

# Nutritional Evaluation of Potato Varieties and Breeding Lines

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## **Why enhance potato nutrition?**

While already nutritional, further enhancing the nutritional content of potato is important for producers and the industry because consumer perception of the health value of potato affects sales. While certainly not all consumers choose foods based on perceived nutritional value, many do, particularly those consumers with more disposable income who are also more likely to be informed about nutritional trends.

Most people understand that eating vegetables supplies vitamins, nutrients and calories necessary for growth, but fewer realize that plants contain additional substances called phytochemicals that have various health-promoting effects such as reducing the risk of heart attacks or cancer. Americans appear ever more interested in the health benefits of fruits and vegetables and this trend will likely continue as new medical research increasingly reveals exactly which phytochemicals are health-promoting and these findings are publicized in the national media. If so, then the perceived nutritional content of a food could become increasingly important for sales.

Negative press coverage can lead consumers to wrongly perceive potato as an unhealthy vegetable and influence them not to purchase potatoes, thereby hurting sales. Examples of bad press include the California Attorney General in August 2005 suing McDonald's, Burger King, Wendy's, Frito Lay and other companies to force them to label their fries and chips as containing a known cancer causing substance. Similarly, a food pyramid guide promoted by Harvard University's School of Public Health that recommends potatoes be eaten only sparingly and one of their scientists has said that when eaten "potatoes do not confer the benefits seen for other vegetables." These and similar reports emphasize that the nutritional content of potato is amongst the most important traits to maximize because no other trait may have as big an impact on sales in coming years. To help counter the recent negative publicity about potato nutrition it is important to ensure the public is well aware of the many nutritional benefits of potato.

## **What's in a potato?**

Just what vitamins and phytochemicals are in potatoes? Which varieties have the most? Can new varieties be developed that have even more? These are questions we are interested in answering, an undertaking made more feasible due to recent scientific advances. With most crops, including potatoes, nutrient profiles are available only for one or two main varieties. Because so little is known about how the amount of many vitamins and phytochemicals varies amongst different potato varieties, measuring these compounds can identify existing varieties that are nutritionally superior and also identify nutrient-rich germplasm that can be used to breed nutritionally enhanced potatoes. The rich genetic diversity of potato has barely been exploited to maximize its phytochemical and vitamin content.

Historically, crop breeding focused on better yields and disease resistance, with little attention paid to the nutritional enhancement of crops.

This is not surprising when one considers that the term “vitamin” did not even exist 100 years ago, nor had a single vitamin had been identified. Even today, much remains to be learned about the link between food and health.

### **Potato as a “Functional Food”**

The increased public and scientific interest in the relationship between food and health is reflected in the trendy emerging concept of “Functional Foods” in which foods are seen as being capable of providing health benefits that go beyond merely meeting basic nutritional needs.

Potato is the most popular vegetable and Americans eat about 140 pounds per year. This creates a unique potential for potatoes to be developed and positioned as a source of vitamins and phytochemicals in the diet. Developing potato as a “functional food,” could create new marketing opportunities amongst consumers who base their buying decisions upon the perceived nutritional value of a food. A nutritionally maximized potato would not only strongly repudiate negative press, but because Americans eat over 130 pounds a year, potato presents a unique and excellent opportunity to provide valuable phytochemicals to the American diet.

