2012-13

Title: Increasing the Nutrient and Phytochemical Status of Colorado Grown Potatoes

Funding source: CCPGA Royalties for Potato Research

Investigators: Lavanya Reddivari, Department of Horticulture and Landscape Architecture, David Holm, San Luis Valley Research Center, Center, CO

Nature, scope and objectives of the proposed research

Background: The recent US Potato Board Report [1] revealed that over the past ten years, while consumption of traditional potatoes declined, specialty/colored potato consumption increased by 17%, possibly due to their putative health benefits. Consumers are becoming increasingly health conscious and taking a more active role in decisions regarding food and diet. Today fruits and vegetables are not just viewed as a source of energy, but as a source of nutrients and health.

Freshly harvested potatoes contain approximately 80% water and 20% dry matter. Starch accounts for 60-80% of the total dry matter, and the protein content is similar to that of cereals on a dry-weight basis [2]. Potatoes are a rich source of iron and this, coupled with the presence of high vitamin C content, helps in iron absorption. It is also a good source of B-complex vitamins, potassium, phosphorus and magnesium [3]. In addition, the potato has no fat and is an abundant source of many phytochemicals. Due to its high consumption, potato is considered as the third largest source of phenolic compounds in the human diet after oranges and apples [4]. Because of its popularity, it is critical to determine the extent to which consumption of bioactive compounds from potato is associated with health-benefits. The US Potato Board, through the National Eating Trends Report [1], revealed that over the past ten years, though the consumption of traditional potatoes (mashed, baked, fried, steamed, boiled and French Fries) declined, specialty/colored potato consumption increased by 17%, possibly due to their putative health benefits. We and others have recently reported that anthocyanin-rich colored-flesh (purple and red) potatoes have up to eight times higher antioxidant capacity compared with their white or yellow counterparts [5,6].

We have reported that total phenolic content of colored-flesh potatoes (90-400 mg GAE/100 gfw) [5, 6] is generally comparable to that of common berries such as strawberries, blueberries, and cranberries (100-412 mg GAE/100gfw) [7-9]. Potatoes are relatively inexpensive and can be

consumed in larger quantities in one meal and can therefore contribute to maintaining a healthy population.

Some of the Colorado potato cultivars and advanced selections are rich in nutrients and bioactive compounds. It is important to improve potato image as a nutrient-rich healthy food to combat the negative press suggesting a modest positive association between potato consumption and risk of type 2 diabetes and weight gain. This could be achieved by identifying and developing the cultivars with highest content of nutrients and bioactive compounds and educating consumers and producers on the health benefits. In this proposed project we will analyze antioxidant- activity, content of bioactive compounds such as phenolics and carotenoids, sensory attributes of Colorado cultivars and advanced selections, and the results will be compiled in to a web site ***potato.colostate.edu***. This information can be accessed by producers and consumers across the globe and will increase national and international visibility, awareness and producer benefit.

Recently completed significant activities:

1) The antioxidant activity of seven clones tested (from San Luis Valley Research Center) and total phenolic content of purple clones increased with storage; advanced purple-fleshed selection CO97227-2P/PW had greater levels of total phenolics, antioxidant activity and a diverse anthocyanin composition as compared with Purple Majesty. Purple-fleshed potatoes were more potent in suppressing proliferation and elevating apoptosis of colon cancer cells compared with white- and yellow-fleshed potatoes. Both fresh and stored (3 months) tuber extracts suppressed cancer cell proliferation and elevated apoptosis, but these anticancer effects were more pronounced with the fresh potatoes. These results suggest that although the antioxidant activity and phenolic content of potatoes were increased with storage, the anti-proliferative and pro-apoptotic activities were suppressed [6].

2) Baking and chipping led to losses in the phenolic and anthocyanin content, and antioxidant activity of the potatoes. These losses were significant for chipping compared to baking. However, with storage, total phenolic and anthocyanin content, and antioxidant activity increased in baked samples while in the chipped samples, they remained constant (Table 1). The anti-proliferative and pro-apoptotic properties of baked samples were similar to that of fresh tubers, but chipping reduced the anti-proliferative and pro-apoptotic properties (Figure 1).

