

AN ABSTRACT OF THE THESIS OF

Linda J. Wechsler for the degree of Master of Science in Food Science and Technology presented on December 16, 2010.

Title: Effect of Sensory Properties and Health Information on Consumer Acceptance and Purchase of Colorful Fresh Market Potatoes

Abstract approved:

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Potato varieties characterized by non-conventional skin and flesh colors (purple, red, yellow) have the potential to revitalize consumer demand for fresh market potatoes because of their unique appearance and health benefits. Red and purple potatoes contain anthocyanins, which are flavonoids responsible for red, blue, and purple pigments in plants. Yellow potatoes contain carotenoids, which are xanthophylls responsible for orange and yellow pigments in plants. Both anthocyanins and carotenoids are antioxidants that benefit human health. The objective of this thesis research was to investigate consumer acceptance of colorful fresh market potato varieties and to understand the effect of health information on purchase intent.

This thesis research was divided into three studies, preceded by a literature review. The literature review summarized research linking raw tuber characteristics to the culinary quality of fresh market potatoes. Specific compounds, genes, and processes affecting potato appearance, flavor, and texture were reviewed.

In the first study, consumer attitudes and opinions about colorful fresh market potatoes were investigated using four focus group sessions with a total of 37 participants. Five colorful potato varieties were shown to participants. Purchase intent for each variety was marked on an anchored line scale after: 1) seeing and handling the raw uncut potato, 2) seeing a photo of the raw potato cut in half, 3) seeing a photo of the potato cooked (boiled) and cut in half, and 4) after receiving health information describing antioxidant benefits. Reactions to colorful potato varieties were mixed. Health information had a greater impact on purchase intent than the photos of the raw and cooked potatoes. Purchase intent was also influenced by positive and negative associations with appearance, concerns about genetic engineering, tampering, and chemicals, preparation and presentation considerations, point of sale, family acceptance, and anticipated flavor.

In the second study, a consumer acceptance test with 222 participants evaluated six colorful fresh market potato varieties alongside a commonly available variety, the Yukon Gold.

Participants rated liking of overall appearance, color, size, and shape for raw uncut potatoes on a 9-point category scale. Participants tasted the potatoes boiled and rated liking of cooked appearance, flavor, and texture on a 9-point category scale. Participant comments describing what they liked and/or disliked about each raw and cooked potato were also captured. For color, yellow and red varieties were accepted over purple varieties. For shape and size, large and round varieties were accepted over small, elongated varieties. Bimodal hedonic score distributions were observed for purple color, small size, and elongated shape. Consumer comments revealed that a uniform raw and cooked appearance, a distinct flavor with no undesirable aftertaste, and a smooth, firm, and consistent texture were all desirable characteristics.

In the third study, the effect of health information on purchase intent for colorful fresh market potatoes was investigated. Participants either received no information, a simple statement, or a detailed statement about antioxidants in colorful potatoes. After reading the information, participants rated purchase intent on a 5-point category scale at a low, medium, and high price. The effect of antioxidant information on the probability of purchase for red and purple potatoes was compared to yellow potatoes. The impact of hedonic rating, price, gender, age, education, income, usage frequency, health interest, food interest, and antioxidant knowledge were also investigated. High hedonic ratings and interest in food had a positive effect on purchase intent for all potatoes. High price had a negative effect on purchase intent for all potatoes. Antioxidant information and interest in health had a positive effect on purchase intent for red and purple potatoes. Age had a negative effect on purchase intent for red and purple potatoes. An advanced degree of education had a negative effect on purchase intent for yellow potatoes.

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Effect of Sensory Properties and Health Information on Consumer Acceptance and Purchase of
Colorful Fresh Market Potatoes

by
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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Linda J. Wechsler, Author

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CONTRIBUTION OF AUTHORS

Dr. Catherine Durham was involved in the design, data analysis, and writing of each chapter.

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EFFECT OF SENSORY PROPERTIES AND HEALTH INFORMATION ON CONSUMER ACCEPTANCE AND PURCHASE OF COLORFUL FRESH MARKET POTATOES

1. CHAPTER 1 – GENERAL INTRODUCTION

The potato (*Solanum tuberosum*) is an herbaceous annual that grows up to 100 centimeters tall and produces a tuber so rich in starch that it ranks as the world's fourth most important food crop after maize, wheat, and rice. The potato belongs to the *Solanaceae* or 'nightshade' family of flowering plants, and shares the genus *Solanum* with at least 1000 other species, including tomato and eggplant. Recent research indicates that *Solanum tuberosum* is divided into two, only slightly different, cultivar groups: *Andigenum*, which is adapted to short day conditions and is mainly grown in South America, and *Chilotanum*, the potato now cultivated around the world (Food and Agriculture Organization (FAO), 2009).

Potatoes originated in the Andes region of South America where they have been used for food for over 10,000 years. Potatoes were domesticated over 8000 years ago, during pre-Columbian times. Potatoes were first spread to European countries, including Spain and England, in the late 1500s. Potatoes became so widely distributed and important in Europe that they were often referred to as 'European' or 'Irish' potatoes. Potatoes are now grown in 160 countries and there are over 4000 cultivars (Camire, Kubow, & Donnelly, 2009). Despite this apparent diversity, the cultivated potato contains only a fraction of the potential biodiversity that is present in South American cultivars and cross-compatible wild species (Vreugdenhil, 2007).

The potato is the world's number one non-grain food commodity, with production reaching a record 325 million tons in 2007 (FAO, 2009). U.S. potato production was 431,318,000 hundred weight (cwt) at a value of \$3,521,219,000 in 2009 (United States Department of Agriculture Agricultural Statistics Service (USDA NASS), 2009), ranking the U.S. the fourth largest producer of potatoes in the world (Food and Agriculture Organization of the United Nations Statistics (FAOSTAT), 2010). Potatoes are grown in nearly every state in the U.S., though about half of all potatoes come from Idaho, Washington, Wisconsin, North Dakota, Colorado, Oregon, Maine, Minnesota, California, and Michigan (FAO, 2009).

The Pacific Northwest states of Idaho, Oregon, and Washington are the largest potato producing areas in the United States (Araji & Love, 2002). The Pacific Northwest sub-region produces potatoes for processing, for the fresh market, and for replanting (seed potatoes). Oregon produces the smallest share of this sub-region, with 37,000 acres yielding 21,460,000 cwt at a value of \$151 million dollars in 2009 (Oregon Department of Agriculture (ODA), 2010).

Only about one third of the potatoes grown in the U.S. are consumed fresh. Americans eat more than 54 kilograms (kg) of potatoes per capita per year. However, fresh potato

consumption has declined from more than 22 kg per person in 1993 to just 16 kg in 2006 (FAO, 2009). The potato industry has followed this trend, with about 60% of annual output processed into frozen products, chips, dehydrated potato flakes, and starch. These products are primarily used by the fast food, snack, and convenience food industries. Some reasons for this trend include growing urban populations, rising incomes, and the diversification of diets and lifestyles that leaves less time for preparing fresh potatoes at home (FAO, 2009).

Fresh market potatoes also suffer from an image problem. Consumer behavior suggests that the potato is considered a dull meal component, a reflection of an old lifestyle, and part of traditional cuisine. Meals involving potatoes also typically contain high amounts of fat (due to complements like oil or dairy products) or are labeled as 'high-carb' and are thus considered unhealthy (Camire et al., 2009; Struik, 2006). Potatoes are also perceived as inconvenient to prepare, and are thus often replaced with other carbohydrates that are considered easier to prepare, like pasta or rice (Vreugdenhil, 2007).

The good news for fresh market potatoes is that they are ever more popular amongst consumers whose children have left home or consumers who are retirees (Jemison, Sexton, & Camire, 2008; Vreugdenhil, 2007). Also, consumer acceptance of 'specialty' potatoes has been increasing during the last several years. Specialty potatoes tend to be non-traditional cultivars of high quality that exhibit unique colors, textures, and sizes. Specialty potatoes comprise only a small percentage of the total market for fresh potatoes consumed (1% versus 70% for Russet-type cultivars), but they usually command a higher price (Olsen et al., 2003). Therefore, there is an opportunity for specialty potatoes to address the decline in consumption of fresh market potatoes by increasing consumer expenditure on premium varieties (Vreugdenhil, 2007).

In fact, specialty varieties may be the key to revitalizing production in states like Oregon, where the local potato industry has suffered from the decreasing demand for fresh market potatoes. This decrease in demand, combined with rising land and production costs, weak prices, and increased competition, has reduced the amount of potatoes sold for consumption to 20% (Associated Press, 2007). Production is focused on seed potatoes instead, which are sold to commercial growers, who, in turn, sell the resulting harvest to processors. The struggling potato industry could rebound in states like Oregon if plans to introduce new varieties into the marketplace take hold, according to potato growers and industry leaders (Associated Press, 2007). Potato growers could create new markets for these varieties and thereby expand their production.

In an effort to introduce new varieties, a number of institutions have genetics and breeding programs actively researching the viability of new cultivars. The Pacific Northwest Tri-State Potato Breeding Program is the largest body of potato research, with collaborators from

Oregon State University, Washington State University, University of Idaho, and the United States Department of Agriculture (USDA) Agricultural Research Service (ARS) in Prosser, WA and Aberdeen, ID.

