Assessment of carotenoid content of yellow-fleshed potato varieties grown in Alberta to determine potential nutritional benefits

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Assessment of carotenoid content of yellow-fleshed potato varieties grown in Alberta to determine potential nutritional benefits

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Dr. Michele Konschuh
Tricia McAllister
Simone Dalpé
Tina Lewis
Dr. Darcy Driedger
Norm Janssen
AAFRD

Dr. Qin Chen
Agriculture and Agri-Food Canada, Lethbridge

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Abstract

Twenty yellow-fleshed potato varieties were grown alongside two check varieties at two Alberta locations; a dry-land site near Edmonton and an irrigated site near Brooks. Tuber flesh color (chroma) was measured after harvest and ranged from 30 in the Russet Burbank check (off-white flesh) to over 50 in several yellow-fleshed varieties. There was very high correlation between locations with respect to tuber flesh color, indicating that flesh color is a variety specific trait not easily influenced by growing location. Total carotenoids, lutein and zeaxanthin were extracted from tubers after harvest, and again after 4 months storage at 8°C for some varieties. Total carotenoid content ranged from 35 to 240 µg per 100 g FW and was positively correlated with tuber flesh color. Lutein concentrations in the same variety were correlated but not consistent between growing locations. Environmental conditions experienced at each site were quite different and it was not clear whether the differences observed were a result of latitude, soil type, environmental conditions or simply tuber size and maturity. Lutein accounted for approximately ⅓ of the total carotenoid content in many varieties and ranged from 9.3 µg per 100 g FW in the Russet Burbank check to over 50 µg per 100 g FW in the deep yellow-fleshed variety, Satina. Zeaxanthin was present in low concentrations and did not contribute significantly to total carotenoid content in the varieties studied.

Five fresh market varieties (Agata, Cecile, Island Sunshine, Piccolo and Satina) were selected for storage and cooking stability analyses. Another five potential processing varieties (Innovator, Sante, Satina, Sinora and Victoria) were selected for storage and frying stability analyses. Less lutein was extracted from stored potatoes than from freshly harvested potatoes, but the decrease in lutein concentration depended on the potato variety. More lutein was recovered from cooked potato than from stored potato for three of the fresh market varieties. Similarly, the concentration of lutein extracted from fried samples was much higher than from stored samples for all of the processing varieties studied. A reduction in moisture content only accounted for a portion of the increase observed. Although the reason for greater lutein concentrations after cooking and frying was not determined, we have put forward some possible explanations.

Introduction

Yukon Gold, a yellow-fleshed potato cultivar developed by Canadian potato breeders (Johnston & Rowberry 1981) has found a niche in North America and has opened the door to acceptance of yellow-fleshed potatoes by consumers. The impetus to develop new, improved yellow-fleshed cultivars has now expanded beyond the goal of simply developing novelty types for specialty markets (Lu et al. 2001). The yellow color of the potato flesh is imparted by carotenoids and Lu et al. (2001) reported that both individual and total carotenoid contents were positively correlated to yellow-flesh intensity in potato tubers. Carotenoids may protect against a variety of chronic diseases including cardiovascular disease (Gaziano et al. 1995) and certain cancers (Colditz et al. 1985). Perhaps the clearest link between specific carotenoids and a health outcome is that for lutein and zeaxanthin with age-related macular degeneration (AMD), the leading cause of visual impairment and blindness in the U.S (Snodderly 1995). Lutein and zeaxanthin are two carotenoids that circulate in human blood plasma and are concentrated in the macula region of the eye. Consumption of foods rich in lutein and zeaxanthin is inversely related to AMD (Seddon et al. 1994) and short-term feeding of foods rich in lutein and zeaxanthin can substantially increase pigment density in the eyes of human subjects (Hammond et al. 1997). Conversely, people with macular degeneration have been found to have lower levels of zeaxanthin and lutein than people without, which supports the premise that these antioxidants provide some protection (Bliss 2003). Recent feeding studies have also shown that although spinach is rich in carotenoids, other foods may contain a more bio-available source of the compounds (Bliss 2003).

As of 2000, there was no dietary reference intake for lutein in the U.S. (Food and Nutrition Board / Institute of Medicine). It is widely believed, however, that health benefits would accrue as a result of increasing lutein consumption in the U.S. from the estimated average intake of 1.3 mg/day (Chug-Ahuja et al. 1993). Studies at the University of Florida looking at the effect of dietary lutein supplements of 2.4 mg/day showed an increase in serum lutein concentration and an increase in macular pigment density. Total carotenoid content in white-fleshed potato varieties ranges from 15 to 185 µg/100 g fresh weight, while yellow fleshed varieties can exceed 500 µg/100g fresh weight of lutein and up to 1.4 mg/100 g fresh weight of total carotenoids (Lu et al. 2001). A typical baked potato serving weighs approximately 170 g; so yellow-fleshed potatoes could supply a significant percentage of dietary lutein.

This trial involved screening several registered or near-registered yellow-fleshed potato varieties for flesh color, total carotenoid content and concentrations of lutein and zeaxanthin to determine whether any of the varieties would supply a good source of dietary lutein. Further we wanted to establish the stability of carotenoids, especially lutein, during storage and processing for some of the most promising lines. Identification of yellow-fleshed varieties with significant carotenoid concentrations would allow the potato industry in Alberta to market products, fresh and processed, as functional foods to health-conscious consumers.

