Potato Progress

Research and Extension for Washington's Potato Industry
Published by Washington State Potato Commission www.potatoes.com
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Volume X, Number 12 *November 9, 2010*

High-Phytonutrient "Baby Potatoes"

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Declining demand is a serious threat to the Washington potato industry. Demand is critical for grower profitability but has steadily been falling, as seen by the 'United Potato Growers of America' recommendation in 2010 that growers only plant 70% of the 2004 acreage. Reduced demand for frozen potato products was a reason cited for the closure of the ConAgra plant in Prosser in May 2010. Growers have no shortage of production related obstacles, but at the end of the day must have customers buying potatoes; a strong case can be made that a major, if not the major, long term threat to Washington growers is how to stabilize demand and protect livelihoods.

The reasons for declining potato consumption are complex, but consumer concerns about the nutritional value of potatoes are thought to be one major factor in decreasing demand, along with changing lifestyles and demographics. More than any other vegetable over the last decade, potatoes have been criticized by some nutritionists. Potatoes, even baked potatoes, are under pressure in school lunch programs, and the WIC program (subsidizes food purchases) may make white-potatoes the only vegetable excluded from the program. This type of publicity has created doubt among the public about potato's healthfulness and fueled the misperception that potatoes are "empty calories" or all starch. If potatoes come to be unequivocally perceived as an unhealthy food, demand may fall even further.

Our research can help protect grower profitability by developing high-phytonutrient potatoes (i.e. high vitamins, antioxidants etc.) that help restore the healthful image of potatoes and provide consumers the healthy choices they are increasingly demanding. High phytonutrient potatoes could create new market opportunities, both inside and outside the state. Washington consumers are more educated and have higher incomes than the national average, and may be an especially good customer base for this type of premium/gourmet potatoes.

The major limitations to developing high-phytonutrient potatoes are lack of knowledge about which potato phytonutrients have the most potential to be increased, and quick/effective methods to screen large amounts of germplasm for phytonutrients. Therefore, we developed high-throughput analytical methods and have been characterizing exactly what phytonutrients are in potatoes, how much

phytonutrients vary among different cultivars and which phytonutrients are the best to target for further enhancement. These methods allowed us to identify “baby potatoes” as being especially high in phytonutrients. By “baby potatoes” we mean potatoes about 1 ounce in size, harvested from young plants around 70-80 days after planting. High-phytonutrient “baby potatoes” have numerous positives, not the least being that high-phytonutrient lines should quickly be available to market, and not require 10+ years development times. Baby potatoes command a price premium because consumers value them for their taste. They are also visually appealing and faster to prepare; traits particularly important to an increasing number of consumers. Pictures of two breeding lines before and after cooking demonstrate the visual appeal (see page 1 and below right). These potatoes may appeal for more upscale consumers (i.e. the middle class), a market demographic in which potato consumption has been decreasing. High- phytonutrient baby potatoes may also be viable options for those school lunch programs that are seeking to reduce or eliminate French fry and potato chip consumption. Once the public becomes more aware of the nutritional merits of high-phytonutrient baby potatoes through effective consumer education efforts, this could help drive demand for such products, grow market share, and help restore the overall healthful image of potatoes.

Trial results: In 2009 we evaluated ~90 genotypes for their ability to produce high-phytonutrient baby potatoes. We procured seed from around the country, most of which was then grown at the Othello WSU research farm. Many of these genotypes were yellow-fleshed or purple- or red-fleshed and a handful were white-fleshed.

A successful baby potato cultivar must have additional traits besides phytonutrients to be successful, including taste and appearance for consumer-oriented traits, along with various agronomic traits required by the fresh market or processing industries. Therefore we evaluated additional traits besides phytonutrient content. Among the most important traits for baby potatoes will be yield, which will depend on a large tuber set. Yield will be even more important for baby potato genotypes because of the reduced tonnage per acre relative to harvesting at maturity. This yield reduction is offset by higher prices.