This program focuses on the development of high yield and high quality potato varieties through molecular and conventional breeding practices. New germplasm is planted in agricultural experiment stations and resulting harvests are evaluated in regional trials (United States Department of Agriculture Agricultural Research Service, 2010). Cultivars that exhibit desirable qualities, such as resistance to pests and disease, are selected and replanted. These trials are repeated until finalists are released to the public. Within this program, Oregon State University (OSU) has focused on producing germplasm for new specialty potato varieties (Oregon State University Department of Crop and Soil Science, n. d.). These potatoes are the result of crosses between South American and conventional cultivars, and exhibit unique colors, such as purple, red, and orange. Although the development of these colorful specialty potatoes is a small part of the overall Tri-State effort, they are of particular interest because they have the potential to revitalize consumer demand for fresh market potatoes. This is due to their unique health benefits, which could appeal to health conscious consumers.

Fresh market potatoes, in general, have much to offer health conscious consumers. Potatoes are rich in carbohydrates, making them a good source of energy. They have the highest protein content in the family of root and tuber crops, with an amino-acid pattern that is well matched to human requirements. A medium-sized potato contains one fifth of the daily recommended intake of potassium and nearly half (45%) of the adult daily requirement of vitamin C. Potatoes are also a good source of B vitamins and minerals such as phosphorous and magnesium. Potato skin also provides a substantial amount of dietary fiber (Camire et al., 2009; Suttle, 2008).

In addition to these nutrients, however, potatoes contain antioxidants. Antioxidants are compounds which, in the presence of an oxidizable substrate and an oxidizing agent, delay the oxidation of the substrate (Brown, Durst, Wrolstad, & De Jong, 2008). All potatoes have high levels of vitamin C (on average 20 milligrams (mg) per 100 grams (g) fresh weight (FW)) which account for up to 13% of their total antioxidant capacity (Brown, 2005). The rest of their antioxidant capacity comes from other vitamins, phenolic compounds, flavonoids, carotenoids, and minerals (Woolfe, 1987). Colorful specialty potatoes are unique because they have the highest levels of antioxidants, primarily in the form of carotenoids and anthocyanins.

Carotenoids are yellow, orange, and red lipophilic pigments synthesized by all photosynthetic organisms. Two classes of carotenoids are found in nature: carotenes, such as beta-carotene, which are linear hydrocarbons cyclized at one or both ends of the molecule, and

xanthophylls, which are oxygenated derivatives of carotenes (Andre et al., 2007). The carotenoids in potatoes are lutein, zeaxanthin, and violaxanthin, all of which are xanthophylls. There is a trace of alpha and beta carotene, but potatoes are not a significant source of pro-vitamin A carotenes (Brown, 2005). Xanthophylls are fat soluble, have half-lives of several days in the human body, and are antioxidants that associate with membranes in cells (Brown, 2008).

Carotenoids are found in all potatoes. White fleshed varieties have 50-100 micrograms (μg) per 100 g FW, while moderately yellow fleshed varieties have from 100-350 μg per 100 g FW. The more intensely yellow fleshed varieties, which can look orange, can be at levels above 1000 μg per 100 g FW. The highest level published is 2600 μg per 100 g FW in diploid germplasm derived from South American *Papa Amarilla* cultivars (Brown et al., 2008).

Anthocyanins are hydrophilic pigments responsible for the red, purple, and blue colors in plants (Andre et al., 2007). Anthocyanins are polyphenols that fall under the class of flavonoids. Anthocyanins in potatoes are primarily acylated glucosides of anthocyanidins (Rodriguez-Saona, Giusti, & Wrolstad, 1998). Red and purple fleshed potatoes have acylated glucosides of pelargonidin, while purple potatoes have, in addition, acylated glucosides of malvinidin, petunidin, peonidin, and delphinidin (Brown, 2005; Lachman, Hamouz, & Orsak, 2005). Total anthocyanins range from 1.5 mg to 48 mg per 100 g FW in a solidly pigmented purple skinned, purple fleshed potato (Brown et al., 2008). Anthocyanins have half-lives of several hours in the body and certain anthocyanins have anti-inflammatory effects (Brown, 2008).

The presence of anthocyanins and carotenoids is under genetic control, and, as a result, total levels are dependent on the cultivar (Brown, Culley, Yang, Durst, & Wrolstad, 2005). In addition to genotype, growing environment (especially elevation above sea level) and methods of cooking influence total anthocyanin and carotenoid levels (Brown et al., 2008; Reddivari, Hale, Scheuring, & Miller, 2004).

Both carotenoids and anthocyanins are secondary metabolites that are important in plant defense (Hahlbrock & Scheel, 1989), but they can also benefit human health. Lutein protects against macular degeneration, the leading cause of visual impairment and blindness in older adults (Camire et al., 2009; Seddon et al., 1994). Polyphenolic compounds such as anthocyanins scavenge and neutralize free-radicals, decompose lipid peroxides, and quench singlet oxygen (Cao, Sofie, & Prior, 1997). In general, diets rich in antioxidant flavonoids and carotenoids have been associated with a lower incidence of atherosclerotic heart disease, certain cancers, and eye diseases such as cataracts (Cao, Booth, Sadowski, & Prior, 1998; Cao et al., 1999; Hertog, Feskens, Hollman, Katan, & Kromhout, 1993; Knekt, Jarvinen, Reunanen, & Maatela, 1996; Kruezer, 2001; H. Wang et al., 1999). A comprehensive review of the health benefits associated with antioxidants in potatoes can be found in Camire et al. (2009).

Despite the wealth of research on the levels and activity of antioxidant compounds in potatoes, only limited knowledge is available about the synergistic or antagonistic interactions between antioxidants and other compounds, including ascorbic acid. More information is required about these interactions, both within the potatoes themselves and with co-consumed foods. More research is also needed on the bioavailability of antioxidants in potatoes (Camire et al., 2009).

The overall objective of this thesis research was to investigate consumer acceptance of new colorful specialty potato varieties developed in part by the OSU Potato Breeding and Genetics Program and to understand the effect of information, especially health information, on the probability of purchase for these types of potatoes.

In Chapter 3, a qualitative study used focus groups with a total of 37 participants to answer the questions: 1) what are current consumer attitudes and opinions on fresh market potatoes in general, and specialty potatoes in particular?, 2) what are consumer attitudes and opinions about new colorful varieties developed by OSU?, 3) what effect does information about raw and cooked appearance and health benefits have on consumer purchase behavior?, and 4) what types of information about colorful potatoes are consumers interested in?

The findings from this study were used to inform the design of a quantitative study involving a consumer test with 222 participants. The first objective of the quantitative study was to capture consumer acceptance ratings for raw and cooked sensory properties of colorful potato varieties. The results of this part of the study are reported in Chapter 4. The second objective of the quantitative study was to answer the questions: 1) what is the effect of health (antioxidant) information on consumer willingness to purchase colorful varieties? and 2) do other factors like price, liking, usage frequency, consumer demographics, prior knowledge about antioxidants, interest in health, and/or interest in food have an effect on purchase intent? The results of this part of the study are reported in Chapter 5.

Chapter 2 is a review of the raw characteristics that affect the cooked or culinary quality of fresh market potatoes. Although this chapter is not directly related to the chapters that follow it, it relates to the overall objective, which is to investigate the factors that may influence consumer demand for new fresh market potatoes, and culinary quality is an important part of this.

2. CHAPTER 2 – A REVIEW OF RAW TUBER CHARACTERISTICS IMPACTING THE CULINARY QUALITY (APPEARANCE, FLAVOR, AND TEXTURE) OF FRESH MARKET POTATOES

2.1. ABSTRACT

The culinary quality of fresh market potatoes is a key driver for consumer acceptance of new cultivars. At present, potato breeding programs only select for culinary quality in limited ways, and this is done late in the breeding selection process. In order to select for cultivars exhibiting desirable appearance, flavor, and texture, analytical measures of these quality traits must be determined and a rapid, accurate method to systematize selection must be developed. Over 50 years of research has linked measurable characteristics with the culinary quality of cooked potatoes. Potato appearance is affected by measureable characteristics such as greening, enzymatic browning, Maillard browning, and after-cooking darkening. Flavor is affected by both volatile and non-volatile compounds. Texture is affected by starch content, swelling pressure due to starch gelatinization, and cell-wall stability. Many measurable traits related to culinary quality are clearly defined, while others require additional research. Genetic research is currently being used to clarify direct links between potato genotype and cooking behavior. Both past and current research can be used by breeding programs to develop superior cultivars that will have the cooked quality attributes consumers desire.

2.2. INTRODUCTION

As consumers demand greater variety and retailers look to fill market niches, the need for potato breeding programs to produce new, high quality cultivars has become increasingly important (Vreugdenhil, 2007). In the fresh market, consumers select potatoes by visual characteristics such as shape and color, but the ultimate criterion of repeat purchase is how new cultivars compare to established cultivars once cooked (Feltran, Lemos, & Vieites, 2004; Kezis, Smith, Peavey, & Lloyd, 1988). Cooked (culinary) quality is determined by appearance, flavor, and texture. These features constitute sensory attractiveness for the consumer and ultimately drive purchase decisions (Lisinska & Leszczynski, 1989).

