Chapter

Solanum jamesii as a Food Crop: History and Current Status of a Unique Potato

David Kinder, John Bamberg, Lisbeth Louderback, Bruce Pavlik and Alfonso Del Rio

Abstract

Solanum jamesii is a wild potato found in the US southwest. There is ample evidence that this potato was used by ancestral Puebloans as a food source, where some researchers think it was used as a starvation food while others consider it to be regular food source. Currently this potato is being grown by Native Americans, notably the Navajo, as a specialty food as well as a food crop. There are several attributes to this potato that make it especially suitable for development as our climate changes and food needs become more demanding, including its drought tolerance and ability to be crossed with other wild potato species and cultivars.

Keywords: *Solanum jamesii*, desert adapted, drought tolerant ancestral Puebloan use, starvation crop

1. Introduction

1.1 Background to *S. jamesii*

Solanum tuberosum is often regarded as a crop that originated from the US or Ireland, but in reality, only two wild potatoes are found in the United states (and none in Ireland). They are *Solanum jamesii* and *Solanum stoloniferum* which are found in the desert southwest. *S. stoloniferum* is the tetraploid relative to *S. jamesii (jam)*. Jam predominates in the southwest desert regions and is found in western Texas, northern Mexico and north into southern Utah and Colorado (See **Figure 1**). Collections have been found primarily near sites of ancestral habitation which are primarily found in the high desert of the Colorado Plateau. Elevation maximum for jam can be as high as 2280 meters at Chimney Rock National Monument in SW Colorado and south at 2000 meters in Magdalena New Mexico [1]. Jam can be cultivated as far north as Salt Lake City in open areas where it survives the winter underground. The Escalante formation in central Utah is home to several stands of jam and is cultivated by some traditional Navajo farmers in that area. There is currently an effort being made to cultivate jam for sale as a specialty crop to restaurants.

Jam prefers drier climates to that of the moister environments of the east. It typically grows in sandy soils to leaf litter strewn areas in Pinyon Juniper stands as well as in open well drained silted washes. Jam is known to lie dormant for years before sprouting, which occurs generally after the monsoon rains of July and August. The

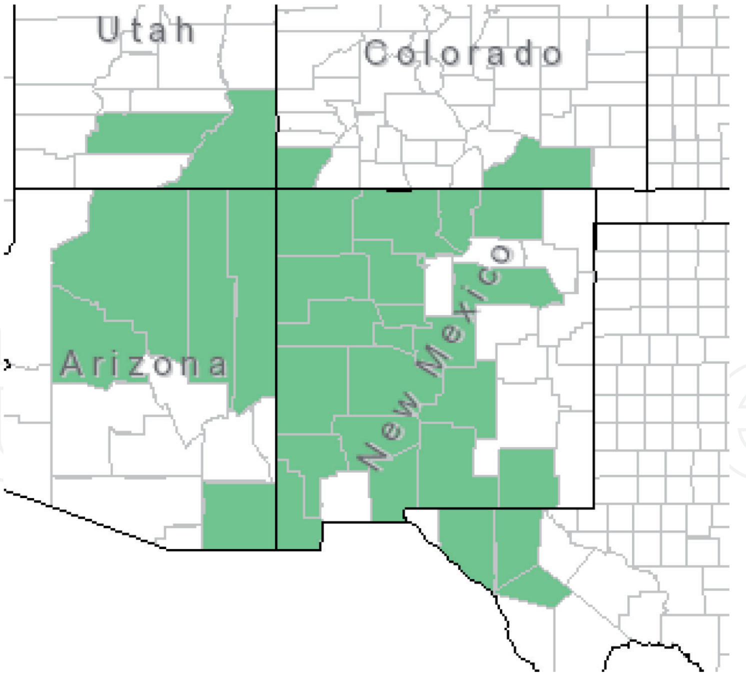

Figure 1.
Solanum jamesii Torr. *Distribution in the US SW. Data source: Plants National Database; home/profile page/ data source and documentation for* Solanum jamesii *Torr.*

plant sprouts and produces a mother tuber followed by additional tubers on stolons that depend on the length of time for growing. We have observed several tubers forming in dry years when monsoon rains did not provide more than 2–3 inches of rain in Mesa Verde's Navajo Canyon. When ample rains were received (6 inches from August to September of that year, 2014) the stolons continued to expand without producing tubers until September as fall approached. In storage Bamberg found that jam tubers that were kept for 8 years were able to sprout and produce a new crop of tubers. Additionally, in years of surveying Chaco Canyon and Mesa Verde, among other sites, there were minimally 10 years between finding sprouting jam in the canyons being examined. The drought tolerance and the ability to lie dormant for several years suggests that the genetics of jam would be well served when crossed with other species of potato. Such work is being conducted at the Wisconsin Potato Gene Bank by Bamberg and colleagues [2].