3) Currently a USDA funded collaborative project with Dr. Jairam Vanamala enabled using pig as a model to study the anti-inflammatory markers and oxidative stress responses. Preliminary results show that purple potato chips reduced serum levels of oxidative stress markers; 8-isoprostane and malondialdehyde compared to high-fat diet control or white potato chips (Figure 2).

Objectives: The Colorado Potato Breeding and Selection Program at San Luis Valley Research Center (SLVRC) evaluates promising selections every year in order to release new cultivars. In this project we will use 20 cultivars/advanced selections grown in years 2011 and 2012. All the analyses will be conducted at CSU

- Prepare and analyze the samples for the variation in vitamin C content, total phenolic content and antioxidant activity.
- Analyze the content and composition of carotenoids
- Selections with greater levels of vitamin C and carotenoid content will be used for metabolite profiling and sensory analysis.
- Compile all the data from two years on afore mentioned parameters and make it available to the consumers and growers via *potato.colostate.edu*

Methods and facilities, including resource needs at the SLVRC

Twenty cultivars/advanced selections grown at the SLVRC will be used in this study. After harvest samples will be transported to CSU and stored in refrigerated coolers temporarily until freeze drying and extraction. Samples will be analyzed for, antioxidant capacity (ABTS), total phenolics (FCR) and vitamin C & carotenoids (HPLC) at CSU. Metabolite profiling of selected lines will be done using LC/MS at proteomics and metabolomics facility. Sensory analysis will be carried at CSU in the Food Science and Human Nutrition department.

All necessary equipment is available and protocols are well established to carry out this study. We will rely on SLV personnel in growing and procuring potatoes. Funds are requested for student hourly assistance to carry out sample preparation, analysis and sensory evaluations.

How the project will enhance the competiveness of Colorado potato growers

Over the recent years there has been sharp decline in reputation of potato and overall potato consumption due to criticisms about its high carbohydrate content as well as it acting as a magnet for adding high fat toppings. This has however hit the potato industry as people are trying to cut short on potato consumption. Therefore, there is a need to document the nutritional and beneficial properties of potato. This project will educate the consumers and producers on the positive health benefits of Colorado potatoes and also document the content and composition of various health benefiting compounds present in potatoes. This would aid the Colorado potato growers with strong research-evidence to combat the myths regarding potential problems associated with consumption of the innocuous potato and also highlights the potential health attributes.

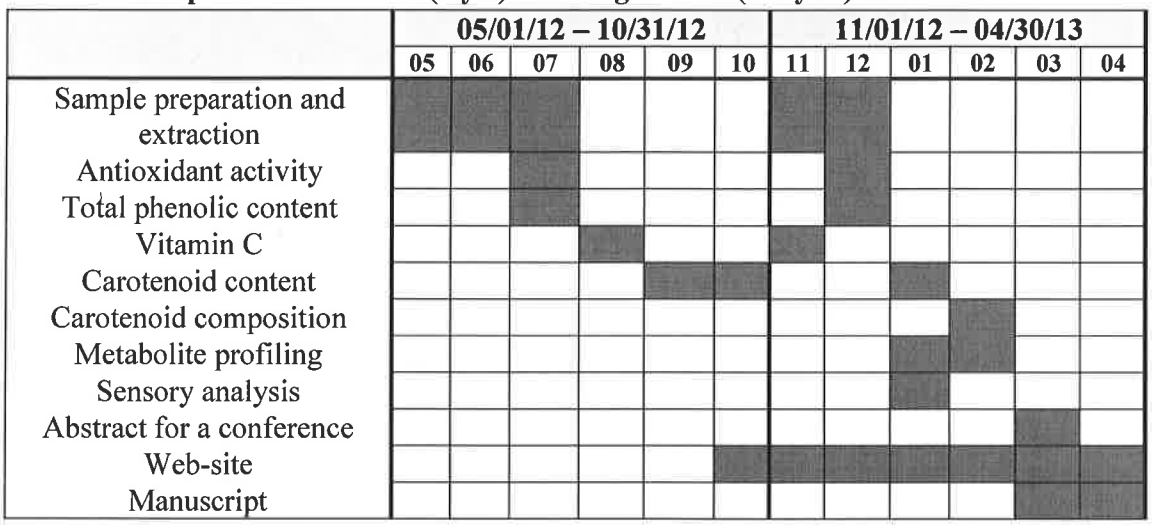
Extension-outreach plan for reporting project information to growers