At present, culinary quality is not the primary selection criteria in cultivar development; most breeding programs only require the absence of off-flavor (Jansky, 2008). Breeding programs focus on yield, tuber appearance, processing quality, and disease or pest resistance instead (Bradshaw & MacKay, 1994). If flavor and texture are assessed, this is usually done in the later stages, after selection for more easily quantifiable traits has been completed (Vreugdenhil, 2007). Additionally, the assessment of flavor and texture is typically performed by a

trained sensory panel, which tends to be expensive, highly subjective, and has a low sample throughput (W. L. Morris, Ducreux, Bryan, & Taylor, 2008).

In recent years, potato breeders and growers have expressed the desire to assess culinary quality at earlier stages in a breeding program in order to improve the market value of new cultivars (Jansky, 2008). If traits like flavor and texture were strongly associated with quantifiable raw tuber characteristics, a more thorough and objective assessment of culinary quality could be made at any stage in the breeding selection process. This would encourage the routine use of consumer driven selection criteria early on, ultimately increasing the chances of success in the marketplace for new cultivars.

Over 50 years of research has been devoted to linking quantifiable raw tuber characteristics with culinary quality. This review seeks to summarize the findings that relate these measurable traits to cultivar appearance, flavor, and texture. The research described herein is focused on the factors that affect the culinary quality of fresh market (not processing) cultivars and is meant to guide future research in the development of consumer driven selection criteria for potato breeding programs.

2.3. APPEARANCE

Morphological characteristics of a tuber, such as its size, shape, skin color, flesh color, eye-depth, and defects (e.g. knobs and growth cracking), all determine the initial acceptance of fresh market cultivars by consumers (Harris, 1992). Consumers generally desire tubers that are evenly sized and uniformly shaped, although the desired shape may vary depending on the end use or regional preference. A clean, bright, blemish free skin is required, with no visible damage or sign of disease (Harris, 1992). In addition to basic morphological characteristics, appearance is affected by pre-cooking discoloration (greening and enzymatic browning), cooked color formation (Maillard browning), and post-cooking discoloration (darkening).

2.3.1. Greening

Potato tubers exposed to light become greenish in color due to the accumulation of chlorophyll in their external layers (Lisinska & Leszczynski, 1989). The conversion of amyloplasts into chloroplasts begins after one day of exposure to light (Murajafra, Krsnikrasol, & Wrischer, 1994). Greening reduces the culinary quality of potatoes because of the strong association of green potatoes with bitter taste and the presence of toxic substances (Talbert & Smith, 1987). Although chlorophyll itself is harmless, its formation is accompanied by glycoalkaloid accumulation. Glycoalkaloids are formed through a separate biochemical pathway that is also

accelerated by light exposure (Edwards & Cobb, 1998). Increased glycoalkaloid levels are the cause of bitterness and toxicity in green potatoes. Glycoalkaloid toxicity is a concern for consumers because doses greater than 2 mg per kg of body weight can cause gastrointestinal disturbances like vomiting, diarrhea, and abdominal pain (Mensinga et al., 2005) and doses of 3-6 mg per kg of body weight are considered fatal (S. C. Morris & Lee, 1984).

Greening is exacerbated after harvest when tubers are stored and displayed under bright lights (Dale & MacKay, 1994; Grunenfelder, Knowles, Hiller, & Knowles, 2006). Light intensities as low as 53.8 lux can induce greening, after which the degree of greening is directly related to light intensity levels (Sharma & Salunkhe, 1989). Temperature also affects greening, with little response at temperatures below 5°C. At temperatures above 10°C, however, significant greening is observed (Kozukue & Mizuno, 1990).

In addition to light and temperature, the extent of greening depends on the cultivar. Significant differences in susceptibility to greening have been observed between cultivars (Dale, Griffiths, Bain, & Todd, 1993), but the exact genetic basis for this tendency is unknown. Parfitt and Peloquin (1981) examined diploid material and found indications that several genes were involved in greening, with most of the variation being additive. The study surprisingly found no dominance or indication of maternal inheritance for this trait. A more recent study by Jakuczun and Zimnoch-Guzowska (2006) evaluated greening in 17 diploid potato families derived from the same parents, and found a significant maternal effect. The correlation for the extent and depth of tuber greening within most families was significant. These results indicated that cultivars with a low tendency for tuber greening could be selected in diploid families. As a result, although the exact genetic mechanism for greening is unknown, its broad-sense heritability is sufficiently large to permit effective selection in potato breeding programs (Dale & MacKay, 1994; Vreugdenhil, 2007).

2.3.2. Enzymatic browning

When potatoes are peeled or cut in preparation for cooking, they can develop a reddish-brown discoloration on the newly exposed surface. This pigment slowly turns grey or black after several hours of exposure (Stark & Love, 2003). Discoloration is unappealing to consumers and can become a serious consumer perception problem for any food preparation process in which potatoes remain uncooked for more than a few minutes (Stark & Love, 2003).

Discoloration of raw potatoes is a result of enzymatic oxidation in injured cells when exposed to the atmosphere (Talbur & Smith, 1987). The reaction is triggered by the enzyme polyphenol oxidase (PPO), which catalyzes the oxidation of phenolic substrates into quinones. These quinones spontaneously polymerize to form a black, brown, or grey pigment (Coetzer,

Corsini, Love, Pavek, & Tumer, 2001). This reaction is related to the process that causes black spot bruise (Stark & Love, 2003).

Enzymatic browning is positively related to tuber phenolic content (Mondy, Koch, & Chandra, 1979) and the presence of PPO (Vreugdenhil, 2007). PPO in potatoes has been linked to a family of at least six genes, namely POTP1, POTP2, POT32, POT33, POT41, and POT72. These genes are differentially expressed, with POT32 being the major form expressed in tubers, followed by POT33 and POT72 (Thygesen, Dry, & Robinson, 1995). POT32 has been strongly implicated as a candidate gene for PPO-induced discoloration (Vreugdenhil, 2007). In addition to phenolic content and PPO, enzymatic browning is influenced by growing conditions (Talbert & Smith, 1987) and is highly affected by tuber pH, as the activity of PPO is inhibited by low pH (Lisinska & Leszczynski, 1989; Pizzocaro, Torreggiani, & Gilardi, 1993).

2.3.3. Maillard browning

Although some browning in cooked potatoes is desirable (e.g. in baked, fried, and roasted potatoes), excessive browning produces an unacceptable color and a bitter taste, and is considered a major quality defect (Roe & Faulks, 1991). Browning during cooking is caused by a combination of the Maillard reaction and caramelization at high temperatures. The Maillard reaction is a complex reaction between the aldehyde groups of reducing sugars and the free amino groups of amino acids (Talbert & Smith, 1987). Caramelization is a term for describing a complex group of reactions that occur due to direct heating of sucrose (Fennema, 1996). It has been reported that the controlling factor in excessive browning of potatoes is the reducing sugar content rather than the total sugar content (Talbert & Smith, 1987), suggesting that Maillard browning is the primary contributor.

The reducing sugars involved in the Maillard browning of potatoes are glucose and fructose (Haase, 2007) and the major free amino acids are asparagine, glutamine, glutamic acid, arginine, and aspartic acid, with some cultivar dependent variations (Brierley, Bonner, & Cobb, 1997; Davids, Yaylayan, & Turcotte, 2004). The contribution of reducing sugar concentration to the development of cooked color was confirmed by Rodriguez-Saona et al. (1997), who developed a model system in which soluble constituents like sugars and proteins were removed from raw tubers and then reintroduced to observe their role in tuber browning. The study found that reducing sugar concentration drove the formation of brown pigments in fried potato chips. Amino acids are important substrates in the Maillard reaction as well, but their participation in chip color has been reported to be marginal since their concentration is rarely a limiting factor (Marquez & Anon, 1986).

The total concentration of reducing sugars in potatoes is largely affected by storage conditions. Storage temperature dictates the stage of carbohydrate metabolism (starch to sugar conversion) in a tuber. At low storage temperatures (~4°C), there is an accumulation of reducing sugars due to decreased metabolic activity. This is known as 'cold-sweetening'. At ambient temperatures, metabolic activity increases (sugars are converted to starch), resulting in decreased reducing sugars (Vreugdenhil, 2007). This process is called 'reconditioning'.

The genes involved in carbohydrate metabolism are numerous and have been extensively mapped (Chen, Salamini, & Gebhardt, 2001). The enzymes most strongly associated with cold-sweetening/reconditioning are amylases, phosphoglucosmutase (PGM), UDP-glucose pyrophosphorylase (UGPase) (Sowokinos, 2001), glucose-6-P/Pi translocator (GPT), sucrose phosphate synthase (SPS), invertases (Li et al., 2005), ADP-glucose pyrophosphorylase (AGPase), and sucrose synthase (SuSy) (Vreugdenhil, 2007). Out of these, the candidate genes that have received the most attention are UGPase (Menendez et al., 2002) and the apoplastic invertase locus *invGE/GF* on chromosome IX (Li et al., 2005). Linkage disequilibrium studies may further confirm the importance of these two candidate genes and their utility in marker-assisted breeding of cultivars with desirable reducing sugar levels (Vreugdenhil, 2007). The Solanaceae Coordinated Agricultural Project (SolCAP) is a federally funded project in the U.S. and is currently working to better understand the genetics of carbohydrate metabolism in potatoes (Zarka, n. d.).