We do know that jam was used by ancestral Puebloans. At this juncture we do not know if they first found it by browsing, or if the use coincided with the beginning of agriculture. Early agricultural methods are murky where we extrapolate backwards for the methods of cultivation by native groups in the SW who practiced traditional agricultural techniques, but even those might not reflect how agriculture was carried out in the beginnings of the settling. Indeed, there is potential that the various groups or tribes were seminomadic, and left crops such as jam for their return to the area. Mesa Verde is an example where we see entering and exiting the area over the course of the year, and where grain was stored sealed in silos against animal intrusion and protected from the weather by overhangs.

Louderback [3] showed the presence of starch grains on stone tools that could be dated to 8950 BC. The starch grains are very characteristic for jam and were identified on food processing tools (metates). Other starch grains were also present suggesting a somewhat varied diet of plants that were grown in the ground. We are very confident that jam was an important food crop and provided for a varied diet to the early groups who settled the Americas first. Below is a map showing the approximate distribution of jam in the US SW. There are a few examples of stands in Northern Mexico, but research in those areas to further discover stands have been hampered by violence in the areas.

1.2 Characteristics of *S. jamesii*

Jam has the characteristic flower of the Solanum genus as shown in the two photos below (**Figure 2**). The flowers are white with yellow centers. When pollenated jam can produce fruit, but we have noted that even with pollinators present jam often will not fruit. We have rarely seen fruiting of the jam populations in MEVE and have yet to observe it in Chaco Canyon, albeit Chaco Canyon receives only 2–3 inches of moisture in a year which might speak to the non-fruiting. However, the population of Chaco is more homogeneous when compared to the population at MEVE, and Pavlik has proposed that when the genetics are similar, fruiting is limited but when more diverse genetic populations are present the fruiting becomes more robust (personal communication). We have observed this in experiments where two populations of jam are presented fruiting becomes abundant, but when single collections are grown, fruiting is rare.

Jam is also found growing in heavy grass stands where the grass has died back following sprouting in the spring. This is seen in the photo below of a stand of jam in Bandolier National Monument (**Figure 3**). This stand was adjacent to a block

Figure 2.
S. jamesii *blooms. Photo credit: David Kinder.*

Figure 3.
S. jamesii *in situ, august 2019. Photo credit: David Kinder.*

house ruin just below the cliff structures. The soil here is sandy with silt from flooding of the nearby river in the canyon.

The fruit are small and green with very small seeds (**Figure 4**). These seeds are among the smallest of the Solanaceae family [4]. They are bitter in taste, and we have not observed animal consumption of fruits; however, that may be because of limited fruiting in the wild and limited time in the field.

e tubers themselves can range from the size of a small pea up to 2 cm (**Figure 5**). Some larger tubers have been produced under cultivation. The tubers in the photo above show the variability in size. The darker colored tubers are older (and said to be stronger by native cultivators). Glycoalkaloid content is variable depending on stand. The two glycoalkaloids commonly found in jam are Chaconine and Solanine. The genin portion of the alkaloids is identical (solanidine) differing only in the sugar portion. The genin portion is not as toxic as the glycoalkaloid predominately causing liver damage. It should be noted that Chaconine possess anticancer

Figure 4.
S. jamesii *fruit. Photo credit David Kinder.*

Figure 5.
S. jamesii *tubers showing variation in size of wild harvested potatoes. Photo credit: David Kinder*

activity in cell culture. This is similar to the activity of tomatine which is primarily found in green tomatoes. To our knowledge no one has looked for tomatine in the fruit of jam.

