

Evaluation of 8 Processing Tomato Varieties for Sun Drying in Northern Afghanistan

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Introduction

There is significant potential to develop the export market for dried fruit and vegetables in Balkh, and possibly other northern provinces. There is intensive, irrigated vegetable production near and around Mazar-i-Sharif, particularly in Dedadhi, Sherabad and Balkh districts. Vegetables such as tomatoes, cucumbers, eggplant, okra, onions, watermelon, melon, hot peppers, spinach, carrots, various greens, cabbage and cauliflower are grown. Mazar serves as the main market for this production area. The market is characterized by relatively high prices early in the season, and then a steady decline in prices as the market becomes flooded with produce. This is especially true for a crop like tomatoes, which are widely grown, highly perishable and packed in wooded crates for transport, a packing method that increases post harvest losses. Farmers often have little or no choice of whom or when to sell highly perishable crops, as there is no cold storage or processing for fruit and vegetables and none being developed in the foreseeable future due to a poor electricity supply. However, with a low cost vegetable processing method such as sun drying, farmers could gain more income from tomato production.

There is a demand for sun dried tomatoes in the U.S. Some Central countries, such as Uzbekistan and Kyrgyzstan, are attempting to meet this market demand. It is also possible that Afghanistan could enter this market with a high quality product. Tomatoes grow very well in Balkh province, and there are high temperatures and uninterrupted sunshine for sun drying.

However, one of the first steps is to determine what processing tomato varieties are needed and which ones have the right qualities (e.g., yield, sugar content). This report describes a variety trial that evaluated 8 processing tomato varieties for their suitability for Balkh province in northern Afghanistan. It also describes the drying methods used on two batches of tomatoes and examines the potential to export sun dried tomatoes.

Materials & Methods

Eight varieties of processing tomato (all determinate Roma types) were put into a trial of 3 replications. Seven varieties were from the Campbell Seed Co. and one variety, 'Roma VF,' was the check variety (see Table 1). The seven Campbell varieties are hybrids and were specifically developed for drying.

Table 1. List of processing tomato varieties evaluated at JDA Dedadhi farm in Balkh

CXD 226

CXD 222

Roma VF (check, OP)

CXD 253

CXD 142

CXD 265

CXD 258

CXD 223

Entries were seeded and transplanted according to the local system. Seeds were planted on February 8 into soil that had animal manure mixed into it. This was all done under a low plastic tunnel (see Picture 1 for an example) to provide heat for germination. Plants were transplanted on April 12 into the ditch-furrow system used by Afghan farmers to grow tomatoes (see Picture 2). Although 8 plants/plot was aimed for, some plots had 6 or 7 plants. Plants were transplanted 60cm apart and rows were 2.8m apart. The area of each plot was effectively 10.6m².

Each transplant was planted into soil that had a mixture of manure and DAP that had been applied and buried earlier. No other fertilizer was added during the rest of the season. The plot was irrigated as needed, which was approximately every 5-7 days.

After the plants had grown for about 3 weeks soil from the ditches was mounded up to help support the plant. This is a typical Afghan cultural practice in tomato production (see Picture 3).

Because some plants were transplanted when they were rather large, there was some very early fruit production, probably caused by transplant shock. Therefore, all fruit was removed from plants on May 7 so that plants had more time to grow vegetatively so they would support more fruit later on during the season.

The first harvest was done on June 18 and the last harvest on August 1. For harvest, fruit was divided by marketable and unmarketable yield. The criteria for unmarketable fruits were blossom end rot (BER), sunscald (SS), and insect and fungal damage. A qualitative rating was given for foliage cover and notes made on any tendency in varieties toward fruit disorders such as BER and SS. Good foliage cover will reduce SS and give more marketable fruit. Soluble solids (Brix - %) ¹ and individual fruit weight data was taken on 5 sample fruits at four of the six harvests.

The Campbell's varieties were developed for drying, so two harvests of all 8 varieties in the trial were sun dried after being soaked in potassium bisulfite. The drying procedure is described in Appendix 1.