In addition to unacceptable dark color and bitter taste, the Maillard reaction is responsible for the formation of acrylamide, an odorless and colorless crystalline solid resulting from the hydration of acetonitrile at high temperatures (Pedreschi, 2007). Acrylamide is a concern for consumers because it is a known carcinogen in experimental animals (Pedreschi, 2007). Acrylamide occurs in carbohydrate-rich foods combined with cooking methods using high temperatures (>120°C) (Pedreschi, 2007; Vreugdenhil, 2007). It is mainly formed in potatoes by the reaction of asparagine with reducing sugars (Beclaski, Lau, Lewis, & Seaman, 2003; Mottram, Wedzicha, & Dodson, 2002; Stadler et al., 2004; Weisshaar & Gutsche, 2002). Early in the Maillard pathway, the glycoconjugate of asparagine and a reducing sugar undergoes a Strecker-type degradation leading to azomethine ylides, subsequently forming acrylamide after a beta-elimination reaction of the decarboxylated Amadori compound (Yaylayan, Wnorowski, & Locas, 2003). Despite the fact that population based control studies have found no positive association between acrylamide exposure and cancer risk (Vreugdenhil, 2007), consumers still associate dark color and burnt flavors in potatoes with carcinogenic effects. As a result, tools have been identified to lower the acrylamide formation in cooked potatoes. Strategies for fresh market potatoes focus on minimizing reducing sugar content through breeding and controlled storage conditions (Haase, Matthaus, & Vosmann, 2004).

2.3.4. After-cooking darkening

The development of a grayish color in tuber flesh after boiling, baking, or steaming is known as after-cooking darkening (Stark & Love, 2003). After-cooking darkening greatly detracts from the appearance of cooked potatoes, although it has no known effect on flavor or nutritive value (Talbur & Smith, 1987). Since many food products are accepted or rejected on the basis of color alone, after-cooking darkening is considered a key quality defect (Wang-Pruski & Nowak, 2004).

The dark color is caused by a non-enzymatic oxidation reaction that starts during cooking, and reaches its maximum level approximately two hours after cooking is complete (Wang-Pruski, 2007). Discoloration appears first and to the greatest degree just under the skin at the stem end of the potato, and decreases in intensity toward the apical end (Talbur & Smith, 1987). The dark color ranges from light grey to almost black, depending on the cultivar (Wang-Pruski, 2007). The darkening is due to the formation of a colorless reduced ferrous ion-chlorogenic acid complex. This ferrous complex is non-enzymatically oxidized to a dark ferric complex following exposure to oxygen (Friedman, 1997).

The primary factor in this reaction is the concentration of chlorogenic acid; high concentrations of chlorogenic acid in a tuber results in a greater degree of after-cooking darkening (Vreugdenhil, 2007). Although iron is involved in the reaction, its concentration is not a limiting factor. However, iron chelating agents, such as citric acid and ascorbic acid, can decrease the degree of after-cooking darkening by preventing iron from reacting with chlorogenic acid (Wang-Pruski, 2007). Hence, the severity of darkening is dependent on the ratio of chlorogenic acid to citric acid (Silva, Chase, Hammerschmidt, & Cash, 1991).

The presence of chlorogenic acid in potatoes is controlled in part by genes involved in the shikimate and the phenyl-propanoid pathways. The final step in these pathways is catalyzed by quinate-hydroxycinnamoyl transferase (HQT), which couples caffeoyl-D-glucose to D-quinic acid and results in the formation of chlorogenic acid (Friedman, 1997). The potato HQT gene sequence has been identified in the cultivar *kuras* by an expressed sequence tag (EST) sequencing project (Crookshanks, Emmersen, Welinder, & Nielsen, 2001). Niggewig et al. (2004) reported that the over-expression of HQT in tomato plants caused them to accumulate higher levels of chlorogenic acid, with no side effects on the levels of other soluble phenolics. Since tomatoes are closely related phylogenetically to potatoes, these results point to HQT as an important contributor to the formation of chlorogenic acid in potatoes.

In addition to genetic factors, after-cooking darkening is influenced by environmental conditions such as growing season, soil type, growing location, and storage conditions (Wang-

Pruski & Nowak, 2004; Wang-Pruski et al., 2007). Maturity also has an effect on after-cooking darkening, as immature tubers have been found to darken more than mature tubers (Stark & Love, 2003).

2.4. FLAVOR

After price, flavor is the major determinant of consumer choice for potatoes (W. L. Morris et al., 2008). For a new fresh market potato cultivar to be successful, it must have a flavor profile that is liked by consumers. This may prove challenging, however, as evaluation of flavor to a large extent depends on individual tastes and habits (Lisinska & Leszczynski, 1989). Flavor preferences are further affected by human genetic factors, age, sex, and exposure to different diets or foods (Drayna, 2005).

Potato flavor is a combination of taste and aroma. Taste and aroma profiles are created by the constituents naturally present in a tuber and the reactions they partake in during cooking. Aroma profiles are composed of volatile compounds created during heat driven reactions, and taste profiles are composed of soluble non-volatile compounds residing in the cooked tuber (Harris, 1992).

2.4.1. Volatile compounds

The volatiles present in raw and cooked potatoes have been studied extensively, and over 250 compounds have been identified in potato volatile fractions (Maga, 1994; Vreugdenhil, 2007). Volatile compounds are responsible for cooked potato aroma, which is a major component of potato flavor. Volatile type and quantity depend on the cultivar and cooking method (Lisinska & Leszczynski, 1989). Heat and mass transfer differences between different cooking methods are responsible for the quantitative and qualitative differences in volatile profiles (Oruna-Concha, Bakker, & Ames, 2002b; Wilson, MacKinnon, & Jarvis, 2002).

The main chemical reactions responsible for the production of volatiles during cooking are the Maillard reaction between reducing sugars and free amino acids, the Strecker degradation of methionine to produce methional, and the thermal and enzymatic degradation of fatty acids. The Maillard reaction and the Strecker degradation produce a large number of volatile compounds, including furans, pyrazines, pyridines, and pyrroles. Fatty acid degradation results in alkanes, alkenes, aldehydes, alcohols, alkyl furans, and acids (Vreugdenhil, 2007).

Several specific compounds have been directly related to desirable flavor and aroma characteristics in cooked potatoes. For example, methional (Lindsay, 1996), methoxypyrazines (Murray & Whitfield, 1975), and the lipid-degradation product, cis-4-heptenal (Josephson &

Lindsay, 1987), all exhibit a 'cooked potato' odor (Vreugdenhil, 2007). Off-flavor notes can be caused by dienals (Josephson & Lindsay, 1987; Petersen, Poll, & Larsen, 1999), (z)-4-heptenal (Josephson & Lindsay, 1987), and increased concentrations of pyrazines (Sapers, Osman, Dooley, & Panasiuk, 1971). Attempts have been made to discriminate which volatiles are specific to methods of cooking, cultivars, and storage conditions (Duckham, Dodson, Bakker, & Ames, 2002; Duckham, Dodson, Bakker, & Ames, 2001; Oruna-Concha, Bakker, & Ames, 2002a; Oruna-Concha et al., 2002b; Oruna-Concha, Duckham, & Ames, 2001), but the key contributors in these areas have not been clearly identified (W. L. Morris et al., 2008). Also, studies that correlate potato volatile profiles with sensory evaluation data are sparse (Vreugdenhil, 2007).

Recent work, however, has demonstrated that boiled tubers from *Solanum phureja* cultivars score better in sensory evaluations than those from *Solanum tuberosum* (T. Shepherd et al., 2007; Winfield et al., 2005). Winfield et al. (2005) compared sensory profiles of 16 *S. phureja* cultivars and six *S. tuberosum* cultivars against volatile data. Generally, the *S. phureja* cultivars scored considerably higher on an overall acceptability scale. The acceptability measure also showed strong correlations with other less subjective sensory traits, such as 'creaminess' and 'flavor intensity'. Principal component analysis of volatile profiles of boiled *S. tuberosum* and *S. phureja* revealed that hexanal, pentanal, pentyl-furan, and alpha-copaene accounted for most of the variation between the two groups analyzed. In particular, the levels of alpha-copaene were considerably greater (up to 100-fold) in the *S. phureja* profiles.

In an attempt to explore this difference in sensory profiles, the fatty acid and polar lipid contents of *S. phureja* and *S. tuberosum* have also been compared (Dobson, Griffiths, Davies, & McNicol, 2004). The absolute levels of linoleic and alpha-linoleic acids were found to be significantly higher in *S. phureja*. Significant differences between these two species are also evident with regard to amino acid content. The elevated levels of leucine, isoleucine, and valine in *S. phureja* have been shown to be related to increased levels of branched chain aldehydes, esters, and alcohols (Dobson et al., 2007).

A recent study by Ducreux et al. (2008) compared gene expression levels of two *S. phureja* cultivars and two *S. tuberosum* cultivars to search for candidate genes responsible for sensory differences. It was found that a sesquiterpene synthase gene was highly expressed in *S. phureja* tubers and its corresponding full-length cDNA was demonstrated to encode alpha-copaene synthase. The presence or absence of alpha-copaene is one of the main differences in the volatile profiles of *S. phureja* and *S. tuberosum*. Other potential flavor genes, identified from their differential expression profiles, included those encoding branched chain amino acids aminotransferase and ribonuclease, suggesting a mechanism for 5'-ribonucleotide formation in potato tubers during cooking.