2. Evidence for early use of jam and probability of cultivation

There is ample ethnobotanical information that indicates jam was used by multiple tribes in the American SW and northern Mexico. This ethnobotany stems from reports in the last 150 years and is assumed to have been information passed down from previous generations. The potato is ephemeral in the archaeobiology record, but there is one example of jam being found in a burial in Chaco Canyon during excavation of a grave in the 1920s [4]. This suggests that jam was at least important to those living in Chaco canyon at the time.

More recently Louderback and Pavlick found stone tools in the Escalante wash which had been used for food processing that had jam starch grains on them [3]. Jam starch grains are unique and easily distinguished from others. The tools date to over 10,000 years ago supporting the use of the potato as a food in the early first migrations. The starch grain finding supports processing of jam, but does not indicate whether it was cultivated. One assumes that cultivation began in central America and was passed northward along with corn and other food stuff, and likely with the planting of gardens the potato was also planted as well. However, the overlap between foraging and gardening is blurred by the ephemeral nature of agriculture in general with assumptions made as to what was or was not cultivated. More concrete evidence of cultivation occurs when water manipulation structures are found where those are mainly made of stone or other more permanent materials. In those same areas, wooden tools used for digging in the soils have been found (**Figure 6**). For example, in Mesa Verde there is an abundance of check dams found throughout the areas where habitation sites are found and where jam is found growing in the remnants of those structures. While this is not proof of ancestral cultivation of jam, it is compelling evidence that jam was included with other crops grown in those check dams with their fertile silty soils. This is contrasted to Chaco Canyon where the check dams were not made of stone but what remnants remain were made from soil and with time eroded. The jam found there grows in the silty washes. Chaco is unique in that it is an outlier in terms of moisture it receives, does not have a substantial water source, and was likely abandoned by the 1300s where it is thought they assimilated into the Pueblo groups located along the Rio Grande (based on Linguistic considerations by Ortman) [5].

A substantial number of jam stands that are found in areas where there is evidence of ancestral Puebloan habitation are especially large prompting one to suppose that the potatoes were cultivated along with other plants. For example, in Mesa Verde's Navajo Canyon which is adjacent to the side canyons where most of the cliff dwellings are located is a mega-population of jam that runs the length from spruce canyon's mouth to the Navajo canyon overlook where an ancient landslide blocked the valley below which then filled with silt. This canyon is thought to have been under cultivation while it was occupied more than 1000 years ago judging by the storage structures and the finding of tools for cultivating soil [4].

An interesting feature of stands of jam in major population centers such as Chaco Canyon, Mesa Verde, Bandolier Nat. Monument, and other places is that the populations are often bracketed by *Lyceum pallidum*. While this is not true of all stands, it is true of mega populations we have identified so far.

Figure 6.
Early digging tools, Museum of Natural History, University of Utah. Photo credit: David Kinder.

Genetic diversity of jam. Examination of genetic diversity can give clues to how long a population has survived in a particular area, or how the population might have drifted from surrounding populations of the same species. In the case of jam, there are a multitude of markers associated with the populations, but one remarkable finding is that the mega-population of MEVE contains 80% of the markers found in other jam populations. While one might think this is the ground zero for the beginning of jam, an alternative and more reasonable interpretation is that this populations is comprised of additions from around the southwest which were carried into MEVE and cultivated, or at least planted leading to this diversity of markers [6]. Since starch grains can give information as to sources of jam in the archeologic record, this might prove to be a useful tool applied here [7].

A further interesting finding is that the jam found in Chaco Canyon has relatively few markers that overlap with other communities without great diversity suggesting that only a single source from outside the canyon was brought in and planted/cultivated. It is known that Chaco Canyon was used for cultivation and certainly many interpretations of the use of Chaco suggest it was a trade center more so than a residential area only. No doubt ceremonies and other events were held there. The populations in Chaco are extensive with one mega-population occurring in the wash west of West Mesa beyond Peñasco Blanco. This wash contains the remnants of buildings thought to have been constructed as shelter for those engaged in tending crops, however this hypothesis is still being considered and is hampered by lack of resources to explore this canyon beyond that which occurred in the early part of the 1900s.

Jam is thought to have been consumed in several ways, with ethnobotanical information among several sources indicating that it was boiled and eaten with clay (8). The white clay is most likely kaolin which is thought to take away the bitter taste. The matter of the taste is subjective as jam is similar in taste to the russet potato. There were anecdotal reports from natives whose families had consumed jam where they roasted, sauteed the tubers in fat, flattened the tuber and roasted on a hot stone over an open fire and mashing the tubers following boiling. None of these methods are however recorded in literature and come from modern Navajo for the most part as well as Hopi.