Objectives

- To determine concentrations of total carotenoids and lutein and zeaxanthin in yellow-fleshed potato varieties grown in Alberta.
- To determine whether growing location (Brooks versus Edmonton) has an impact on total carotenoid content in yellow-fleshed potato tubers.
- To determine the stability of carotenoids, especially lutein and zeaxanthin, during storage of potato tubers with significant concentrations of carotenoids.
- To determine the stability of carotenoids, especially lutein and zeaxanthin, during cooking or processing of varieties with significant concentrations of carotenoids.

Methods

The trial was conducted in replicated plots at the Crop Diversification Centre South (CDCS) in Brooks, AB, and the Crop Diversification Centre North (CDCN) in Edmonton, AB. Twenty different yellow-fleshed varieties were included in the trial (Table 1). Two check varieties were also included as known comparisons. Three companies agreed to provide seed for the trial, and each company was asked for input in variety selection. Early generation seed (E2 or E3) of each variety was used for this trial. Seed was cut, if necessary, to ensure seed pieces of no more than 70 to 85 g, suberized, and planted 30 cm apart in 6 m rows spaced 90 cm apart. Each variety was grown in a randomized complete block design with four replicates (see plot plan).

Table 1: Yellow-fleshed potato varieties included in the lutein screening trial.

Variety	Seed Supplied By
Agata	Solanum International
Adora	HZPC Americas
Amandine	Solanum International
Baby Boomer	Solanum International
Cherie	Solanum International
Fabula	HZPC Americas
Innovator	HZPC Americas
Island Sunshine	Parkland Seed Potatoes
Mozart	HZPC Americas
Piccolo	Solanum International
Provento	Parkland Seed Potatoes
Red Scarlet	HZPC Americas
Rosara	Solanum International
Russet Burbank	Check
Cecile (RZ94-83)	HZPC Americas
Sante	Parkland Seed Potatoes
Satina	Solanum International
Sinora	Parkland Seed Potatoes
Velox	Solanum International
Victoria	HZPC Americas
Yukon Gold	Check

At CDCS the plots were managed following the guidelines for the Western Canadian Potato Breeding Program. Potatoes were planted approximately 12 to 14 cm deep using a two-row wheel planter on May 19, 2004 at CDCS. The plots were hilled prior to emergence and were irrigated at CDCS to maintain soil moisture close to 70%. Eptam (2.0 L/ac) was applied pre-planting (April 15), Lorox (1.8 L/ac) was applied pre-emergent (June 8) and Prism (24 g/ac) was applied post-emergent (June 23) to control weeds. Foliar fungicides were applied approximately every 2 weeks during the growing season to prevent early blight and late blight from developing (Table 2). Insecticides were applied July 15 (Sevin, 0.5 L/ac) and July 30 (Admire, 80 mL/ac) to control Colorado Potato Beetles. Reglone (1 L/ac) was applied August 27 to desiccate the plots. All treatments at CDCS were harvested mechanically September 9 and 10.

Table 2: Foliar fungicides applied to the potato crop at CDCS to prevent early blight and late blight development.

Date of Application	Fungicide	Rate
June 22	Quadris	0.250 L/ac
July 8	Dithane DG Rainshield	0.60 kg/ac
July 16	Ridomil Gold/Bravo	8.83 L/10 ac
July 30	Bravo 500	0.75 L/ac
August 12	Dithane DG Rainshield	0.60 kg/ac
August 27	Quadris	0.250 L/ac

At CDCN, plots were managed as dry-land plots following the guidelines for the Western Canadian Potato Breeding Program. Potatoes were planted approximately 12 to 14 cm deep using a two-row wheel planter on May 17, 2004. Plots were hilled May 25, prior to emergence, but difficult conditions at hilling resulted in some dragging and damaged tubers. Lorox (1.8 L/ac) was applied pre-emergent and plots were hand weeded in early July to control weeds. Foliar fungicide (Bravo, 1 L/ac) was applied approximately every 2 weeks during the growing season to prevent early blight and late blight from developing (4 applications). No insecticides were required. Reglone (1.4 L/ac) was applied August 31 to desiccate the plots. Harvest was delayed by early snowfall September 8 and 9 in the Edmonton area. All treatments at CDCN were harvested September 16.

Tubers were weighed to obtain yield estimates and graded into small, medium, large and deformed categories. Medium tubers (48 to 88 mm in diameter) were weighed to obtain estimates of marketable yield. Yield estimates have been presented in ton/acre although small plot trials do not always accurately reflect commercial yield potential (Appendix). A sample of 25 marketable tubers was washed and used to determine specific gravity by the weight-in-air over weight-in-water method. Each of these tubers was then cut longitudinally to assess brown center, hollow heart and other internal defects. Also, a composite sample of marketable tubers of each variety from each location was submitted to the Food Science lab at CDCS for measurement of flesh color (chroma) and analysis of total carotenoids, lutein and zeaxanthin. Samples of each variety were stored at 8°C for analysis of carotenoid stability in storage and lutein concentration after cooking or processing.

Field data were statistically analyzed using GLM and Duncan's Multiple Range Test ($p \leq 0.05$; SAS). Lab analyses were based on composite samples, so no statistics were applied.