The best baby potato lines will produce a large number of small potatoes, not a small number of large. The potatoes listed in **Table 1** are sorted on the basis of high to low number of tubers per seed and include days to vine kill and the percentage of tubers that were smaller than 26 mm in size. The sizeable majority of top performers in terms of tubers per seed are breeding lines, most from the Tri-State program. The top performer was PORO2PG12-1, which had almost 29 tubers per seed, whereas among all the cultivars, Aeggeblomme had the highest yield. When considering the tuber per seed data it’s important to realize this is only based on one year of field data and this is not a direct apple to apple comparison because the seed was obtained from different sources. Tubers per seed is influenced by seed age and for a study of this size it is not possible to have identically treated seed for all the genotypes. Thus, at this point it is important to not discount a genotype that might only have middle of the pack yield, but has high phytonutrients. Such a genotype grown from different seed and managed under a tailored regime could potentially have much higher yields. On the other hand, genotypes with very poor yields are less likely to become stars, regardless of seed/management practices. Most genotypes were planted with a 6-inch row spacing. Additional information is available for many of these genotypes and Roy Navarre, Mel Martin or Chuck Brown can be contacted with any specific questions.

Table 1: Agronomic data for each genotype

Genotype	Tubers per seed	Days to vine kill	Tuber yield (Percentage Less than 26mm)	Genotype	Tubers Per Seed	Days to Vine Kill	Tuber yield (Percentage Less than 26mm)
PORO2PG12-1	28.5	81.0	40.7	Oriana	12.0	70.0	29.6
Aeggeblomme	24.9	81.0	28.1	Yellow Finn	11.8	68.0	43.8
AK 8-9	24.1	81.0	46.2	Smart	11.7	70.0	18.3
PORO7PG3-1 2	23.2	81.0	52.4	Nicola	11.5	70.0	28.5
COTX05037-4Y/y	23.1	81.0	48.4	Red Gold	11.2	68.0	41.4
PORO7PG2-1 2	21.8	68.0	29.1	AK 3-1	11.2	81.0	98.3
PORO7PG15-3 1	21.7	81.0	77.7	ATTX98444-16	11.2	69.0	17.7
PORO7PG21-1 2	21.5	81.0	28.2	Milva	10.9	68.0	26.7
ORO6147-3 1	21.3	69.0	42.6	PORO1PG16-1	10.8	75.0	5.1
ORO5112-1	21.1	70.0	27.2	ORO4036-5	10.6	70.0	19.9
A003545-2 1	19.5	69.0	29.8	OR00068-11	10.5	70.0	16.0
Piccolo	19.2	69.0	29.7	COTX05249-3	10.5	70.0	8.0
ORO6138-1 2	18.2	75.0	47.0	A003525-2 2	10.4	69.0	9.6
PORO6PG24-2	17.9	70.0	17.1	PORO4PG11-2	10.4	70.0	38.1
PORO7PG63-1 2	17.7	70.0	27.8	PORO3PG23-1	10.3	68.0	24.8
Baby Boomer	17.4	69.0	25.6	Dark Red Norland	10.2	75.0	35.9
Marilyn	16.8	69.0	25.5	Carola	10.0	68.0	14.7
A005189-2 2	16.3	68.0	27.3	All Blue	9.7	70.0	8.6
ORO5045-1	16.2	70.0	53.8	ORO6156-1 2	9.7	68.0	14.2
Annabelle	15.8	75.0	26.5	PORO2PG37-2	9.7	69.0	34.9
COTX04050-1P-P	15.6	68.0	28.6	Maris Piper	9.6	68.0	16.8
PORO7PG20-2 2	15.3	68.0	29.1	AK 3-7	9.2	70.0	9.1
ORO4198-1 2	15.3	70.0	38.4	NDTX4756-R/y	8.9	70.0	28.5
PORO3PG23-1	15.1	70.0	20.0	Miriam	8.0	68.0	27.3
AK 20-2	14.6	70.0	26.3	PORO2PG26-5	7.9	74.0	32.8
ORO4131-2	14.2	81.0	84.4	PORO7PG24-2 2	7.8	74.0	64.5
NTDX059886-1Y/y	14.1	69.0	10.7	Terra Rosa	7.3	74.0	70.8
PORO7PG26-1 2	13.9	70.0	21.6	Ambra	7.1	74.0	32.6
PORO7PG63-4 2	13.8	70.0	53.9	Yukon Gold	7.1	74.0	37.6
Sifra	13.8	69.0	20.1	COTX04003-1R/y	7.0	74.0	31.6
Charolette	13.5	68.0	37.1	A00286-3Y	6.9	74.0	21.6
PORO5PG26-11	13.3	69.0	36.6	Romanze	6.7	74.0	31.0
ORO6151-2 2	13.3	68.0	27.8	COT92416-1R	6.6	74.0	66.0
PORO5PG56-1	13.2	69.0	11.1	Keuka Gold	6.5	74.0	40.7
Bintje	13.1	81.0	86.9	PORO3PG80-2	6.5	74.0	55.3
Gala	13.0	69.0	27.0	Rose Gold	6.5	74.0	22.2
PORO1PG45-5	12.9	68.0	13.1	ATX02263-1R/y	6.3	74.0	35.5
PA96RR1-193	12.7	70.0	33.2	Adora	5.1	74.0	99.4
Purple Majesty	12.6	70.0	23.1	PORO3PG80-2	5.1	74.0	9.5
AK 8-3	12.2	70.0	24.3	COTX94218-1R	4.7	74.0	18.3
Vivaldi	12.2	69.0	20.1	NDTX4784-7R	4.5	74.0	100.0
ORO5020-1	12.2	70.0	66.3				
AK 29-6	12.2	81.0	20.4				