3. Characteristics of the potato nutritionally

Potatoes are considered super foods by many, and *S. tuberosum* certainly helped maintain the Irish population during the years of English domination until the unfortunate occurrence of the potato blight. S. jamesii is no exception to the nutritional value from the perspective of minerals and other trace nutrients. Examining potatoes from Chaco Canyon and Mesa Verde for their nutritional content demonstrated that jam nutrient content is consistent between populations. It was also clear that soil content of various minerals could have some degree of influence on content but not to a great degree.

Potatoes harvested in the wild compared to *S. tuberosum* for several nutritional markers averaged 4% for protein for jam, 2% protein for *S. tuberosum*. Average amounts (in mg/100 gm wet wt. potato) for Calcium 30 mg Jam, vs. ~11 for *S. tuberosum*; for iron, ~3 mg jam, ~1 for *S. tuberosum*. For Zinc, ~0.9 vs. ~0.4 *S. tuberosum*. Calcium content was high with approximately 600 mg vs. 400 for *S. tuberosum*. In general this is twice the protein, zinc, and three times the calcium and iron [4].

Daniel Moerman's book on ethnobiology [8] of various medicinal and food plants shows among the southwestern native groups jam was an important component for the Apache, Hopi, Kawaik, Navajo and Pueblo groups along the Rio Grande river. Today many traditional Navajo grow potatoes for their own use.

The finding of jam starch grains on stone tools dating back over 10, 000 years from the present shows that the potato was an important component of the diet of ancestral Americans. That is especially important when considered in the light that corn did not reach the southwest until some 5000 years later making a slow migration onto the Colorado Plateau.

4. Potential for use in modern times – Advantages of jam for dry climate adaption

Jam has been known to exist in the American SW for some decades, and was not considered significant in the early days of plant study of indigenous people's use of this potato. More recently with interest in maintaining gene banks of native plants, and to use them for breeding purposes either by selection of plants with certain characteristic or deliberate crossing of one species with another there has been a more robust look at where these potatoes are found, and how they can be managed to the betterment of the potatoes. This work has been spearheaded by Bamberg and colleagues at the Wisconsin Potato Gene Bank (Greenbay WI) as well as others including Pavlik and Louderback at the U. of Utah. The storage potential added to various crosses with other wild or domestic potatoes holds promise for the future where potatoes can be grown in more arid climates, or can be stored for extended periods of time and maintain viable tubers for planting. In terms of third world populations where drought causes extensive starvation this small potato could be developed with potatoes with other favorable characteristics to provide a food source for those populations. Thus harnessing the potential favorable genes from jam could well produce a series of potatoes with the favorable nutritional content as well as the ability to thrive in some inhospitable climates for addressing starvation around the globe. However, it remains to be seen what this potential will mean to further production of cultivars.

5. Conclusion

Jam has a long and untold story that is just beginning to be worked out. It has characteristics that have allowed it to survive in harsh conditions, and has nutritional content that makes it even more attractive for consumption by humans. Its potential to add its genes to other potatoes is great where drought tolerance would benefit many populations greatly where more modern crops fail. Indeed, underground growing of foods would prevent browsing to adversely affect the production of potatoes in some populations unlike the attractiveness of corn for some foraging animals.

Given the findings of the use of potatoes in the American SW, as well as noting that other plant materials were used for food. The old adage of the Three Sisters – Corn, Squash and Beans – should more properly be replaced by Succotash instead to reflect the broad diet of the first Americans.

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Conflict of interest

We see no conflicts of interest for any author. The authors have collaborated on several aspects of this work, and no monetary or benefits are expected to ensue from this work.

Author details

David Kinder[1*], John Bamberg[2], Lisbeth Louderback[3], Bruce Pavlik[3] and Alfonso Del Rio[4]

1 Ohio Northern University, Ada, OH, USA

2 Wisconsin Potato Gene Bank, Green Bay, WI, USA

3 University of Utah, Salt Lake City UT, USA

4 University of Wisconsin, Madison, WI, USA

*Address all correspondence to: d-kinder@onu.edu

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