Once initial assessments were complete, five varieties were selected (high lutein content, good yield and grade, and low to moderate specific gravity; see Appendix) for fresh market varieties. These potatoes were peeled, diced and either frozen or cooked then frozen. Another five varieties were selected (high lutein content, good yield and grade, and high specific gravity; see Appendix) for potential processing varieties. Eight tubers were used to cut fries, half of the fry strips from each potato were frozen, the other half were processed into fries, then frozen. These samples were analyzed for total carotenoids, lutein and zeaxanthin. The samples frozen before cooking/frying were compared to the post-harvest samples to determine stability of carotenoids during storage. The samples frozen after cooking/frying were compared to the before cooking/frying samples to show stability of carotenoids during cooking and processing.

Flesh color was measured using a HunterLab ColorQuest color measurement instrument. Tubers were prepared for color analysis by dicing into 1 cm cubes and using approximately 250 mL for color measurement. Measurements were made in triplicate. Chroma was measured using the CIELCh color scale, D65 illuminant and a 10° observer angle. Chroma is a measure of color intensity. Previous unpublished work in our lab indicated that chroma is the best indicator of yellowness in white and yellow-fleshed potatoes.

The composite sample provided for carotenoid analysis was diced and frozen (approximately 1 cm cubes). Carotenoid analysis was based on the method of Lu et al. (2001). Carotenoids were extracted from a 100 g sub-sample with 100 mL tetrahydrofuran containing 0.05% butylated hydroxytoluene, 2 g sodium carbonate and 3 g Celite 545 as a filter aid. The mixture was blended for 1 minute and vacuum filtered through Whatman 1 filter paper. The filter cake and paper were extracted a second time with fresh extraction solvent and the filtrates combined. Most of the yellow color was removed from the potatoes during the first extraction. The combined filtrate was evaporated on a rotary evaporator to remove the tetrahydrofuran. The concentrated extract was transferred quantitatively with a small amount of methanol to a separatory funnel containing 50 mL saturated aqueous sodium chloride. The aqueous solution was extracted repeatedly with methylene chloride until all the yellow color was removed. Generally, two extractions were sufficient. The methylene chloride extract was dried over anhydrous sodium sulfate. The extract was then evaporated to dryness. The residue was re-dissolved in mobile phase containing beta-apo-8'-carotenal as an internal standard to a final volume of 25 mL (fried samples were diluted to 50 mL). The extract was filtered though a 0.45 μm filter into an HPLC vial.

Analysis of carotenoids was performed on an Agilent 1100 liquid chromatography system using a Phenomenex Synergi Hydro RP column (4.6 x 250 mm) and diode-array detection at 450 nm. The mobile phase consisted of 70% acetonitrile, 15% methanol, 15% methylene chloride, 0.05% butylated hydroxytoluene and 0.01% N,N-diisopropylethylamine. Elution was isocratic at 0.8 mL/min. Linearity and retention times were verified with lutein and zeaxanthin standards. Carotenoid concentrations were calculated relative to the internal standard concentration.

Results

Composite samples of marketable potatoes from each location were used to determine the concentration of lutein and zeaxanthin per 100 g fresh weight of tuber. These samples were also used to determine flesh color intensity (chroma) and total carotenoid concentration from each potato variety at each location. The data for CDCS and CDCN are reported in Table 3.

Table 3: Flesh color intensity (chroma) and concentration of carotenoids (lutein, zeaxanthin = Zea, and total carotenoids; mcg per g FW) in yellow-fleshed potato tubers grown at two locations in Alberta.

	CDCS (Brooks)				CDCN (Edmonton)			
Variety	**Chroma**	**Lutein**	**Zea**	**Total**	**Chroma**	**Lutein**	**Zea**	**Total**
Russet Burbank	30.3	13.5	0.0	30.0	31.5	9.3	0.0	21.0
Innovator	41.9	22.7	1.4	90.0	43.6	23.5	1.5	85.0
Baby Boomer	42.3	17.6	0.6	69.0	44.6	25.3	1.2	86.0
Amandine	42.6	9.9	0.0	35.0	44.7	24.0	2.3	78.0
Provento	43.1	13.9	0.0	78.0	45.6	20.2	0.0	115.0
Cherie (red)	43.2	27.2	0.9	109.0	42.9	31.0	1.8	133.0
Adora	43.5	17.7	1.5	83.0	44.0	18.5	1.7	71.0
Velox	44.8	13.9	0.0	77.0	46.2	12.7	0.0	54.0
Sante	45.0	27.2	2.2	120.0	47.4	36.2	2.1	142.0
Agat	45.5	23.5	0.0	95.0	46.2	29.0	1.5	93.0
Red Scarlett	45.5	17.6	0.0	74.0	47.2	16.3	0.0	60.0
Yukon Gold	46.6	12.6	0.4	65.0	46.0	10.6	2.0	59.0
Fabula	46.8	17.0	1.3	93.0	48.0	23.9	2.4	115.0
Cecile (red)	47.5	40.6	0.0	195.0	49.5	32.4	1.0	128.0
Sinora	47.6	28.2	0.9	111.0	50.2	17.3	0.0	54.0
Penta	47.6	27.5	0.8	116.0	47.8	26.3	1.5	93.0
Mozart red)	48.0	18.6	0.0	62.0	48.6	31.3	1.0	96.0
Rosara (red)	48.2	21.7	0.6	146.0	51.2	24.8	2.2	125.0
Piccolo	50.2	23.6	1.0	110.0	53.3	21.5	1.4	102.0
Satina	50.7	54.0	3.3	227.0	51.0	50.8	4.2	110.0
Victoria	51.1	22.5	0.9	124.0	49.6	21.9	2.1	110.0
Island Sunshine	53.6	45.0	1.2	240.0	53.0	34.3	0.5	133.0