For statistical analysis, significant differences between means were detected using Tukey's test (Statistix 7.0) at the 5% confidence level.

¹The Brix meter is the standard tool for rapidly measuring percent soluble solids in a fruit, which is an indicator of percent sugars and ripeness.



Picture 1. Low plastic tunnel system for growing tomato transplants (JDA research farm, Dedadhi, Balkh).



Picture 2. Processing tomato plot planted according to Afghan ditch-furrow system (Dedadhi, Balkh).



Picture 3. Afghan cultural practice of mounding of tomato plants for support.

Results & Discussion

Overall the Campbell varieties did very well against the check ‘Roma VF.’ Table 2 summarizes the results of the replicated trial. There was no significant difference in yield, fresh:dry ratio or fruit size. However, there were significant differences in the percentage of soluble solids, earliness and susceptibility to BER. ‘CXD 226,’ ‘CXD 265’ and ‘Roma VF’ had the highest soluble solids of the varieties, with means of 5.59%, 5.55% and 5.27%, respectively. The qualitative value assigned to foliage cover showed that ‘CXD 265’ and ‘CXD 222’ had the best foliage cover. Roma VF was the latest variety and was most susceptible to BER. ‘CXD 258’ was also susceptible to BER. There was a tendency in all varieties for BER to increase as the season progressed.

Table 2. Average yield, soluble solids, fresh:dry ratio, fruit size and foliage cover for processing tomato replicated trial.

| Variety | Yield (mt/ha)* | Soluble Solids (%) ^w | Fresh:Dry Ratio | Fruit Size (g) | Foliage Cover ^x | Notes |
|---------|-------------------|---------------------------------|-------------------|--------------------|----------------------------|--|
| CXD 222 | 27.7 ^a | 5.3 ^{bc} | 12.2 ^a | 101.6 ^a | 4.3 | |
| CXD 226 | 26.9 ^a | 5.6 ^a | 12.2 ^a | 98.3 ^a | 3.7 | |
| CXD 223 | 26.3 ^a | 5.0 ^{cd} | 13.0 ^a | 96.8 ^a | 3.7 | |
| CXD 265 | 25.2 ^a | 5.6 ^{ab} | 13.4 ^a | 95.1 ^a | 4.7 | |
| CXD 142 | 25.1 ^a | 5.1 ^{cd} | 13.9 ^a | 107.6 ^a | 2.7 | |
| CXD 253 | 21.9 ^a | 4.9 ^d | 13.8 ^a | 101.2 ^a | 4.0 | |
| CXD 258 | 19.7 ^a | 5.1 ^{cd} | 13.6 ^a | 81.6 ^b | 4.0 | Susceptible to BER |
| Roma VF | 18.8 ^a | 5.3 ^{abc} | 13.2 ^a | 101.8 ^a | 4.0 | Most susceptible to BER, latest variety. |

*Means followed by a common letter are not significantly different at the 5% level of significance.

^wTotal soluble solids determined with a National Industrial Supply Refractometer, 0% to 32% scale.

^xFoliage cover scale: 1 = least leaf cover, many fruit exposed to sun; 5 = most leaf cover, so that most fruit is protected from sun.



Picture 4. CXD 222.



Picture 5. CXD 226.



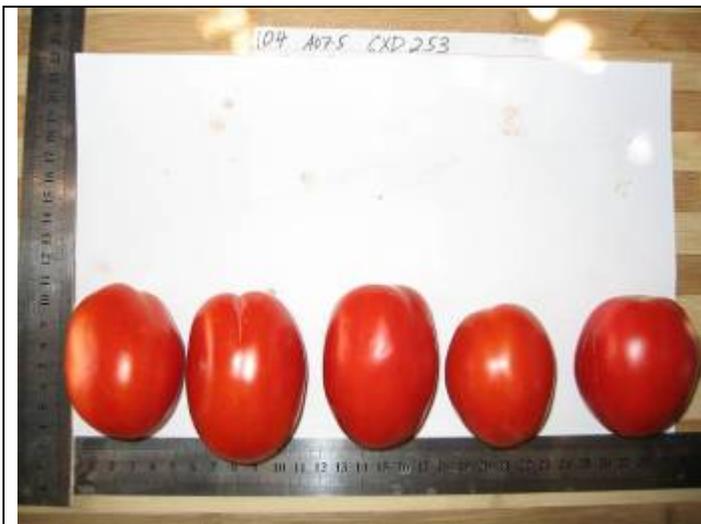
Picture 6. CXD 223



Picture 7. CXD 265



Picture 8. CXD 142.