Phytonutrients: A primary goal of this work was to identify baby potatoes that have good yields and high phytonutrients. We felt there was a good possibility of finding some lines with very high amounts if we screened enough genotypes. Numerous genotypes were identified that had high amounts of phenolic phytonutrients **(Figure 1)**. Plant phenolics are the most abundant antioxidants in the diet and some have other health-promoting effects including longevity, mental acuity, cardiovascular health and eye health; so phenolics are more than just antioxidants. **Figure 1** shows total phenolics in mg/g dry weight. To help put these data in context, the typical mature white-fleshed line has about 1.8 mg/g DW. Every genotype we examined had more than this, and dozens had high concentrations that are more than competitive with other vegetables, including spinach and broccoli. Four of the lines tested at over 10 mg/g DW, of which three were red-fleshed and one yellow-fleshed.

The antioxidant capacity of these genotypes was measured. As expected given the high amounts of phenolics, they tested very high (**Figure 2**). By way of comparison, the typical white-fleshed mature potato tests around 30 micromoles TE/ g DW, so some of these lines have markedly higher amounts of antioxidants than average.

Previously, we've also identified wild-species and primitive germplasm that has even higher amounts, but such material is years away from commercial release. Thus, these findings are particularly exciting because they include cultivars and advanced breeding lines that can be brought to the market quickly. This has been one of the reasons we've been enthusiastic about baby potatoes, because we thought we'd be able to find high-phytonutrient lines that can be marketed in the near future.

Conclusion: A key point is that while some of these genotypes may not be suitable for baby potato production, they may be excellent producers of mid-sized or large potatoes with higher than average amounts of phytonutrients and be useful for other products.

We are currently measuring individual phytonutrients in the most interesting lines by LCMS. Preliminary evidence suggests baby potatoes may contain higher amounts of protein and higher amounts of resistant starch (a starch with health-promoting effects) than at maturity. In 2010 some of the most interesting of these genotypes, along with new genotypes, were planted at Othello for a second year of screening. Once these new lines are evaluated we may be able to make recommendations for the most promising lines for the baby potato market.