Chroma is the measurement of color most closely aligned with our perception of color intensity. The chroma of tuber flesh ranged from 30 in the Russet Burbank check (considered off-white) to over 50 in several of the yellow-fleshed varieties (the higher the number, the more yellow the appearance of the flesh). Yellow flesh color is a heritable trait (Lu et al. 2001) and is characteristic of a particular variety. Although there was very good correlation between chroma values from samples obtained at the two locations (r^2 = 0.925), the values from CDCS and CDCN were not identical. Growing conditions and size at the time of harvest may influence the chroma values for each variety as well.

In the literature, it is noted that individual and total carotenoid content are positively correlated with flesh color. We found that flesh color was more closely correlated with total carotenoids (r^2 = 0.46) than with lutein (r^2 = 0.30), and even then, the correlation was positive but not all that strong. The correlations were stronger for samples from CDCS than from CDCN and may relate to tuber maturity. Certainly, carotenoids other than lutein and zeaxanthin contribute to yellow flesh color and compounds other than carotenoids may also influence the chroma of potato tubers.

Total carotenoid concentration in yellow-fleshed potatoes ranged from 35 to 240 µg / 100 g FW. Lutein, zeaxanthin, and several other carotenoids have been reported to be present in yellow-fleshed tubers (Brown et al. 1993, Lu et al. 2001, Brethaupt and Bamedi 2002). Lutein and zeaxanthin specifically, have been linked to improved eye health in clinical studies (Bruno and Medeiros 2000, Moeller et al. 2000, Krinsky et al. 2003). Lutein was present in appreciable amounts in all of the varieties examined, even the non-yellow check, Russet Burbank. However, zeaxanthin was present in very low quantities and did not contribute significantly to the total carotenoid concentration in the tubers. In most varieties, lutein made up to ⅓ of the total carotenoid content. It was beyond the scope of this trial to identify other carotenoid compounds present in the potato tubers. Lutein concentration ranged from 9.3 µg / 100 g FW in the Russet Burbank check to over 50 µg / 100 g FW in the variety Satina. Again, there was a strong correlation ($r^2 = 0.925$) in lutein concentration between locations, but the numbers were not identical. There may be an influence of growing location (environment, latitude, soil type, etc.) or the size and maturity of the tubers harvested on lutein concentration, but variety seemed to be the greatest influencing factor. Total carotenoid concentration was correlated between CDCN and CDCS samples, but the correlation for total carotenoid ($r^2 = 0.57$) was not as strong as that for lutein ($r^2 = 0.62$). This suggests that compounds other than lutein may be more variable from one location to another.

Based on the lutein data (Table 3), yield data, tuber shape and specific gravity data (Appendix); five varieties were selected to move forward as potential fits for fresh market. Varieties with high lutein, moderate to low specific gravity, high yields of marketable or small potatoes, and pleasant tuber shapes were selected for fresh market interest. These varieties, Agata, Cecile, Island Sunshine, Piccolo, and Satina, were compared to Yukon Gold, a well-known yellow-fleshed variety sold in the fresh market, for storage and cooking data collection.

Based on the lutein data (Table 3), yield, tuber shape and specific gravity data (Appendix); five varieties were selected to move forward as potential fits for the processing industry. Varieties with high lutein, oblong to oval tuber shape, good marketable yield and high specific gravity were selected for processing interest. These varietie, Innovator, Sante, Satina, Sinora, and Victoria, were compared with Russet Burbank, a widely used French fry processing variety, for storage and frying data collection.

Lutein, zeaxanthin and total carotenoids were determined again after approximately four months in storage. Carotenoid stability varied with variety, and in all cases, less total carotenoid and less lutein were recovered from tubers after storage. Differences may be related to the physiology of specific varieties (including size and maturity at harvest) or may relate to variability in dormancy and shrinkage in storage. The storage lutein data for the fresh market and processing varieties are shown in Figure 1.