Picture 9. CXD 253.





Picture 10. CXD 258.



Picture 11. Roma VF.

Although the last harvest was done on August 1, by August 8 many plants had begun putting out new flowers, which went on to develop into fruit that were generally smaller than normal. This was in contrast to local, fresh (“beefsteak”) tomato plants in the area that had mostly senesced or succumbed to disease.

Clearly, most of the Campbell varieties are well adapted to Afghanistan’s growing conditions. Taking into account soluble solids and foliage cover, the varieties ‘CXD 226’ and ‘CXD 265’ had the best performance. Good foliage cover is important to reduce damage from sunscald (SS), which decreases marketable yield. The conditions in Balkh, Afghanistan are ideal for SS damage as the time between May and August, when tomato fruit are developing and ripening, has very little cloud cover. See Picture 12 for an example of sunscald damage.

Two varieties— Roma VF and CXD 258 were more susceptible to BER in the earlier part of the season than the other varieties. BER was also present very early in the season on a small number of fruit throughout the plot (see Picture 13 for an example of BER). The Afghan farmer who was hired by JDA to work at the JDA research farm commented that all the tomatoes grown by farmers have this problem to begin with, but then it goes away.



Picture 12. Sunscald damage (white area) on fruit.



Picture 13. Blossom end rot (BER).

BER is caused by insufficient calcium during fruit formation. Calcium deficiency can be caused by too much nitrogen being applied, rapid plant growth, and large fluctuations in moisture. This plot did not have any additional nitrogen applied after the initial manure and DAP application before transplanting.²

Plants did grow fairly rapidly due to Balkh's typical hot summers, and water was readily available, although there may have been some gaps between irrigations that were too long. It is possible that the soil properties contributed to binding up available calcium.

There was also some fruit rot early in the season that tended to be concentrated on the lower part of the plant where the fruit was often touching the soil and there was little air circulation because of the plant structure, thus allowing for moisture build up on this part of the plant (see Picture 14 for an example of rot). In addition, the local practice is to dig into the irrigation ditch between the beds and mound up the soil on the side of the tomato plant that is facing the ditch. This is done to support the plant, but it likely contributes to less air circulation for the first crop of fruit developing near the base of the plant.

² DAP is 18% N and 46% P.



Picture 14. Rot with secondary attack by insects.

All of these varieties are also well suited for sun drying. Sun dried samples of each variety have been sent back to the States for quality analysis. If the samples come back as clean and of acceptable market quality, there is excellent potential for a sun dried tomato business to be started in Balkh province. There is demand in Turkey, Europe and the United States for sun dried tomatoes. Buyers exist who would be willing to buy sun dried tomatoes from Afghanistan if the quality, quantity and price are right.

Compared to U.S. yields of processing tomatoes, the yields obtained in this trial are low. According to the USDA, the average yield in 1960 of processing tomatoes in the U.S. was 32.5 mt/ha (see Table 3) while the highest yield in this trial was 27.7 mt/ha. Yields in other countries range from 43.8 mt/ha (Brazil) to 98.9 mt/ha (Israel) from 1995 – 2000 (see Table 4). In China in 2003, the estimated processing tomato yield was 41.2 mt/ha (source: 2005 Tomato Products Situation and Outlook, USDA FAS). Obviously Afghanistan has a long way to go to attain comparable yields, but this can be done with some simple improved production practices.