Although it is still uncertain which volatile compounds could be used to improve the flavor of new cultivars, further exploration of the genetic and sensory differences between *S. phureja* and *S. tuberosum* could lead to a better indication of which volatiles are important for desirable potato flavor (Vreugdenhil, 2007).

2.4.2. Non-volatile compounds

In addition to the volatile compounds which dictate aroma, potato flavor is comprised of soluble cellular constituents that are responsible for taste. These soluble matrix associated compounds define the taste parameters of salty, sweet, sour, bitter, and umami (a Japanese word meaning 'delicious') (W. L. Morris et al., 2008; Vreugdenhil, 2007). The taste of a cooked potato is also influenced by 'mouth-feel' or texture (Harris, 1992). The major taste components in potato tubers are sugars, amino acids, lipids, phenolic compounds, 5'-nucleotides, and glycoalkaloids (Maga, 1994).

2.4.2.1. Sugars, amino acids, lipids, and chlorogenic acid

Sugars contribute directly to sweetness (Jansky, 2008), participate in Maillard reaction pathways, and help form umami-tasting glutamate glycoconjugates (Beksan et al., 2003). Amino acids do not directly contribute to taste but instead serve as intermediates in flavor generating pathways like the Maillard reaction, or combine with salts to create umami compounds. Lipids have a strong effect on mouth-feel but generally have no direct contribution to taste. Phenolic compounds such as chlorogenic acid can contribute negatively to taste, and have been positively correlated with sensations of bitterness and astringency (Mondy, Metcalf, & Plaisted, 1971). However, this correlation has been disputed (Sinden, Deahl, & Aulenbach, 1976).

2.4.2.2. 5'-nucleotides

Umami compounds generally enhance flavor and mouth-feel, giving the impression of creaminess and viscosity (Halpern, 2000). Compounds including monosodium glutamate (MSG), several process derived glutamate glycoconjugates, adenosine-5'-monophosphate (5'-AMP), inosine-5'-monophosphate (5'-IMP), and guanosine-5'-monophosphate (5'-GMP) all exhibit umami-like sensory characteristics (Bellisle, 1998). Although raw potatoes contain only very small amounts of 5'-nucleotides and no 5'-GMP, cooked potatoes contain appreciable levels, higher than most other plant foods (Vreugdenhil, 2007). This is due to the accumulation of 5'-nucleotides resulting from the action of nucleases during cooking, particularly from RNA degradation.

Ribonucleases are particularly active in potatoes when they reach 50°C during cooking. As the temperature increases to 60°C, nuclease activity becomes significant (Solms & Wyler, 1979). The availability of 5'-nucleotides, glutamic acid, and sugar compounds all contribute to the level of umami taste intensity in the potato tuber (Yamaguchi, Yoshikawa, Ikeda, & Ninomiya, 1971). The taste activity of 5'-GMP is the most potent in this array, having a 2.3-fold greater effect than 5'-IMP (W. L. Morris et al., 2008).

Although only limited sensory evaluation data is available to support the importance of umami compounds in defining potato flavor (Vreugdenhil, 2007), studies conducted as early as 1971 have reported a link between nucleotide content and potato flavor (Solms, 1971). A recent study by Morris et al. (2007) found that steamed or boiled tubers with high levels of 5'-GMP received higher quality perception scores from consumers.

2.4.2.3. Glycoalkaloids

Glycoalkaloids are naturally occurring toxic compounds that are produced in all parts of the potato plant and protect tubers from disease and pests (Friedman, 2006; Lisinska & Leszczynski, 1989). Although normally of little concern, under unusual conditions glycoalkaloids may reach levels high enough to cause off-flavors in cooked potatoes (Sinden et al., 1976). In low amounts, glycoalkaloids are responsible for a characteristic 'pungent flavor' in cooked potatoes (Lisinska & Leszczynski, 1989). Increased glycoalkaloid levels produce flavors described as 'bitter', 'burning', 'scratchy', or 'acidic', all of which are generally undesirable (Sinden et al., 1976; Stark & Love, 2003; Vreugdenhil, 2007).

Glycoalkaloid content in potatoes is referred to as total glycoalkaloids, or TGA (Lisinska & Leszczynski, 1989). The average range of TGA in mature potato tubers is 3-10 mg per 100 g FW (Friedman, 2004; Lisinska & Leszczynski, 1989; Peksa, Apeland, Gronnerod, & Magnus, 2002; Sinden et al., 1976). Some individuals can detect a bitter taste in tubers at levels as low as 10 mg per 100 g FW. TGA at 14-15 mg per 100 g FW results in a pronounced bitter flavor (Osman, 1983), while 20 mg per 100 g FW is considered hazardous to human health (Korpan et al., 2004; Rodriguez-Saona, Wrolstad, & Pereira, 1999). Tubers exceeding 20 mg per 100 g FW may not be used for consumption (Friedman, 2006; Vreugdenhil, 2007).

The glycoalkaloids present in potato tubers are alpha-solanine and alpha-chaconine, both of which are derived from solanidine (Friedman, 2004; Friedman & McDonald, 1997; Maga, 1980; Stanker, Kamps-Holtzapfel, & Friedman, 1994). The concentration ratios of alpha-solanine to alpha-chaconine vary depending on plant anatomy and cultivar, and can be found within a range of 1:2 to 1:7 (Bejarano, Mignolet, Devaux, Carrasco, & Larondelle, 2000).

Glycoalkaloid accumulation in potato tubers is a complex process and the total amount present depends on factors such as genotype, soil and weather conditions, fertilizer use, potato maturity at harvest time, tuber size, mechanical damage, storage conditions, and access to light (Brandt & Molgaard, 2001; Frydecka-Mazurczyk & Zgorska, 2002; Haddadin, Humeid, Qaroot, & Robinson, 2001; Machado, Toledo, & Garcia, 2007; Percival, 1999; Sengul, Keles, & Keles, 2004; Tajner-Czopek, Leszczynski, Lisinska, & Prosba-Bialczyk, 2006).

Both forward and reverse genetic approaches have been used to study glycoalkaloid content in tubers. Forward genetics is an approach that identifies a gene or set of genes that are responsible for a particular phenotype, whereas reverse genetics identifies which phenotypes arise as a result of particular genes (Gibson & Muse, 2009). The forward genetics studies have used quantitative trait locus (QTL) methodology, but these results have not been compared with reverse genetics studies (Vreugdenhil, 2007).

The first forward genetics studies using molecular markers reported QTLs on many chromosomes, indicating polygenic inheritance of glycoalkaloids. Yencho et al. (1998) analyzed the segregation of solanine, chaconine, solasodine, and solamargine to identify QTLs for the production of the aglycones solanidine and solasodine. Two QTLs for solanidine were identified on chromosomes I and IV, with the QTL on chromosome I accounting for 17-22% of the phenotypic variation. The importance of this locus has been confirmed by Ronning et al. (1999) and Hutvagner et al. (2001), who both mapped a QTL involved in glycoalkaloid production from *Solanum chacoense*.

Mutation breeding has been included in the reverse genetic approaches for manipulating total glycoalkaloid levels in potatoes (Love, Baker, ThompsonJones, & Werner, 1996). Although this method results in mutants with low TGA levels, it is not the most efficient method, as screening for phenotypes is extremely time consuming.

2.5. TEXTURE

Cooked potato texture is also important in consumer acceptance of new potato cultivars, as cultivars often differ markedly in texture after cooking. As with flavor, potato texture is a complex trait to analyze because it is affected by genotype, storage conditions, and cooking methods (Harris, 1992; Vreugdenhil, 2007). Nevertheless, there have been attempts to correlate raw tuber characteristics with specific texture profiles.

Texture after cooking is the result of many contributing factors. These factors are starch content (Burton, 1989), starch swelling pressure (Hoff, 1972; Jarvis, Mackenzie, & Duncan, 1992; Shomer, 1995a; Shomer, Vasiliver, & Lindner, 1995b), and the weakening of the cell wall middle lamella due to pectin release (Burton, 1989; Faulks & Griffiths, 1983; VanMarle, DeVries,

Wilkinson, & Yuksel, 1997; VanMarle, Vandijk, Voragen, & Biekman, 1994). Each of these factors contributes to potato texture in complex and often contradictory ways.

2.5.1. Starch content

About 80% of fresh tuber weight consists of tuber solids, or dry matter (Stark & Love, 2003). 65-80% of this dry matter is starch (Talbut & Smith, 1987). Starch is the primary determinant of tuber density, which is commonly referred to as specific gravity (Stark & Love, 2003). Specific gravity measurements are most commonly used to predict cooked texture for potatoes because these measurements have been shown to correlate well with starch content (Burton, 1989; Vreugdenhil, 2007). Specific gravity is measured by taking the underwater weight of a potato and comparing it to its weight in air (Harris, 1992).

Potatoes exhibiting high specific gravity are described as 'mealy', meaning they retain their form when cooked but are easily broken down and, if agitated with an equal volume of water, will give a slurry consisting of essentially single cells (Burton, 1989). The flesh structure of a mealy potato tends to be granular and smooth (Lisinska & Leszczynski, 1989), dry rather than moist (Jarvis & Duncan, 1992), and is susceptible to sloughing (the flaking and disintegration of the outer layers flesh and skin) (Warren & Woodman, 1974). Russet-type potatoes typically exhibit a mealy texture, and this is desirable for baked, roasted, and fried preparations (Stark & Love, 2003).