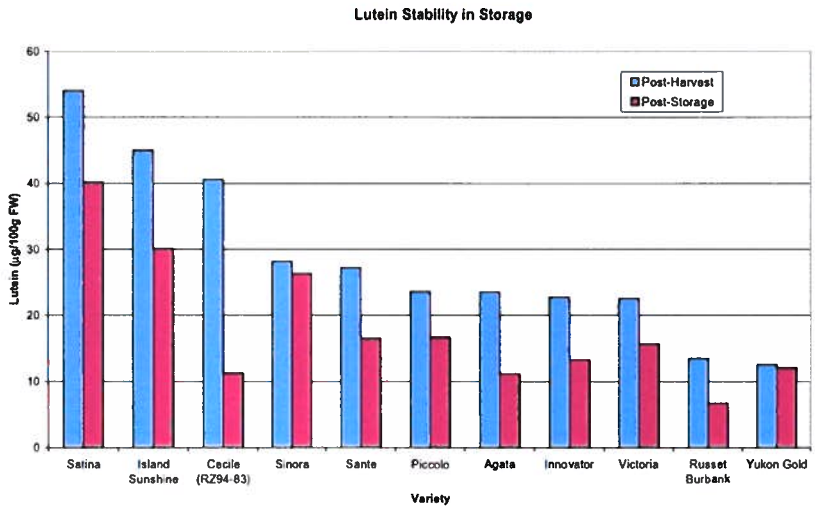

Figure 1: Concentration (µg / g FW) of lutein extracted from yellow-fleshed potatoes at harvest (post-harvest), and after four months storage (post-storage).

Total carotenoids, lutein and zeaxanthin were extracted from samples that had been cooked out of storage (Figure 2). These potatoes were diced, boiled, frozen and used for carotenoid extraction. As noted, less lutein was recovered from stored potatoes than from freshly harvested potatoes. After cooking, lutein recovery differed with variety (Figure 2). In Satina and Piccolo, less lutein was recovered after cooking than before. In Island Sunshine, Cecile, Yukon Gold and Agata, more lutein was recovered after cooking than before. This trend was observed for total carotenoids as well regardless of whether concentration was expressed in terms of fresh weight or dry weight of tuber tissue, so the differences cannot be explained on the basis on moisture content alone.

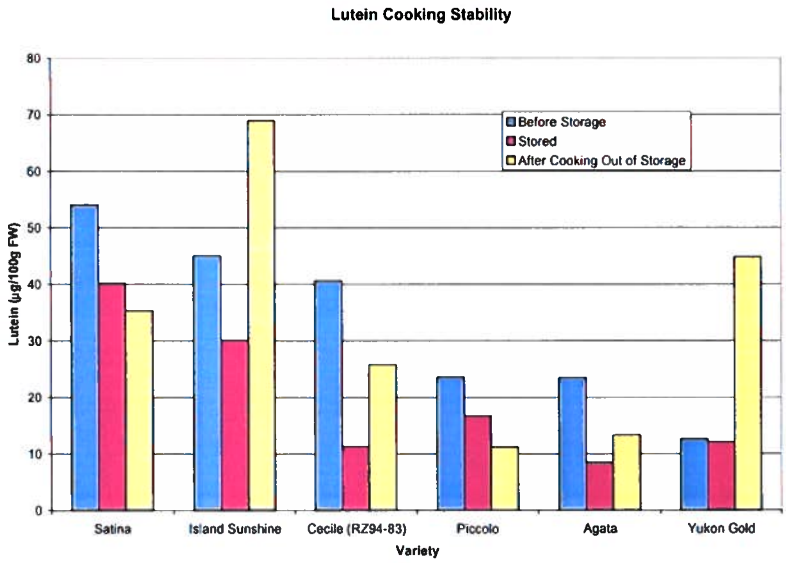

Figure 2: Concentration (µg / g FW) of lutein extracted from yellow-fleshed potatoes at harvest (before storage), after four months storage (stored), and after cooking out of storage.

Total carotenoids, lutein, and zeaxanthin were also extracted from samples that had been fried out of storage (Figure 3). These potatoes were sliced into fry strips, blanched, frozen, fried and used for lutein extraction. As already noted, less lutein was recovered from tubers after storage than after harvest. However, the quantity of lutein extracted from fried samples was much higher than from stored samples for all varieties fried. This trend was also observed for total carotenoid concentrations. This can in part, be accounted for because of changes in moisture content as a result of frying, but was true of all varieties expect for Sante, even when expressed in terms of dry weight of tuber tissue.

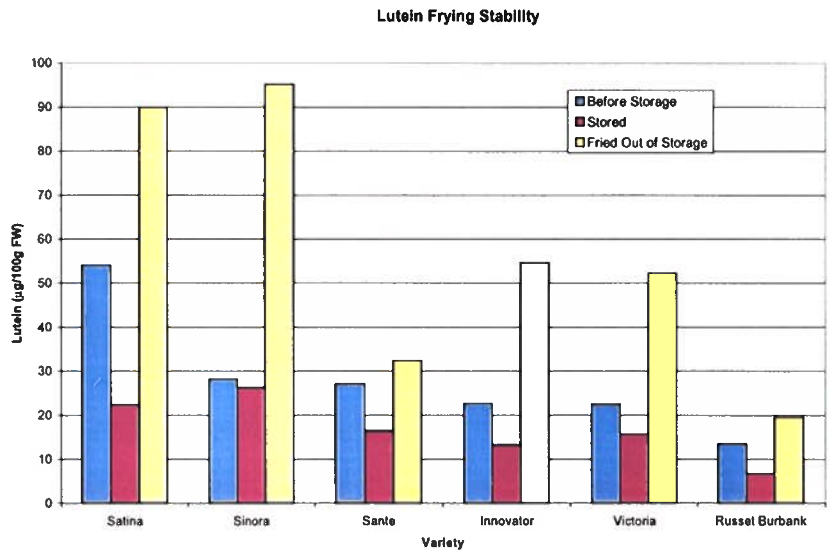

Figure 3: Concentration (µg / g FW) of lutein extracted from yellow-fleshed potatoes at harvest (before storage), after four months storage (stored), and after frying out of storage.