Information generated from this project will be posted on the Web-site and will be available for the growers. Also the results will be communicated to the growers during field days organized by the SLVRC and South West Regional meetings. Results will also be presented as posters and oral presentations at Potato Association of America annual meetings to increase the exposure.

Potential for results to leverage additional outside funding

Results from this project will serve to provide preliminary data for submitting research proposals to federal funding agencies such as USDA. Dissemination of results from this study as publication and website will increase the popularity of Colorado potato cultivars. This exposure will aid in maintaining collaborations and also attracting funding from various sources and also play a role in increasing the ales of both market potatoes and seed cultivars grown in Colorado.

Timeline and expected short term (1 yr.) and longer term (3-5 yrs.) outcomes



Short term (1-2 year) expectations: Antioxidant activity, phenolic content, vitamin C and carotenoid content of tubers already harvested and stored will be analyzed. Along with these parameters, carotenoid composition, metabolite profiling and sensory analysis will be carried out for tubers which will be harvested in November, 2012. Results will be disseminated to the growers, consumers and industry through field days, regional meetings, posters and presentations in conferences and Web-site to increase the national exposure of Colorado cultivars. Publication of manuscript will highlight the positive health attributes of potato

Long term (3-5 year expectations): The long term goal is to improve the nutrient status and health attributes of Colorado grown potatoes through breeding. This requires continuous screening of tubers year after year for bioactive compounds and minerals. Developing molecular markers to use in the breeding program for bioactive compounds or health attributes would also be useful. This will further increase the funding opportunities to develop nutrient dense healthy potatoes. We will also plan to investigate the health benefiting properties of potatoes using *in vitro* and *in vivo* models.

Detailed annual budget (personnel, materials and supplies, travel, equipment, services) and budget justification.

Personnel: Investigator will oversee the project and train the graduate student to carry out the analysis. Masters student will devote 25% effort (10 hours/week) to this project at a total cost

of $7,935 (salary + 5.8% fringe) for one year. Student will be responsible for procurement of potatoes, sample preparation and analyses. We also request support for student hourly at 10 hours a week to assist in sample preparation and sensory evaluation at a total cost of $3,027 ($12 /h X 10 h/week X 25 weeks + 0.9 % fringe).

Materials and Supplies:

Description	Amount
Solvents and buffers	$1,000
Reagents and standards	$1,250
Chromatographic column	$750
Disposable sterile plastic ware, gloves etc.	$300
Other supplies (filters, glass vials, well plates)	$500
Sensory evaluation supplies	$250
Metabolite profiling (10 samples in duplicate) (Done at Proteomics and Metabolomics Facility at CSU, Fort Collins)	$1,200

Equipment: Our facilities have all the necessary equipment for this project.

Travel: Travel ($1,000/yr.) costs cover investigator and student trips to SLV for collection of potatoes and field days.

Total: **$ 17,212** (Personnel - $10,962 + Material & supplies - $5,250 + Travel $1,000)

Literature cited.

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Table 1. Total phenolic content of potatoes after storage and processing.