Potatoes exhibiting low specific gravity are described as 'waxy', and when cooked, have a moist appearance and disintegrate less easily (McComber, Osman, & Lohnes, 1988). Waxy potatoes readily cut into pieces, and have a firm, fibrous structure (Jarvis et al., 1992; Lisinska & Leszczynski, 1989). New potatoes and red-skinned cultivars typically exhibit a waxy texture, and this is desirable for boiled and steamed preparations (Stark & Love, 2003).

Although specific gravity is often correlated with the degree of disintegration after cooking, differences in texture from material with similar specific gravity do occur (Harris, 1992; Warren & Woodman, 1974). The uncertain nature of the relationship between starch content and degree of disintegration was illustrated by Matsuura-Endo et al. in 2002. For individual tubers within each cultivar studied, tuber disintegration generally increased with starch content. There was, however, a significant difference in the degree of disintegration between cultivars with the same starch content. It was also found that a cultivar that contained high starch content in the area outside the vascular ring was more prone to disintegration, despite similar overall starch contents (Matsuura-Endo, Ohara-Takada, Yamauchi, Mori, & Fujikawa, 2002a; Matsuura-Endo et al., 2002b).

Tuber starch content is a highly heritable polygenic trait and has been largely mapped using QTL analysis (Vreugdenhil, 2007). Genes contributing to the phenotypic effects of starch are located on all chromosomes of the potato (Gebhardt et al., 2005). In addition to genetics, starch content is strongly affected by storage environment, particularly storage temperature (Kaaber, Brathen, Martinsen, & Shomer, 2001). At or below 4-6°C, starch is converted to sugars, and at or above 6-8°C, sugars are converted back to starch (Kaaber et al., 2001). Therefore, the sugar content of potatoes may vary from only trace amounts to as much as 10% of the dry weight of the tuber, depending on storage temperature. Potatoes with these high levels of sugar have a 'wet' or 'soggy' texture after cooking (Burton, 1989; Talburt & Smith, 1987).

2.5.2. Swelling pressure

In addition to the amount of starch present in a tuber, the gelatinization of starch during cooking has been cited as a factor in potato texture. When the temperature of a potato is raised to about 50°C, water passes from the non-starchy parts of the plant cells into the starch granules, which then begin to swell. The starch granules will then gelatinize in the range of 64-71°C (Talburt & Smith, 1987). It has been theorized that in potatoes with high starch content, cells tend to round-off from the swelling of gelatinized starch. This is believed to increase the internal pressure in tuber cells, leading to cell separation and hence tuber disintegration (Reeve, 1977). In potatoes with low starch content, the cells tend to retain their original orientation with respect to each other and thereby are less prone to disintegration. Based on this theory, researchers claim that the amount of starch in individual tuber cells has a greater effect on cell separation than the total amount of starch in a tuber (Talburt & Smith, 1987).

Jarvis et al. (1992) quantified starch swelling pressure directly and demonstrated that pressure contributes to cell separation. Microscopic observations of rounded cells in cooked potato tissue have also been cited as evidence of this mechanism (Burton, 1989). These observations, however, can also be explained in terms of unrestrained thermal expansion of cells separated from their surrounding tissue. According to this interpretation, the observed rounding-off of cells is the result, rather than the cause, of cell separation (Warren & Woodman, 1974).

2.5.3. Cell wall weakening

The degree of cell separation in cooked potatoes has been found to correlate better with the release of pectic material than with starch content (VanMarle et al., 1994). Cell cohesion in tubers depends on the shared pectin layer that resides between the walls of adjacent cells. This layer is called the middle lamella (Burton, 1989). The cell walls, together with the middle lamella,

create the mechanical skeleton of the tissue, and are mainly responsible for the strength of the tissue (Zdunek & Umeda, 2005). Upon cooking, the pectin in the middle lamella is solubilized (Harris, 1992; Hoff, 1972; Iritani, Powers, Hudson, & Weller, 1977). This results in a loss of adhesion between cells and a weakening of the walls of individual cells (Burton, 1989; VanMarle et al., 1994). Ultimately, this pectic loss and redistribution changes the cellular structure of the potato, resulting in cell separation and tissue deformation, or softening.

Recent findings by Van Dijk et al. (2002) suggest there is a minimal relationship between pectin and potato texture, however. In the study, two potato cultivars with very different cooked textures were segregated into small, medium, and large tubers with low and high dry matter and were stored for set periods of time. The study found no significant differences in pectin composition and amount between the cultivars. Instead, the study found that starch content was the dominant factor dictating differences in cooked potato texture.

A study by Kloosterman et al. (2010) used quantitative trait loci (QTL) mapping methodology to find candidate genes responsible for differences in the texture of mealy and waxy potatoes. The study identified a candidate gene with a homology to a tyrosine-lysine rich protein (TLRP) that is commonly found in the cell walls of tobacco and tomato plants and is responsible for cell wall firmness. TLRP's are thought to be involved in cross-linking other proteins to the cell wall, making them insoluble (Domingo, Sauri, Mansilla, Conejero, & Vera, 1999). The candidate gene, named StTLRP, was expressed 5-fold higher in the firmer tubers evaluated by the study, and was tentatively linked to tuber firmness after cooking (Kloosterman et al., 2010).

2.6. CONCLUSION

Although raw tuber appearance is considered the most important factor influencing the purchase of fresh market potatoes (Jemison et al., 2008), if consumers are unhappy with the cooked quality, the chances of repeat purchase are greatly reduced. As a result, if potato breeding programs seek to release new cultivars with a high chance of marketplace success, culinary quality must be considered early on in the breeding selection process.

As shown by this review, there is a wealth of research that has linked raw measurable characteristics with the cooked quality of potatoes. Some of these linkages have been clearly defined and quantified, like the effect of glycoalkaloid levels on potato flavor. Other linkages remain unclear due to incomplete research or complex interactions, like the factors contributing to potato texture.

The research cited in this review can be used by potato breeding programs to develop an analytically directed selection process for culinary quality. For example, to select for the culinary quality of flavor: 1) the flavor chemistry of cooked potatoes must be determined, 2) a rapid,

accurate analytical method for measuring flavor must be developed, and 3) the chemistry of flavor preference for target populations of consumers must be determined (Y. Wang & Kays, 2003). Once this information is gathered, a process for selection can be set up to gather superior clones exhibiting certain flavor attributes. These superior clones can then be tested using sensory panels made up of target consumers to verify their desirability (Y. Wang & Kays, 2003).

As touched upon in this review, research identifying genes that correspond to potato appearance, flavor, and texture is paving the way for genetic predictors of culinary quality (Ducreux et al., 2008; Vreugdenhil, 2007). These studies co-localize QTL for appearance, flavor, and texture with the map locations of candidate genes to help identify key genes that contribute to specific traits. This method is becoming more feasible with the progress of the potato genome project by the Genomics Sequencing Consortium (Visser et al., 2009). This project released the first draft of the potato genome in September 2009. Mapping genes of unknown function may enable the identification of genes closely related to tuber culinary quality (Ducreux et al., 2008).

Another tool available to researchers is the comparison of the *S. phureja* and *S. tuberosum* cultivars. *S. phureja* can be differentiated from *S. tuberosum* on the basis of a number of important tuber quality traits such as flavor, texture, and color (DeMaine, Carrol, & Torrance, 1993; Dobson et al., 2004; W. L. Morris et al., 2004). The genetic similarity of the two cultivar groups, coupled with the substantial phenotypic differences, suggest a relatively simple genetic architectures for the traits that differ so markedly. Thus, a comparison of gene expression profiles in representative *S. phureja* and *S. tuberosum* clones may reveal the identity of candidate genes that influence a wide range of quality traits, including culinary quality (Ducreux et al., 2008).

In sum, the combination of the current body of research with advances in potato genetics research will serve to better guide breeding programs in selecting for traits that lend to culinary quality, and hence increased consumer acceptance of new fresh market cultivars.

3. CHAPTER 3 – UNDERSTANDING CONSUMER ATTITUDES TOWARDS COLORFUL FRESH MARKET POTATOES AND THE EFFECT OF INFORMATION ON PURCHASE INTENT: A FOCUS GROUP STUDY

3.1. ABSTRACT

A focus group study was conducted to understand consumer attitudes and opinions on colorful fresh market potatoes. Four focus groups were conducted with a total of 37 participants. Each focus group consisted of either conventional or specialty users of fresh market potatoes. Participants were shown five different colorful fresh market potato varieties and were asked to rate purchase intent on an anchored line scale. Purchase intent was assessed for each variety after: 1) seeing and handling the raw uncut potato, 2) seeing a photo of the raw potato cut in half, 3) seeing a photo of the potato cooked and cut in half, and 4) after receiving health information describing the antioxidant benefits of colorful potatoes. Participant reactions to the colorful potato varieties were mixed. Health information had a greater impact on purchase intent than the photos of the raw and cooked potatoes. Health information had a significant effect on purchase intent for the purple and red (skin and flesh) potatoes. Other factors affecting purchase intent were positive and negative associations with appearance, concerns about genetic engineering, tampering, and chemicals, preparation and presentation considerations, point of sale, family acceptance, and anticipated flavor.