The greater recovery of lutein after cooking or frying may be explained by a number of possible rationales:

1. Because lutein is lipophillic (soluble in solvents, not water), heating as a result of cooking or frying and cell disruption may increase the quantity of lutein extracted by the same method; or

2. Some other carotenoid compounds (for example lutein epoxides and lutein esters) may be converted to lutein during the cooking or frying process; or

3.The reduction in water concentration in the tissues as a result of cooking and frying may result in less interference during the extraction process and allow for greater extraction efficiency.

It was, however, not within the scope of this project to determine which explanation best fits the data.

Conclusions

Total carotenoid content in the yellow-fleshed potatoes studied ranged from 35 to 240 µg per 100 g FW and can be influenced by the growing location, storage and cooking or frying. The concentration of lutein in yellow-fleshed potatoes depended on the variety, among other factors, and ranged from 9.3 µg per 100 g FW to over 50 µg per 100 g FW in the varieties studied. Lutein concentrations in raw potatoes were higher after harvest than after storage for all varieties studied, but lutein concentrations were still significant after 4 months at 8°C. Lutein recovery after cooking or frying was greater than recovery from raw stored potatoes for most varieties studied. When boiled or fried, an average size yellow-fleshed potato can contribute five times the dietary lutein, and eight times the total carotenoid content found in more common potato varieties.

Presentation to Industry

Preliminary data was presented in a Power Point slide show at a breakfast meeting of the Potato Growers of Alberta in Taber, Alberta February 22, 2005. A second presentation of data is being arranged for a Potato Growers of Alberta area meeting in Edmonton August 18, 2005 and a poster version of the results will be prepared for the Potato Growers of Alberta Annual Meeting in November. A copy of this report will be provided to all of our industry sponsors a once it is approved.

Industry Reaction

The reaction from industry so far has been positive. Potato production has remained static in Alberta while acres of potatoes are being reduced in other growing areas. This project is being perceived as an effort to add value to fresh potato sales, and to provide a marketing angle to processors and packers alike. The data from the NIF project allowed us to move forward with the concept. We applied to Ag & Food Council this spring for funds to allow us to explore the impact of growing location and time of harvest on several varieties for two additional years. We have industry funds from several interested parties as well. The information generated in the NIF project and the two-year Ag & Food Council project will give us a firm base of scientific information from which to initiate a marketing study. It is not clear how industry intends to use the information to advantage. A collective effort between industry competitors is unlikely. Individual industry members may capitalize on this information in different ways.

Summary

The color of yellow-fleshed potatoes is imparted by carotenoids. Carotenoids are anti-oxidant compounds that may protect against a variety of chronic diseases and certain cancers. Lutein and zeaxanthin are two specific carotenoid compound associated with a reduced incidence of age-related macular degeneration and cataract formation. This project involved screening twenty yellow-fleshed potato varieties grown in two Alberta locations, and analyzing them for tuber flesh color intensity, total carotenoid content and concentrations of lutein and zeaxanthin. Total carotenoid content ranged from 35 to 240 µg per 100 g FW and was positively correlated with tuber flesh color intensity. Lutein accounted for approximately ⅓ of the total carotenoid content in many varieties and ranged from 9.3 µg per 100 g FW in the Russet Burbank (off-white) check to over 50 µg per 100 g FW in the variety Satina (deep-yellow). Zeaxanthin was present in low concentrations and did not contribute significantly to the total carotenoid content in the varieties studied.

Five promising fresh market varieties (Agata, Cecile, Island Sunshine, Piccolo and Satina) were selected for storage and cooking analyses. Five varieties (Innovator, Sante, Satina, Sinora and Victoria) were selected as promising processing varieties for storage and frying stability analyses. Less lutein was extracted from stored potatoes than from freshly harvested potatoes, but the decrease in lutein concentration depended on the potato variety. More lutein was recovered from cooked potato than from stored potato for three of the fresh market varieties. Similarly, the concentration of lutein extracted from fried samples was much higher than from stored samples for all of the processing varieties studied. A reduction in moisture content only accounted for a portion of the increase in lutein concentration observed. Although the reason for greater lutein concentrations after cooking and frying was not determined, we have put forward some possible explanations. Potato varieties with significant concentrations of lutein and zeaxanthin may be marketed in the future as functional foods.

Sponsors

AAFRD New Initiatives Fund

Potato Growers of Alberta

Con Agra Limited (Lamb-Weston)

Maple Leaf Potatoes

McCain Foods Ltd.

Solanum International

HZPC Americas Corp.