Potato clones	Baked			Chipped				Uncooked
	Day 30	Day 60	Day 90	Day 0	Day 30	Day 60	Day 90	Day 90
Atlantic	11.2±0.6	17.9±1.0	22.5±0.9*	2.51±0.03	2.61±0.05	2.18±0.02	1.83±0.01	25.1±0.4
Yukon Gold	12.7±0.6	12.8±0.8	25.0±0.8*	3.04±0.03	3.51±0.04	2.65±0.01	2.27±0.01	29.1±0.6
Purple Majesty	69.6±1.5	125.7±7.2*	117.3±3.4*	10.2±0.21	8.34±0.33	7.92±0.31	9.06±0.29	118.1±3.8
AC97521-1R/Y	20.7±0.6	26.7±1.2	38.1±1.3*	3.54±0.04	3.72±0.05	2.96±0.03	2.55±0.02	38.3±0.6
CO97232-2R/Y	31.9±1.1	35.1±2.4	50.2±1.4*	3.11±0.04	3.74±0.03	2.82±0.02	2.33±0.01	44.6±0.5
CO97215-2P/P	143.9±4.5	148.3±2.4	191.7±9.6*	13.14±0.30	13.28±0.23	13.46±0.28	10.86±0.21	117.3±5.0
CO97227-2P/PW	180.1±4.7	213.5±8.5*	307.7±8.0*	18.72±0.50	18.02±0.31	14.98±0.23	13.34±0.32*	205.4±5.5

The letters (P/P, P/PW and R/Y) after some of the advanced selections denote skin/flesh color. P: purple-fleshed; PW: purple-fleshed with white-fleshed patches; R: red skin; Y: yellow-fleshed. *Indicates significant differences ($p < 0.05$) in the phenolic content compared with the initial time point (Day 30 for baked and Day 0 for chipped). Results are presented as mean ± SE of eight replicates for each time point and expressed as mg gallic acid equivalents/100 gfw.