3.2. INTRODUCTION

The influence of consumer attitudes, beliefs, and opinions is important in the acceptance of foods that are possible alternatives to conventional foods (Barrios, Bayarri, Carbonell, Izquierdo, & Costell, 2007). Uncommon or novel foods must offer distinct advantages over existing products in order to succeed in the marketplace. These advantages can come from intrinsic sensory properties (i.e. appearance, flavor, and texture) or from extrinsic information made available to the consumer prior to or during purchase. This information can be in the form of health benefits, nutritional properties, safety information, place of origin, image or brand, packaging, or price (Di Monaco, Cavella, Torrieri, & Masi, 2007). Information prompts different consumer responses and these depend on the message and the target group (Aaron, Mela, & Evans, 1994; Tuorila, Andersson, Martikainen, & Salovaara, 1998), but information has been shown to raise sensory and hedonic expectations, which affects consumer perceptions of quality and potentially affects purchase (Caporale & Monteleone, 2001; Cardello & Sawyer, 1992; Lange, Rousseau, & Issanchou, 1999).

Focus group studies have investigated the relationship between information and consumer acceptance and/or purchase of novel foods and technologies. Hashim et al. (1996) conducted a focus group study to gauge consumer reactions to information promoting the consumption of irradiated poultry. The study found that education, informative labels, posters, and in-store sampling were effective ways of encouraging consumers to buy irradiated poultry. Deliza et al. (2003) used focus groups to evaluate consumer attitudes towards label information about the technology used to process pineapple juice. Three different labels were evaluated, with varying nutritional, sensory, and technological information. The study found that a majority of the groups perceived pineapple juice as higher quality when information about health and technology was provided.

Barrios et al. (2007) used focus groups to investigate consumer opinions, attitudes, and beliefs regarding functional foods in general and yogurt in particular. They found that purchase and consumption of yogurt was more dependent on sensory qualities and price than on the nutritional information printed on the label. Di Monaco et al. (2005) explored the effect of information about price and health on consumer liking and willingness to purchase chocolate bars. A combination of consumer testing and focus groups was used, and it was found that price affected purchase intent for chocolate bars, but price and health claim were incapable of altering hedonic responses. In sum, these studies indicated that consumer response to information varies and can be influenced by prior beliefs or expectations, price, and the food or technology in question.

No prior focus group study has been performed to probe consumer attitudes and opinions on colorful fresh market potatoes, or to explore the effect of information on consumer purchase intent for these unique varieties. The first objective of this study was to understand current consumer perceptions, use, and purchase behavior for fresh market potatoes in general and specialty potatoes in particular. The second objective of this study was to gauge consumer response to a range of colorful varieties and to investigate the effect of information (appearance of raw flesh, appearance of cooked flesh, and health information) on willingness to purchase. The flow of the focus group was intended to simulate a real-life fresh market purchase scenario, where consumers are first presented with potatoes in their raw uncut form next to a set of other, more common varieties (like the Russet and the Yukon Gold). The groups were then presented with information they might see displayed next to potatoes at the point of sale (e.g. on a placard or on product packaging).

Participants selected for the focus groups represented either the target market for new colorful fresh market varieties (frequent users of specialty potatoes) or the potential market (frequent users of fresh market potatoes, but not specialty varieties).

3.3. MATERIALS AND METHODS

3.3.1. Design

The entire study was conducted at OSU's Food Innovation Center (OSU-FIC) located in Portland, Oregon. Four focus groups were conducted over the course of two days, with two sessions per day, one in the morning and one in the afternoon. There were eight to ten participants in each group, totaling 37 participants. The focus groups were conducted in a room designed for focus group research. The sessions were 90 minutes in length and were led by an experienced moderator. The moderator followed a discussion guideline (Figure 3.1) that was designed according to the recommendations of Lawless and Klein (1991). The sessions were audio and video recorded.

3.3.2. Participants

Out of 37 participants, 13 were male and 24 were female. Nine participants were 21-30 years of age, eight were 31-40 years of age, 12 were 41-50 years of age, seven were 51-60 years of age, and one participant was 60+ years of age. Participants were selected for the focus groups based on their response to a screener (Appendix 1). The screener asked potential participants a variety of questions assessing purchase and usage of fresh market potatoes. In order to qualify for the experiment, participants were required to be the primary shoppers in their household (Question 21) and the primary cooks in their household (Question 23). Participants were also required to cook potatoes at home at least once a week (Question 30).

Selected participants were categorized as conventional users (CU) or specialty users (SU) of fresh market potatoes, depending on their response to the kinds of potatoes they buy (Question 25). Conventional users were participants that: 1) did not select 'purple/blue' potatoes as a variety they purchased and 2) selected commonly available varieties instead: 'brown/Russet', 'yellow', 'red', and/or 'white'. Specialty users were participants that selected one or more of the following varieties as the varieties they purchased: 'purple/blue', 'fingerling', or 'other' (if 'other' was specified as a variety that was not commonly available).

Two out of the four focus groups were composed of conventional users, and two were composed of specialty users. All participants were recruited from a list of consumers living in the Portland metropolitan area provided by the OSU-FIC. Participants were compensated \$75.

3.3.3. Procedure

Prior to the focus group, participants were asked to read and sign an informed consent document (Appendix 2). Participants were seated around a table and the session was started by the moderator. Introductions were made and the moderator stated the ground rules of the focus group, namely that participants should respect others' opinions and only one person should speak at a time. In order to get everyone acquainted and to get the participants thinking about the topic of interest, each of the participants was asked to state their name and their favorite way to prepare potatoes at home. This warm-up exercise allowed for a less threatening and more permissive environment (Kreuger & Casey, 2000).

After the warm-up exercise, participants were asked to discuss their current purchase and use behavior for fresh market potatoes in general. Then they were asked to talk about what makes a specialty potato different from other, more common varieties, and to talk about their purchase and use of specialty varieties, if applicable. Participants were then given a paper ballot (Appendix 3) and shown five different samples of colorful fresh market potatoes developed by the OSU Potato Breeding and Genetics Program: a small red skinned, red fleshed fingerling (POR01PG22-1) named 'Ama Rosa', a small purple fleshed, purple skinned fingerling (POR01PG16-1) named 'Purple Pelisse', a large yellow fleshed, yellow skinned potato (POR03PG80-2), a small mottled purple and yellow skin and flesh potato (POR03PG23-1), and a medium yellow fleshed, yellow skinned potato with red eyes (POR02PG26-5) (Table 3.1).

A single raw uncut sample from each potato variety was displayed on a tray (Appendix 4). A reference tray was placed next to the sample tray, displaying potatoes currently available in the market: Russet Norkotah, All Blue, Red La Soda, and Yukon Gold (Appendix 4). The purpose of the reference tray was to provide participants with examples of commercially available fresh market potatoes, to be used as a visual reference when evaluating the OSU varieties.

For each potato, participants were instructed to describe the potato's appearance in the space provided on the ballot and to indicate their purchase intent by making a mark on a 12.2 cm line scale with anchors: 0-2.4 cm = 'would definitely buy', 2.4-4.8 cm = 'would probably buy', 4.8-7.2 cm = 'might buy/might not buy', 7.2-9.6 cm = 'would probably not buy', and 9.2-12.2 cm = 'would definitely not buy' (Appendix 3). Participants were asked to evaluate the samples in the order listed on the ballot, and each ballot had a different sample order. Participants were given five minutes to evaluate all the potatoes on their own, and this was followed by a group discussion in which participants were asked to comment on the samples and their willingness to purchase them.

After this discussion, participants were given a laminated card displaying photos of each sample cut in half (Appendix 5) and were asked to mark their purchase intent on the same line scale they used to evaluate the uncut varieties, but in a different color pen. Participant reactions to seeing the flesh of each sample was discussed as a group. This was followed by the distribution of another laminated card displaying photos of each sample cut in half, but this time with the raw half displayed next to the cooked (boiled) half (Appendix 6). Again, participants were instructed to mark their purchase intent on the line scale in a different color pen and reactions to this additional information was discussed as a group.

The last part of the session was devoted to discussing attitudes and opinions on potatoes and a healthy diet. This was followed by the distribution of a handout with a health statement, including definitions of terminology, describing the antioxidant benefits of colorful potatoes (Appendix 7). The antioxidant information was based on the results of research conducted by Brown et al. (2003) and Wegener et al. (2009) and general definitions of terminology found in USDA ARS (2005) and Tsang (2005).

The handout was read aloud by the moderator and participants were asked to make a final mark on the line scale indicating their purchase intent with the addition of this information. Reactions to the health information were discussed as a group, and participants were asked to assess the clarity, length, and efficacy of the statement provided. Participants were also asked to comment on how the information could be improved and if there was any other information they desired.

3.3.4. Data analysis

Data analysis and interpretation was conducted according to the methodology recommended by Krueger and Casey (2000). All materials, including audio and video recordings, ballots, and notes made by participants were fully transcribed. Transcripts from each session were reviewed using the long-table method, comparing across groups to reveal common themes. Terms used by participants to describe samples were collected from the ballots and notes and summarized in Table 3.2. Line scale results were analyzed using Statistical Analysis Software (Version 9.1, Cary, NC) and are summarized in Table 3.3.

3.4. RESULTS AND DISCUSSION

3.4.1. Attitudes, opinions, and behavior, fresh market potatoes

3.4.1.1. Purchase motivation

In response to the question, 'What are some reasons you buy potatoes?' participants in all four groups cited economy, versatility, and flavor as motivating factors. Potatoes were considered economical because they are low-cost, can be used to bulk up a meal, store well over time, and are filling.