Table 3. U.S. yields of processing tomatoes for selected years. Source: *Vegetables and Melons Outlook/VGS-317/October 19, 2006*, Economic Research Service, USDA & *Vegetables and Melons Outlook/VGS-308/April 21, 2005*, Economic Research Service, USDA.

| Year | mt/ha |
|-------------|--------------|
| 1960 | 32.5 |
| 1980 | 52.9 |
| 2004 | 91.4 |
| 2005 | 81.1 |

Table 4. Yields for Processing Tomatoes in selected countries, 1995 – 2000, Source: FAO-STAT.

| Country | MT/HA | | | | | |
|---------------------------|-------------|-------------|-------------|-------------|-------------|-------------|
| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
| EU Average | 51.3 | 59.1 | 52.0 | 58.5 | 59.0 | 59.5 |
| France | 55.8 | 57.9 | 52.0 | 63.3 | 61.7 | 60.0 |
| Greece | 59.1 | 65.5 | 59.3 | 62.4 | 56.3 | 60.0 |
| Italy | 44.2 | 48.8 | 46.9 | 54.7 | 58.3 | 55.0 |
| Portugal | 59.3 | 64.6 | 55.1 | 58.1 | 59.7 | 63.5 |
| Spain | 38.0 | 58.6 | 46.5 | 54.0 | 59.2 | 59.2 |
| Selected Others | | | | | | |
| Brazil | 45.9 | 43.8 | 45.6 | 45.3 | 57.2 | 54.1 |
| Chile | 73.8 | 74.4 | 75.0 | 73.6 | 76.0 | 75.0 |
| Israel | 98.9 | 97.0 | 92.8 | 88.1 | 88.1 | 92.9 |
| México | 45.8 | 52.6 | 45.5 | 47.6 | 58.7 | 50.0 |
| United States | 73.4 | 75.4 | 78.9 | 70.2 | 82.1 | 76.7 |
| 10-Country Average | 59.4 | 63.9 | 59.8 | 61.7 | 64.7 | 64.6 |

Higher yields could be obtained through increasing planting density and improving soil fertility. The number of plants/unit area could be increased by reducing the row to row distances. As these Campbell varieties are highly determinate and compact, row to row distance on the bed could be reduced from 2.8m to at least 2m, and maybe 1m. Plant to plant distance could also be reduced from 60cm to 40cm. These higher densities would give yields of 60 – 70 mt/ha.

To improve soil fertility, an application of urea would be helpful as long as it is before flowering, otherwise the nitrogen will encourage vegetative growth when the plant needs to be putting its' resources into flower and fruit production. Remedying the calcium deficiency is more problematic, given that agricultural sources of calcium amendments are not available in Afghanistan.

Potential for Export of Sun Dried Tomatoes

Using the highest yield figure from this trial (27.7 mt/ha), and the average drying ratio of all varieties (13.1:1), it would take 7.1 ha of fresh production to fill one 20' container of dried tomatoes. For twenty 20' containers it would take 142 ha of fresh production (see Table 5).

Table 5. Production of sun dried tomatoes at 27.7 mt/ha.

| | Number | units |
|---|----------------------|-------|
| 1 x 20' container of sun dried tomatoes | 15 | mt |
| Fresh yield - tomatoes | 27.7 | mt/ha |
| Dry yield @ 13.1:1 (Fresh:Dry) | 2.1 | mt/ha |
| # of ha needed to plant to fill 1 x 20' container | 7.1 | ha |
| # of ha needed to plant to fill 20 x 20' containers | 141.6 | ha |
| # of mt dried tomato in 20 x 20' container | 300.0 | mt |
| Price for dried tomato- FOB | \$ 1.50 | kg |
| Price for dried tomato- FOB | \$ 1,500.00 | mt |
| Income from 20 x 20' containers | \$ 450,000.00 | |

As discussed earlier it is very plausible that yields could be increased with better production practices. With a modest yield increase to 40 mt/ha, which is certainly attainable, the hectares needed to fill one container with dried tomatoes decreases to 4.9 ha. For twenty 20' containers it would take 98 ha of fresh production. With a significant yield increase to 60 mt/ha, which is a U.S. yield, 3.3 ha are needed to fill one 20' container with dried tomatoes. For twenty 20' containers it would take 66 ha of fresh production. See Table 6 for details.