Parkland Seed Potatoes

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Appendix

Figure A1: Plot plan for lutein screening trial 2004

Lutein Screening Trial 2004 - Field 71
22 cultivars x 4 reps
6 metre rows, 20 hills/plot row, 30 cm plant spacing

N ←

1	Guard	Guard	Guard	Guard	Guard	Guard	Guard	Guard	Guard
2	1001 Agata 9	1011 Yukon Gold 2	1021 Mozart 17	2009 Adora 21	2019 Cherie 5	3007 Adora 21	3017 Mozart 17	4005 Agata 9	4015 Sinora 12
3	1002 Sinora 12	1012 Cherie 5	1022 Penta 14	2010 Mozart 17	2020 Rosara 6	3008 Provento 13	3018 Penta 14	4006 Baby Boomer 3	4016 Amandine 4
4	1003 Red Scarlet 18	1013 Sante 11	2001 Penta 14	2011 Amandine 4	2021 Yukon Gold 2	3009 Red Scarlet 18	3019 Piccolo 8	4007 Adora 21	4017 Penta 14
5	1004 RZ94-83 19	1014 Island Sunshine 10	2002 Sante 11	2012 Baby Boomer 3	2022 Piccolo 8	3010 Island Sunshine 10	3020 Baby Boomer 3	4008 Sante 11	4018 Yukon Gold 2
6	1005 Adora 21	1015 Fabula 15	2003 Red Scarlet 18	2013 Fabula 15	3001 Cherie 5	3011 Russet Burbank 1	3022 Agata 9	4009 Victoria 20	4019 Cherie 5
7	1006 Rosara 6	1016 Baby Boomer 3	2004 Velox 7	2014 Sinora 12	3002 Velox 7	3012 Sinora 12	3021 Victoria 20	4010 Piccolo 8	4020 Rosara 6
8	1007 Velox 7	1017 Russet Burbank 1	2005 RZ94-83 19	2015 Victoria 20	3003 RZ94-83 19	3013 Amandine 4	4001 Mozart 17	4011 Red Scarlet 18	4021 Satina 22
9	1008 Innovator 16	1018 Piccolo 8	2006 Provento 13	2016 Satina 22	3004 Sante 11	3014 Innovator 16	4002 Provento 13	4012 Island Sunshine 10	4022 RZ94-83 19
10	1009 Provento 13	1019 Amandine 4	2007 Innovator 16	2017 Agata 9	3005 Yukon Gold 2	3015 Satina 22	4003 Russet Burbank 1	4013 Fabula 15	Guard
11	1010 Victoria 20	1020 Satina 22	2008 Russet Burbank 1	2018 Island Sunshine 10	3006 Fabula 15	3016 Rosara 6	4004 Innovator 16	4014 Velox 7	Guard
12	Guard	Guard	Guard	Guard	Guard	Guard	Guard	Guard	Guard

3 m

6 m

78 m

12 m

Table A1: Description, characteristics and resistance or susceptibilities of yellow-fleshed potato varieties and check varieties used in the trial

	Description					Characteristics			Resistance or Susceptibilities													
Cultivar	**Maturity**	**Skin Color**	**Flesh Color**	**Tuber Shape**	**Eyes**	**Yield Potential**	**Storage**	**Utilization**	**Comon Scab**	**Hollow Heart**	**Blackleg**	**Fusarium**	**Rhizoctonia**	**Late Blight**	**PVA**	**PVS**	**PVX**	**PVY**	**PLRV**	**Wart**	**Nematodes**	**Metribuzin**
Adora	early	light yellow	pale yellow	oblong	shallow/medium	high		boil, bake	MR		MS	R					R	MR	MR		R(G)	
Agata	early	smooth, yellow	yellow	oval/long	shallow	high	very good, short dormancy	boil, bake	MR		MR	MR		MR					MR	HR	R(A)	R
Amandine	early	pale yellow	pale yellow	long	very shallow	high			R					R				S	S			
Baby Boomer	mid-season	yellow	yellow	round	medium	high	good	bake, wedges	R					S								
Cecile		deep red	bright yellow	oval/long	shallow			boil, bake														
Cherie	early	red	pale yellow	oval/long	very shallow	high	good	boil, bake	MR					MS								
Fabula	mid-season	yellow	pale yellow	oval	shallow	very high		boil, bake	MR					R	HR		R	R	HR	HR		
Innovator	early	reddish brown	cream	oval/long	shallow	high	good, can recondition	boil, bake, fry	MR					R		MR	MR	MR		HR		S
Island Sunshine	very late	buff, flaky	yellow	round	deep	high	very good, long dormancy	boil, bake	MR			MR		HR(1)				S	S			
Mozart																						
Penta	mid-season	yellow / red eyebrows	yellow	round	shallow/medium	high	good, good dormancy	boil, bake	MR		MS		MR	MR	R		R	S	MR	S	R(A)	
Piccolo	medium early	yellow	yellow	oval/long	shallow	high	good dormancy	boil, bake	R					S								
Provento	mid-season	yellow	yellow	round/oval	shallow	very high		boil, bake	MR		MR	MS		MR	HR		HR	R	R	HR	S	MR
Red Scarlett	early	red	pale yellow	oval	shallow	high		boil, bake	MR					MS				MR	MR	HR		
Rosara	first early	red	yellow	oval/long	shallow	high	medium	boil, bake	R	R	R		MR	R								
Russet Burbank	very late	russet, netted	white	long	shallow	high	good	boil, bake, fry	R		HR	R						HS				
Sante	mid-season	buff	light yellow	oblong	shallow	very high	good	boil, bake, fry	MR		MS	MR		HR	HR		HR	HR	HR	HR	HR	S
Satina	medium early	yellow	deep yellow	oval	shallow/medium	very high	good	boil, bake		HR	MR		HR	MR						R		
Sinora	early	yellow	light yellow	round/oval	shallow/medium	high	good	fries, chips	MS					MR			R	R	MR			
Velox	first early	yellow	light yellow	oval/long	very shallow	high	medium	boil, bake, fry	MR	MR	HR		MR	MR						MR		
Victoria	mid-season	yellow	yellow	oval/long	shallow	high	good	boil, bake, fry	S					MR			MR	R	R	HR		