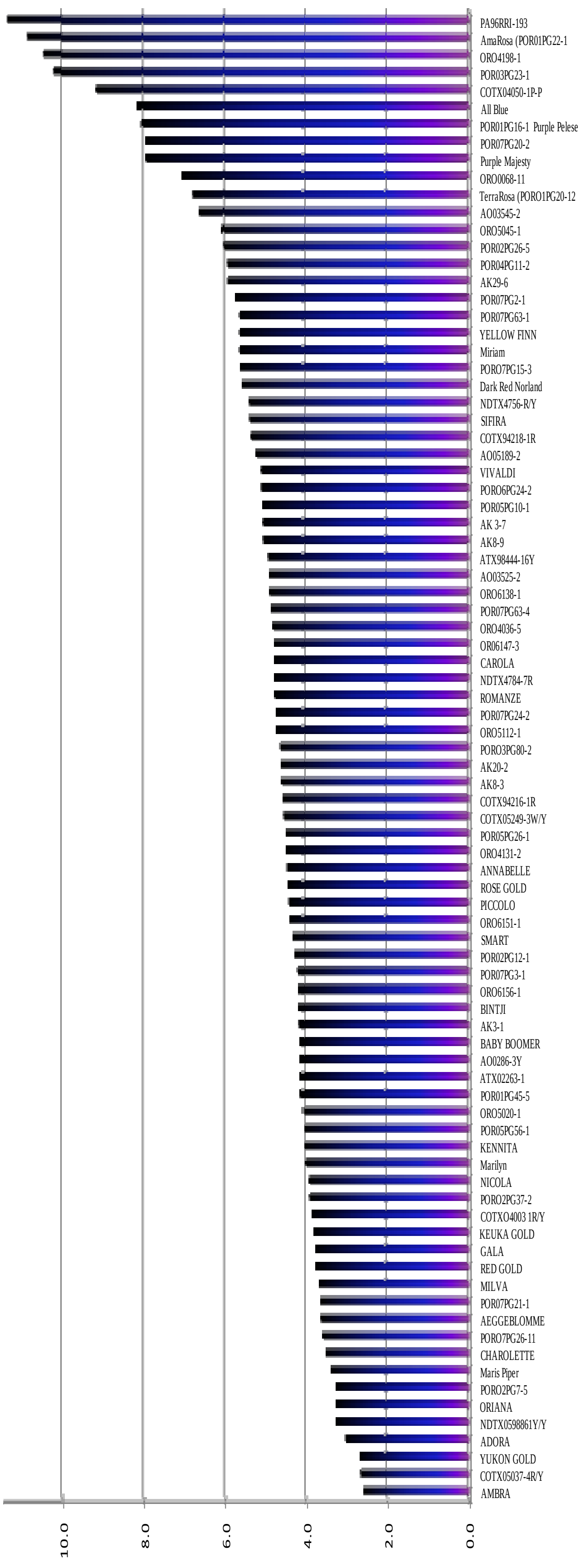

Figure 1. Total phenolics (mg/g DW) in ~90 lines grown at Othello.

