as caterers and restaurants and we can prepare the product weeks before the heavy need times for selling rhubarb-based drinks in the fair booths.

Activities Performed

Rhubarb Yield:
The yields of the 10 rhubarb lines harvested at the Matanuska Experiment Farm (MEF) were as dismal in 2014 as they were outstanding in 2013. In 2013, the average yields per plant of the varieties 'Sutton', 'Crimson Wine' and 'German Wine #2' exceeded 30 pounds. In the 2014 harvest only the variety 'Sutton' averaged more than 10 pounds per plant with most varieties averaging in the 3-7 pound range.

Total Harvested Weights:

Variety	2014 Rank	2014 Total lbs	2013 Rank	2013 Total lbs
Sutton	1	10.2	3	31.4

Crimson Wine	6	4.0	1	33.4
Sutton Seedless	2	8.3	6	16.6
The Sutton	3	7.9	5	19.9
Crimson Delicious	4	5.9	4	23.4
German Wine #2	7	3.4	2	32.4
Timperly Early	5	4.1	10	1.7
Goliath	8	2.4	8	14.7
Crimson Cherry	9	2.2	7	16.1
Strawberry	10	2.2	9	5.5

Marketable Weight

Variety	2014 Rank	2014 Total lbs	2013 Rank	2013 Total lbs
Sutton	1	9.1	4	11.4
The Sutton	3	7.2	3	13.2
Sutton Seedless	2	8	6	10.5
Crimson Wine	6	3.6	2	13.7
German Wine #2	7	3.1	1	19.6
Crimson Delicious	4	5.1	5	10.7
Timperly Early	5	3.7	10	1.5
Goliath	8	2.2	8	6.4
Crimson Cherry	10	2.0	7	8.8
Strawberry	9	2.0	9	3.4

The varieties in both Tables 1 and 2 are listed in decreasing overall rank between the two harvested seasons. When comparing the two tables we see that the ranking does not vary much between Total Weight, which is most appropriate for determining juicing potential, and Marketable Weight, which is more appropriate for evaluating the varieties for their culinary potential. The Marketable weight is essentially high grading the Total weight for the best material.

When looking at the ranking of the individual varieties we see that although there are some slight rearrangements the best varieties on 2013 also did well in 2014 and the worst performing varieties of 2013 were also the worst performing varieties for 2014. One strong exception to that trend is German Wine #2. It ranked #2 in 2013 with an impressive average yield of 32 lbs per plant and in 2014 its ranking dropped to #7 with a measly average of 3.3 lbs per plant.

I think the major reason for the huge differences between the yields of the 2013 season and the 2014 is moisture stress. After the 2013 harvest there was very little rain and due to the haying operation in the surrounding field, irrigation was not applied until late August when the plants were showing significant drought stress. The 2014 irrigation situation was even worse. With the theft of a critical fitting from the reservoir no irrigation occurred for the entire growing season. Additional evidence that the yield differences were associated with water deficit was seen when comparing the MEF plants with my personal production field about three miles away. Since I was able to irrigate both seasons the yields in my production field were both excellent.

Another indication of how dry the field was came from trying to get juice from individual stalks to determine brix and pH levels of the different varieties. Neither a powerful blender (Vitamix) or a commercial juicing unit could extract adequate juice to clarify and make the determinations on.

Beneficiaries

Although the Alaska rhubarb company is spearheading this project the final beneficiaries are all the rhubarb growers in the state. Since this project has begun, I receive about 4 emails a year from producers that are interested in growing for this project. Likewise, both UAF CES and the Alaska DEC has sent people interested in small-scale juicing my way for assistance in getting their product through the inspection hoops.

Lessons Learned

1. The mechanical press that we designed and had fabricated along with the purchased press cloths and food trays was a similar price as the commercially available bladder press. When both presses are processing thawed rhubarb, the mechanical press is much faster than the bladder press. This extra speed comes at a slight efficiency cost. Possibly if the press was allowed to sit as long as the bladder press has to sit the efficiencies may turn out to be similar, but the mechanical press just is able to cycle through larger loads than the bladder press and it does it in a quicker cycle time.
2. Horticultural management is much more important than the nuances of which part of the part is optimal and when would be the perfect picking time. The growers were interested in high yield of 'good enough' product. Perfection too much time to achieve and wasn't determined to be cost effective. Also, irrigation is critical! Drought stress in 2013 was very closely associated with poor 2014 yields. 2013 was a warm summer and had the plants not been drought stressed they would have grown wonderfully. On a different production site where I was able to get irrigation my 2014 harvest was almost as good as my 2013 harvest. Also, as we have seen in rhubarb the characteristics are not completely stable. Stalk color (intensity of red) changes from year to year and the highest yielding variety in one year may not be the highest yielding variety in the next season.
3. DEC staff is very willing to work with a processor as they try to establish an appropriate protocol. Over and over they stated that they would rather help you avoid a problem than have to work with producers to correct a problem. Unfortunately, processing rhubarb juice is not an area in which anyone in Alaska has experience and we have to get outside expertise in to consult on the project. It often takes inordinate amounts of time to identify the person with the expertise and then it is difficult to do all the collaborating remotely. Over the three-year timeframe of the grant we have made significant progress in the certification area, but we are not completely there yet.