### **Our research**

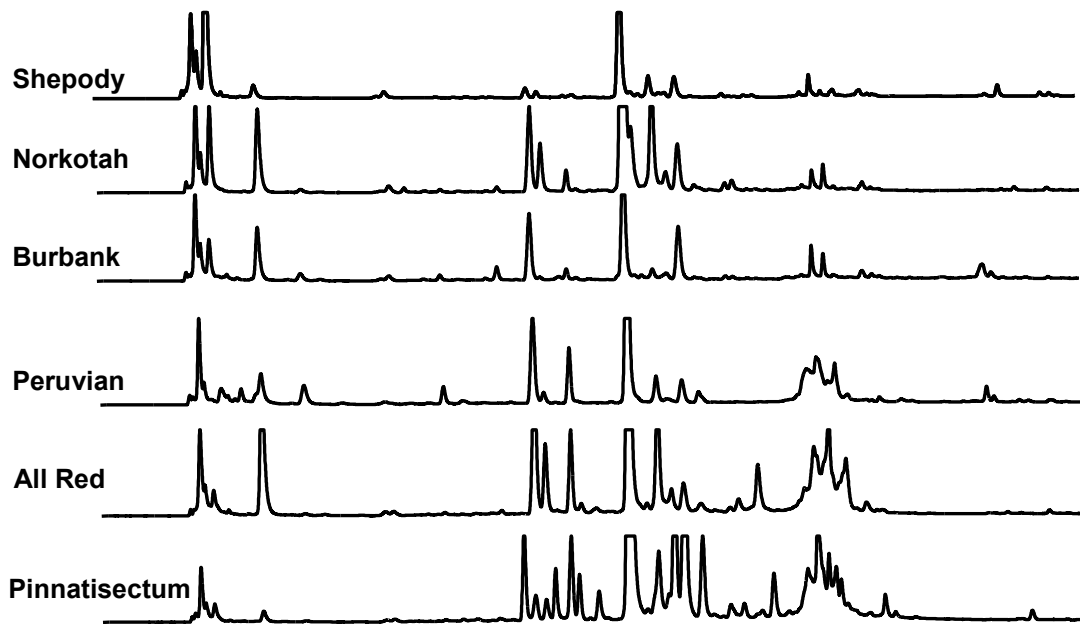
We are using “germplasm mining” in potato to identify compounds that are either desirable in the human diet, or help protect potato against pests or pathogens. Germplasm mining is simply screening many different cultivars or species of a plant to try to identify the ones which have superior genes or phytochemicals. We developed a high-throughput HPLC-MS method and used it to characterize numerous compounds in over 50 varieties thus far. We used this method to identify over 60 potato compounds, including phenolics, flavonoids, glycoalkaloids and vitamin C in a short 12 minute HPLC run.

As shown in **Figure 1**, substantial differences in phytochemical content exist amongst different cultivars or species. For example, note the tremendous differences between Shepody and Pinnatisectum, a wild species of potato (**Figure 2**). The extent of the differences we are observing suggest germplasm mining will be fruitful in helping to determine which varieties have the highest amounts of useful compounds.

### **Potato vitamins**

We are examining the amounts of vitamin C and folic acid in potatoes. According to the USDA databases, one 10.5 ounce baked potato (about 278 calories) can provide 48% and 21% of the daily recommended amounts of vitamin C and folate, respectively. Potatoes are a major dietary source of vitamin C and it is possible that the levels can be increased even higher. Folic acid deficiency is one of the major vitamin deficiencies worldwide.

Most pregnant women take a folic acid supplement because over 500,000 infants with severe birth defects are born each year due to folate deficiency. Furthermore, one scientific study suggested that up to 25% of all heart attacks and strokes may be linked to folate deficiency. We are measuring folate in diverse potato germplasm to see if we can identify tubers with significantly greater amounts of folate than was found in the handful of varieties ever examined previously. To date we have used a microbial assay to examine about 30 varieties and have found about a 2-fold range between highest and lowest folate amounts amongst the different germplasm. We also have obtained many of the genes involved in folate synthesis and are examining how they influence folate levels in tubers.