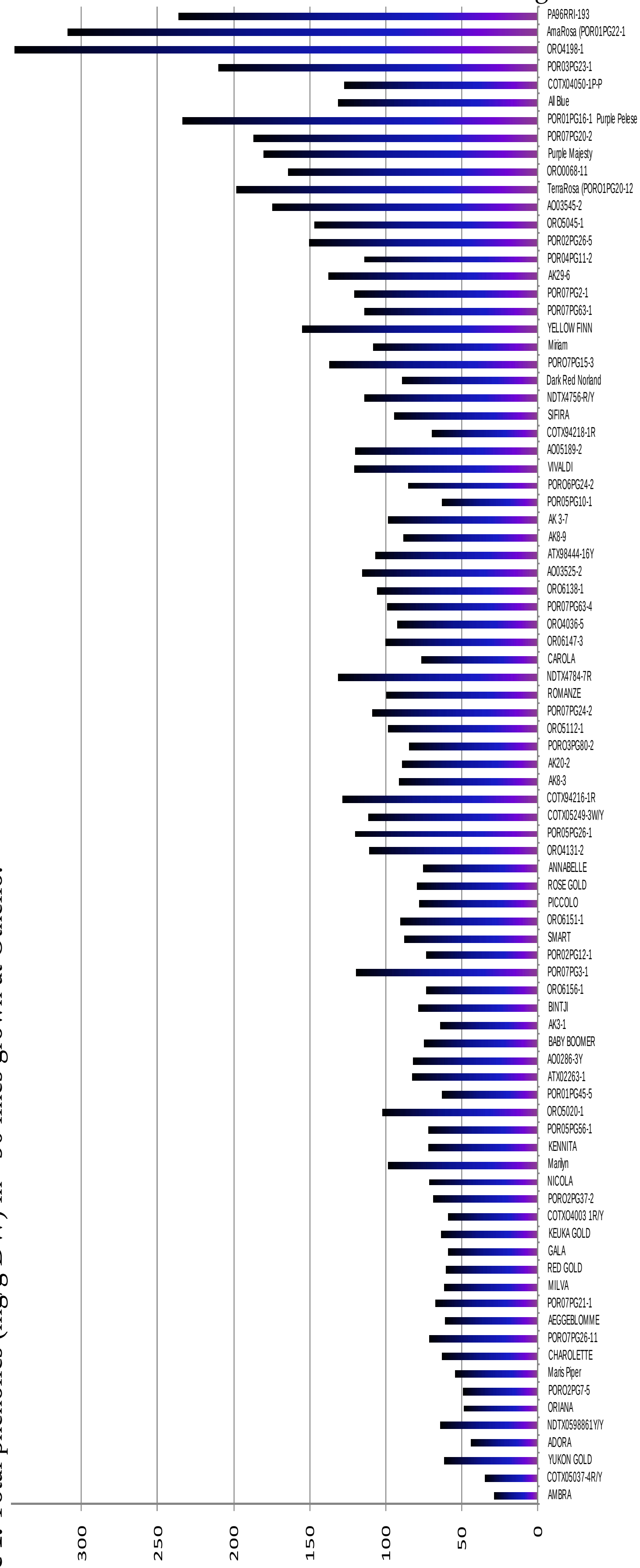

Figure 2. Antioxidants in ~90 potato lines (micromoles trolox equivalents per gram dry weight).

Potato Varieties in the Northwest

Data for the following table were gathered by the National Agricultural Statistics Service (NASS), and summarized here by the editor. In some cases, NASS does not report numbers for certain varieties, and these cases are indicated by the ~. Several minor varieties not listed here were reported by NASS on occasion.

State	Russet Burbank	Russet Norkotah	Shepody	Ranger Russet	Umatilla	Alturas	Other
Idaho							
1999	74.4%	8.3%	4.2%	9.1%	~	~	4.0%
2000	74.9%	8.0%	3.9%	7.7%	1.3%	~	4.2%
2001	70.8%	8.4%	3.8%	11.1%	~	~	5.9%
2002	71.0%	7.5%	3.4%	12.0%	~	~	6.1%
2003	69.2%	10.1%	1.3%	12.9%	~	1.2%	5.3%
2004	63.3%	14.2%	1.7%	12.5%	~	2.9%	5.4%
2005	63.1%	11.8%	1.3%	15.1%	~	2.8%	5.9%
2006	66.0%	10.2%	~	12.7%	~	2.2%	8.9%
2007	62.0%	9.8%	1.3%	14.4%	1.6%	1.7%	9.2%
2008	57.4%	13.1%	2.1%	15.0%	1.6%	1.6%	9.2%
2009	56.2%	14.6%	1.6%	15.0%	1.7%	1.2%	9.7%
2010	59.3%	14.0%	~	12.8%	1.1%	1.8%	11.0%
Oregon							
1999	42.9%	21.4%	12.5%	12.5%	~	~	8.9%
2000	32.7%	27.8%	9.8%	11.2%	3.1%	~	13.3%
2001	38.9%	12.3%	10.8%	22.5%	1.9%	~	13.6%
2002	24.3%	16.8%	18.8%	19.2%	1.8%	~	19.1%
2003	22.3%	25.6%	13.3%	15.4%	~	5.0%	18.4%
2004	22.8%	16.3%	10.3%	31.3%	~	7.2%	12.1%
2005	15.2%	23.8%	17.1%	25.3%	2.1%	7.7%	8.8%
2006	25.9%	20.4%	13.5%	22.5%	2.2%	5.5%	10.0%
2007	24.9%	20.2%	14.0%	18.1%	6.2%	5.1%	11.5%
2008	22.1%	23.8%	12.0%	12.2%	7.5%	4.3%	18.1%
2009	20.1%	26.6%	5.9%	17.7%	5.0%	5.9%	18.8%
2010	17.2%	27.9%	5.8%	17.8%	9.1%	3.1%	19.1%
Washington							
1999	41.3%	15.4%	10.8%	17.6%	6.7%	~	8.2%
2000	33.7%	17.2%	10.8%	20.2%	12.3%	~	5.8%
2001	35.3%	19.3%	6.8%	19.9%	12.1%	~	6.6%
2002	34.8%	11.8%	10.3%	22.3%	8.1%	~	12.7%
2003	34.9%	11.1%	9.3%	22.1%	8.2%	1.5%	12.9%
2004	34.7%	12.9%	8.2%	18.5%	10.7%	3.5%	11.5%
2005	40.6%	14.4%	4.7%	16.0%	10.8%	3.3%	10.2%
2006	34.9%	14.0%	6.9%	15.9%	8.3%	3.7%	16.3%
2007	38.5%	9.6%	6.9%	16.9%	11.7%	3.6%	12.8%
2008	27.1%	9.6%	10.6%	19.1%	15.1%	5.7%	12.8%
2009	30.8%	14.5%	2.3%	13.9%	11.9%	7.9%	18.7%
2010	30.6%	14.2%	2.6%	9.8%	15.8%	9.0%	18.0%