Table 6. Production of sun dried tomatoes at 40 and 60 mt/ha.

| | 40 mt/ha | | 60 mt/ha | |
|---|----------------------|-------|----------------------|-------|
| | Number | units | Number | units |
| 1 x 20' container of sun dried tomatoes | 15 | mt | 15 | mt |
| Fresh yield - tomatoes | 40.0 | mt/ha | 60.0 | mt/ha |
| Dry Yield @ 13.1:1 (Fresh:Dry) | 3.1 | mt/ha | 4.6 | mt/ha |
| # of ha needed to plant to fill 1 x 20' container | 4.9 | ha | 3.3 | ha |
| # of ha needed to plant to fill 20 x 20' containers | 98.3 | ha | 65.5 | ha |
| # of mt dried tomato in 20 x 20' container | 300.0 | mt | 300.0 | mt |
| Price for dried tomato- FOB | \$ 1.50 | kg | \$ 1.50 | kg |
| Price for dried tomato- FOB | \$ 1,500.00 | mt | \$ 1,500.00 | mt |
| Income from 20 x 20' containers | \$ 450,000.00 | | \$ 450,000.00 | |

Conclusions

The Campbell varieties 'CXD 226' and 'CXD 265' had the best overall performance in terms of soluble solids and foliage cover. Fresh:dry ratios were very good, ranging from 12.15:1 to 13.85:1. The check variety 'Roma VF' was inferior in terms of earliness, soluble solids and foliage cover.

There is excellent potential for the Campbell varieties 'CXD 226' and 'CXD 265' to be grown by Afghan farmers for sun drying. A collection and processing center would be needed to create "market pull" for farmers to grow these varieties. Because large areas would need to be put under production to obtain enough dried tomato quantity to fill shipping containers, the price offered to farmers for their tomatoes would have to mirror the fresh tomato market price. Farmers would not displace their fresh tomato production for a processing tomato that would be bought at a lower price. The market price for processing types is lower than the round, fresh types. At the peak tomato season in Mazar, retail prices are 5 Afs/kg (= \$0.10) for processing types and 8 – 10 Afs/kg (\$0.16 – 0.20) for fresh types.

Appendix 1 – Drying protocol for processing tomatoes.

Two concentrations of potassium bisulfite, 6% and 8%, were used on two separately dried batches of processing type tomatoes.

Materials

- 6% or 8% potassium bisulfite solution (6% = 6.4g $K_2S_2O_5$ /100mL water, 8% = 8.7 g $K_2S_2O_5$ /100mL); use tomato:solution ratio of 1:3 (= 1 kg of tomatoes:3L solution)
- Clorox
- 4 bins/buckets to wash tomatoes
- 2 bins/buckets to soak tomatoes in potassium bisulfite
- Sieve to scoop out tomatoes from solution
- Latex gloves for handling fruit (to keep fruit clean)
- Use 8 varieties of tomatoes from Dedadhi JDA farm; combine fruit from replicated plots according to variety.
 - Try to dry 5 – 10 kg/variety (= 15L – 30L solution)
- Remy for drying tomatoes- protects from dirt and dust.

Procedure

1. Sort tomatoes into unmarketable and marketable, save marketable.
2. Remove any stems from fruit.
3. Weigh fruit to be dried.
4. Wash fruit in clean water- 2 rinses (2 buckets/bins).
5. Rinse fruit in chlorinated water (1 bucket/bin).
6. Rinse fruit in clean water (1 bucket/bin).
7. Slice fruit open from stem to blossom end.
8. Dip fruit in 6% or 8% potassium bisulfite solution for 5 minutes.
9. Place on drying surface (Remy) and cover with Remy for 3-5 days; monitor every other day to check drying progress. This must be done in an area where there is full sunlight for as many hours of the day as possible. Keep varieties separate from each other. Do not let dried fruit get hard.
10. After drying, weigh to get fresh:dry weight ratio.
11. Bag sun dried fruit in air tight bags.



Picture 15. Tomatoes drying on and under Remay (2 days after soaking in potassium bisulfite).