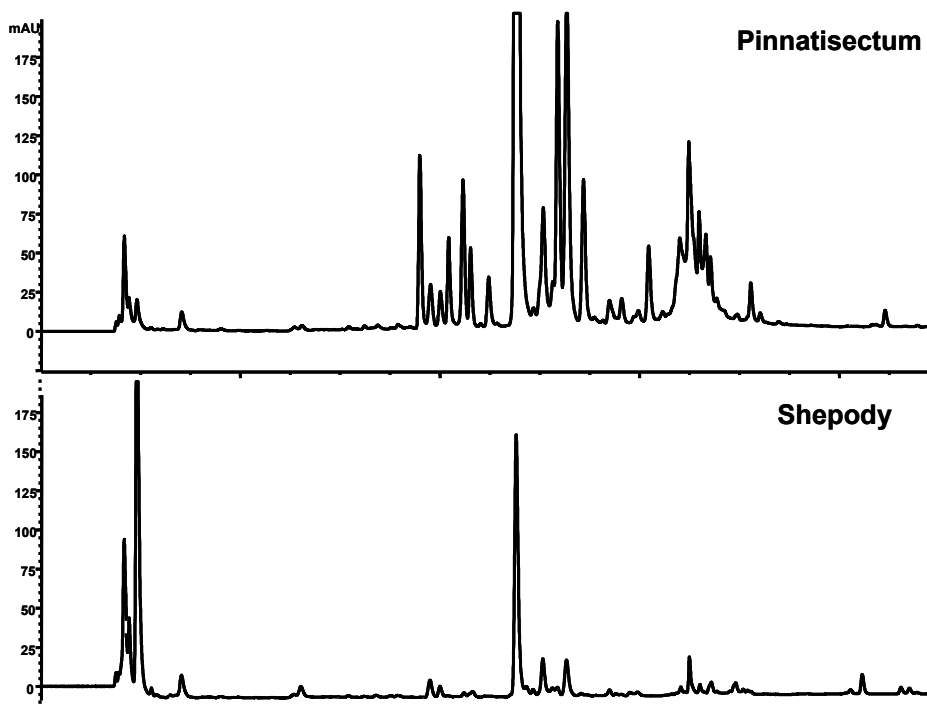


**Figure 1. LC-MS profiles of 6 different potato cultivars or species. Equal amounts of extracts were analyzed and the chromatographs are shown. Note the substantial differences in the profiles.**

### **Potato phenolics**

Besides vitamins, what are some of the compounds in potato with dietary value? Potato has potential as a source of dietary phenolics. These are a diverse group of 1000s of different compounds, some of which are effective against human diseases or have other health-promoting qualities. The contribution of dietary phenolics to health is an area of active ongoing medical research that is only beginning to be understood.

We screened numerous varieties, including mainstream white-fleshed potatoes, specialty potatoes and wild species and found some varieties with over 100 mg/100 gram fresh weight of total phenolics, in samples that are mostly flesh (**Figure 3**). These amounts become substantially greater if all of the skin is included. Amongst the white-fleshed varieties, Norkotah has particularly high levels of phenolics. If we compare high phenolic potatoes to some published reports of total phenolic amounts found in other plants, these potatoes have more phenolics than tomatoes, peas, onions, French beans, cucumbers, white cabbage, carrots, lettuce, or cucumbers. Furthermore, the amounts in the highest abundance potatoes rival some published phenolic amounts for broccoli, Brussels sprouts and spinach. Thus, potatoes are a potentially rich source of dietary phenolics, compounds with numerous health promoting properties, yet little has been done thus far to take advantage of this trait.



**Figure 2. The same chromatographs from two varieties shown in figure 1, but using a smaller scale to highlight differences.**

### **Potato flavonoids**

Potatoes have a group of phenolics called flavonoids. We used mass spectrometry to identify 4 of these compounds, all of which contain either quercetin or kaempferol. In addition, there are several more potato flavonoids that we have not yet fully identified. Over 1000 scientific studies involving quercetin have been published in the last 2 years. The U.S. Department of Defense recently funded a 1.1 million dollar grant to Appalachian State University to study whether quercetin can help maintain soldiers' immune systems. Numerous studies suggest quercetin and related flavonoids have multiple health-promoting effects, including reducing the risk of heart disease, lower risk of certain respiratory diseases, such as asthma, bronchitis, and emphysema and reduce the risk of some cancers including prostate and lung cancer. More medical research is needed in these areas, but the early results are encouraging. Potatoes appear to have significant amounts of flavonoids, and although they do not contain as much as some plants, such as onions, much greater quantities of potatoes are eaten. Thus, the contribution of potato flavonoids to the diet has perhaps not been fully appreciated so far and is an area well-worth further investigation.