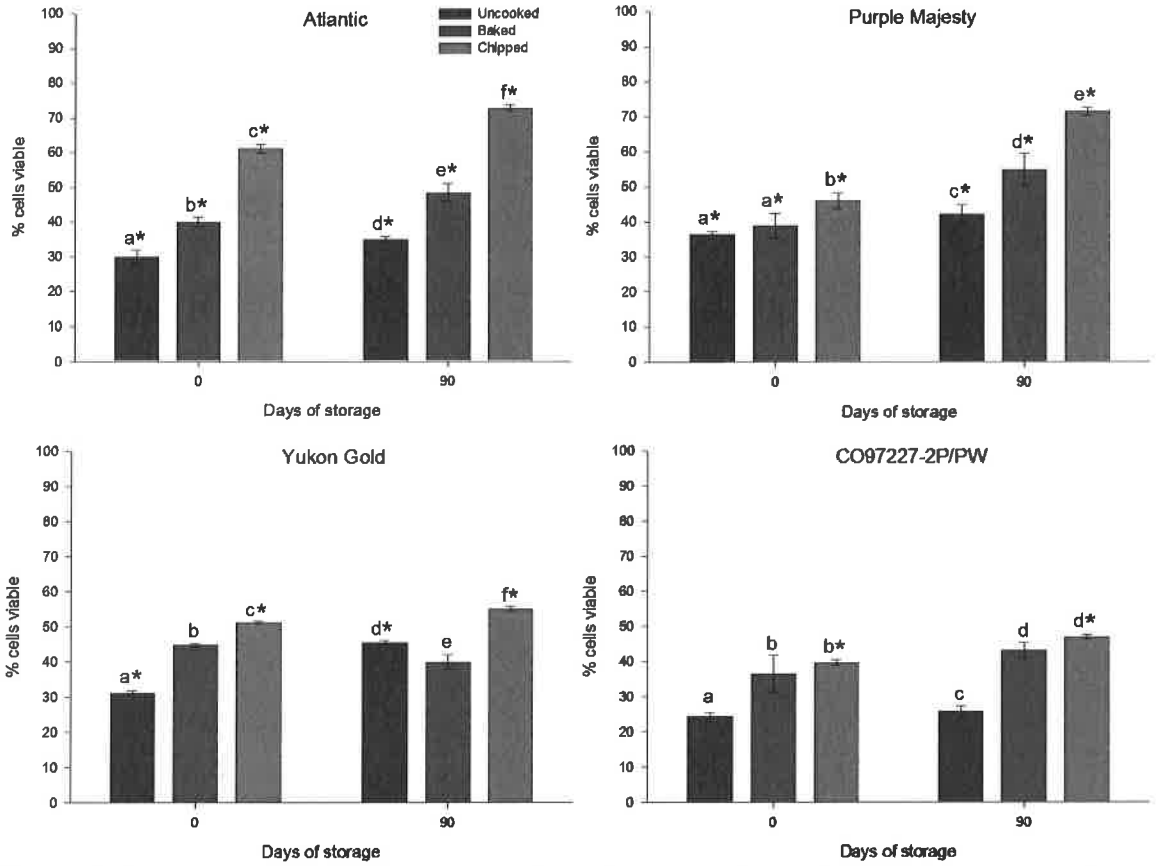

Figure 1. Baking and chipping suppressed the anti-proliferative activity in most potato clones at 30 μg GAE/ml concentration. Values with different letters in each graph indicate significant difference ($p < 0.05$) between % cells viable for different processing methods at a given time point. *Indicates a significant difference ($p < 0.05$) between percentage reduction at two different time points for a given processing method. Results are presented as mean ± SE of four replicates for each time point.

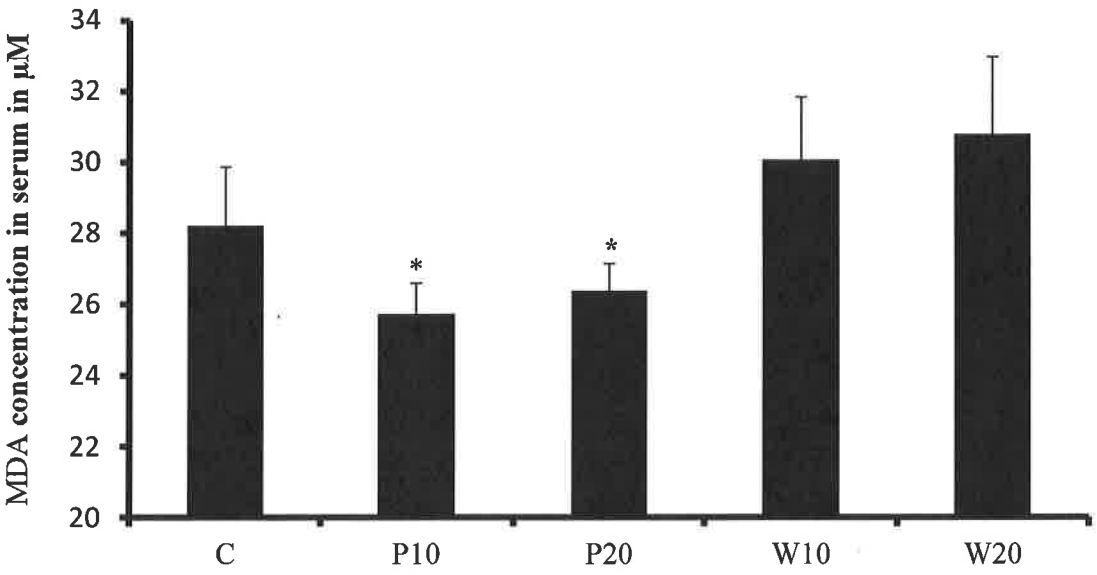

Figure 2. Purple potato chips at 10 (P10) and 20% (P20) of the diet reduced serum melondialdehyde compared to high-fat control (C) and white potato chips at 10 and 20% (W10 & W20). *Indicates a significant difference at $p < 0.05$. Results are presented as mean ± SE of eight replicates for each time point.