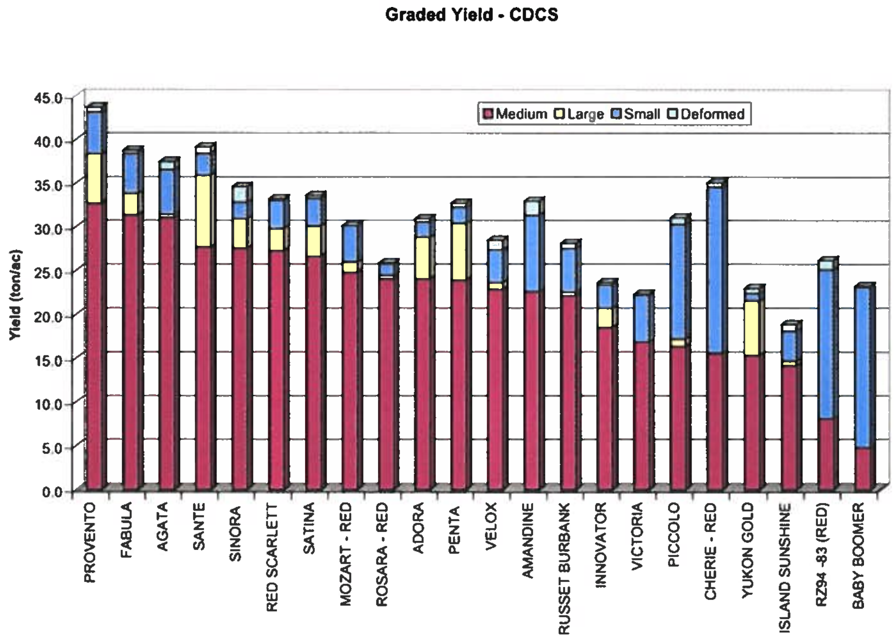

Figure A2: Estimated yield and grade (ton/ac) of each variety of yellow-fleshed potatoes grown at CDCS in Brooks.

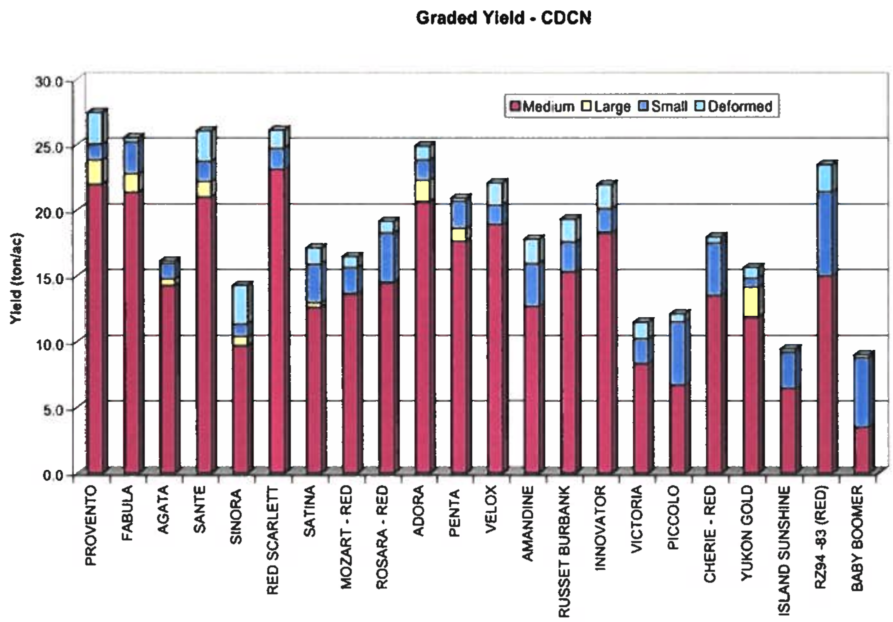

Figure A3: Estimated yield and grade (ton/acre) of each variety of yellow-fleshed potatoes grown at CDCN in Edmonton.

Table A2: Specific gravity of yellow-fleshed potato varieties grown at CDCS (Brooks) and CDCN (Edmonton).

Variety	***CDCS***	***CDCN***
Agata	1.065	1.031
Adora	1.072	1.048
Amandine	1.072	1.041
Baby Boomer	1.097	1.051
Cherie	1.078	1.058
Fabula	1.066	1.044
Innovator	1.081	1.060
Island Sunshine	1.091	1.040
Mozart	1.076	1.048
Piccolo	1.081	1.047
Provento	1.078	1.052
Red Scarlet	1.070	1.045
Rosara	1.077	1.048
Russet Burbank	1.091	1.063
Cecile (RZ94-83)	1.078	1.048
Sante	1.082	1.057
Satina	1.081	1.046
Sinora	1.084	1.043
Velox	1.084	1.059
Victoria	1.078	1.046
Yukon Gold	1.089	1.058