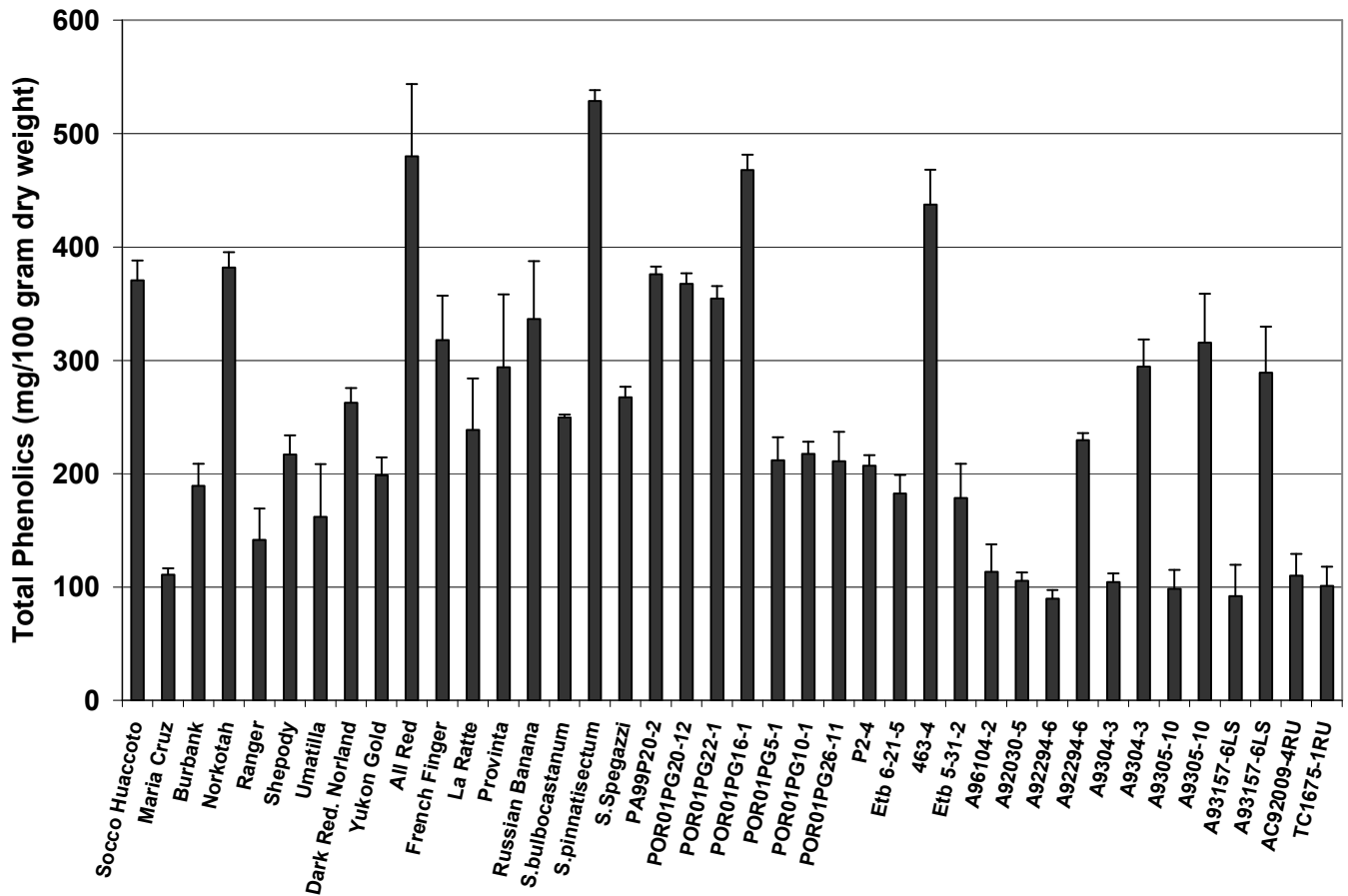


Figure 3. Total phenolics were measured in the shown potato varieties.

### Other potato phenolics

Potato is a particularly rich source of numerous caffeic acid derivatives, including 4 different chlorogenic acids. There is evidence that chlorogenic acid has multiple health-promoting effects. It is known to protect against degenerative, age-related diseases in animals when added to their diet, and may reduce the risk of some cancers and heart disease and have anti-viral and anti-bacterial activity. Chlorogenic acid is an antioxidant, reported by some to be 5 times more potent than vitamin C and it is also thought to boost vitamin C activity. Chlorogenic acid has been shown to slow the release of glucose into the bloodstream after a meal, a trait that could be important to those seeking to follow a low glycemic diet. Both chlorogenic acid and flavonoids supplements are available in health stores.

Last summer the European press, including the BBC, reported that potatoes contained compounds known to lower blood pressure. In June 2005, a British lab reported the discovery of compounds called kukoamines in potatoes. These compounds had previously only been found in a Chinese medicinal plant, in which they are being studied because they lower blood pressure. We have identified at least 5 different kukoamines in some of the locally grown varieties, with different amounts seen in different varieties.

Collectively, this type of research allows new approaches towards the development of nutritionally maximized potatoes. This research also has the potential to identify existing varieties with higher amounts of phytonutrients and create new marketing opportunities.