"[Potatoes are] cheap and filling." (N, Oct 28, CU)

"They're really economical when you use them in combination with a really good cut of meat and you want to stretch the dish out." (B, Oct 28 CU)

"They keep relatively well too. The thing about potatoes is you don't have to worry about having to use them in two days." (E, Oct 28, CU)

Potatoes were described as a basic and versatile food that can be easily incorporated into a meal. Potatoes were also considered convenient because they are always available and are fast and easy to cook.

"They're very flexible. You can grill them, you can fry them, you can put them in soup." (B, Oct 28, SU)

"They are a staple that is easy to fit in with a number of dishes that you have." (B, Oct 26, SU)

"They're easy in every way. Quick to cook, quick to prepare." (NA, Oct 26, SU)

All groups mentioned that they purchased potatoes because they have an enjoyable flavor.

"They're delicious." (A, Oct 26, SU)

"They taste good." (SH, Oct 26, CU)

3.4.1.2. Purchase behavior

In response to the question, 'What kinds of potatoes do you buy?' all groups listed a wide range of potatoes, varying in maturity (e.g. 'new' potatoes), size (e.g. small versus large), shape (e.g. fingerlings), and color (e.g. brown, red, yellow, white, purple). Participants in both SU groups mentioned purple/blue, fingerlings, and new potatoes from the start and were able to recall specific variety names like 'Sangre' and 'German Butterball', whereas participants in the CU groups mentioned more commonplace varieties like the Yukon Gold, Russet, and white potatoes. The SU groups mentioned purchasing and using purple potatoes from the start of the conversation, but the CU groups only mentioned purple potatoes after more common varieties were mentioned. When purple potatoes were mentioned in the CU groups, a strong reaction of surprise and curiosity was elicited, whereas in the SU groups, the mention of purple potatoes elicited no reaction. This reaction may have been indicative of the difference in familiarity between the CU and SU groups with unique specialty varieties like the purple potato. Interestingly, participants in all groups included yams and sweet potatoes in the list of 'potatoes' they regularly purchased.

Across groups, participants were unsure of the correct names for the varieties they purchased. Most participants could not recall specific variety names and instead described varieties by color, shape, and size. The participants that could recall variety names were still unsure of their accuracy. Multiple names were used to describe one type of potato. For example, Russet-type varieties were called 'brown', 'Russet', 'white', 'Idaho', and 'baker'.

"I don't know about Red Bliss. Is that the same as small red potatoes?" (JU, Oct 26, CU)

"I had one the other day. It was like a Russet. It was Kenniwith or something..." (A, Oct 28, CU)

"[I buy] any new potato they have at the Saturday market. I don't know what they are...I don't care about the name." (NAE, Oct 26, SU)

In response to the question, 'Where do you buy potatoes?' participants mentioned conventional grocery stores (e.g. Safeway, Fred Meyer, QFC, Albertson's, Winco, Costco), specialty or natural foods stores (e.g. New Seasons, Whole Foods, and Trader Joe's), farmer's markets or produce stands, food cooperatives, and community supported agriculture. Participants purchased potatoes by the pound, without packaging and/or with packaging, usually in two lb bags or 10-15 lb bags.

When asked, 'How much do you pay for potatoes?' participants recalled that they paid less than \$1/lb for Russets and potatoes on sale, \$1-\$2/lb for common varieties and potatoes purchased at the farmer's market, and \$2-\$2.50/lb for specialty varieties and organic potatoes. Some participants were very price conscious and could recall specific prices per pound, as well as price fluctuations and differences. Most participants, however, stated that they didn't normally pay attention to price because they expected the price of potatoes to be inexpensive and stable.

"Potatoes are usually cheap so I just buy them." (K, Oct 28, SU)

"A lot of the time, I don't even look at the price." (K, Oct 28, SU)

"It's not a product that the price fluctuates dramatically between seasons, so you can just grab a bag." (ME, Oct 28, SU)

"I guess the thing is that I don't stop and think about what they cost, because it's never going to be too much. There's a lot of stuff in the grocery store where I would be price conscious...but if I'm in a store I trust, and they've got potatoes, I'm just going to get them." (B, Oct 28, CU)

Intended preparation was a bigger driver of purchase than price. Participants stated that they often selected potatoes based on a specific recipe or preparation, and did not consider price.

"They don't break your budget and you want them in the recipe, so you just go buy it." (I, Oct 28, SU)

"I would say, I look at the price, but if I was planning on making something...unless the price was exorbitant, I would still buy it." (S, Oct 26, CU)

It was also mentioned that potatoes rarely go on sale and that there is no opportunity for cost comparison due to the lack of brand competition.

"And it's not something that often goes on sale either." (T, Oct 28, SU)

"You don't have an option. There's one Russet. You don't get two brands to pick from. It's not like cost-compare shopping when you are buying pasta or something." (JU, Oct 26, CU)

Perception of price was also somewhat dependent on point of sale. Participants expected potatoes sold in conventional grocery stores to be cheap. Farmer's markets or produce stands could be cheap or expensive, depending on the seller, organic status, and varieties offered. Specialty or natural foods stores were considered more expensive sources of potatoes.

3.4.1.3. Specialty varieties

In response to the question, 'What characterizes specialty potatoes?' all groups cited unique appearance, limited availability, high price, unique point of sale and display, specific culinary preparations, and distinct flavor as the major indicators of specialty status. Participants mentioned unique potato color (e.g. purple), shape (e.g. fingerlings), and size (e.g. small potatoes) as characteristics that differentiated specialty potatoes from more common varieties. Participants in both SU groups mentioned that specialty potatoes were produced in small quantities by a limited number of growers, and were typically not available year round.

"You can only get them at certain times a year." (NA, Oct 26, SU)

"If it's not available all the time, it's a specialty potato." (NAE, Oct 26, SU)

"A specialty potato for me would be that it's a small production. It's something one or two people can grow in their field versus acres and acres of one potato that needs to go to every Safeway in the country." (CR, Oct 26, SU)

All groups also expected that specialty potatoes would cost more than common varieties.

"When I think of specialty or gourmet, I think of price point. I know I can get a bag of Russets for a whole lot less than I can get fingerlings." (L, Oct 26, SU)

Although there was the expectation that specialty potatoes would be priced higher than common varieties, price was still not a factor in purchase because specialty potatoes were purchased less frequently and in smaller quantities than other varieties.

"I mean, I complain how expensive potatoes, the nice potatoes, have become. But I still buy them. It's not like something I do every day so I am not as price sensitive as I am for a Russet. I make a big deal about my Russets if they are not cheap." (NAE, Oct 26, SU)

"I'll get, you know, 'x' number [of specialty potatoes]. I'm going to get five of the best kind of looking potatoes that I'm going to find, and that's it! Just for that dish." (S, Oct 28, CU)

Point of sale had an effect on the perception of potatoes as specialty. For one SU group, specialty status was largely determined by where the potatoes were sold. If the potatoes were sold at a seasonal location (e.g. a farmer's market) or a location that sold specialty foods (e.g. a natural foods store), the potatoes were considered specialty. Conversely, if the potatoes were sold at a conventional store and were available year-round, they were considered common.

“The question is: what’s the quality? I wouldn’t necessarily buy a specialty potato at Safeway.” (B, Oct 28, CU)

“I think of specialty as the retail store. If it’s going to be a big bag at Safeway, it’s not very ‘special’. (M, Oct 26, SU)

It was also noted that specialty potatoes are typically displayed in a separate location from more common varieties, usually in a separate container (e.g. plastic or wooden bin) or in a separate area of the store.

“They’re in the little bins. They’re not in huge bags.” (ME, Oct 28, SU)

“Often, they’re in organic displays instead of the regular displays.” (T, Oct 28, SU)

All participants agreed that specialty potatoes were prepared and presented in a different way than common varieties. Specialty potatoes were considered more central to a recipe or dish, as opposed to an ingredient or a side dish, and were typically prepared with a specific recipe in mind.

“When I cook with those, the focus is more on the potato.” (E, Oct 28, CU)

“You wouldn’t use [specialty potatoes] in every recipe.” (ME, Oct 28, SU)

It was also noted that specialty potatoes were not prepared every day. They were typically purchased and prepared for a specific occasion, and as a result, were purchased less frequently and in smaller quantities than more common varieties. Participants mentioned that specialty potatoes were purchased loose, as needed, as opposed to more common varieties, which were purchased in bags to store at home for daily use.

“You don’t make them all the time. I don’t make specialty potatoes all the time.” (PA, Oct 28, CU)

“I’m more likely to buy the non-specialty potatoes in a bag that might last a week or two and get the small, specialty ones...when I feel like I am going to be using them.” (E, Oct 28, CU)

“I buy [specialty potatoes] loose at the farmer’s market and for the staple potatoes I cook, I get one or two pound bags of red, Yukon, or fingerlings.” (CR, Oct 26, SU)

Specialty potatoes were also described as having a unique flavor that is often preferred to more common varieties.

“The purple has a very distinct flavor.” (T, Oct 28, SU)

“They’re a little more pricier, but they taste better.” (RO, Oct 28, CU)

“I just associate [small] size with more gourmet or it’s going to taste better.” (SH, Oct 26, CU)

3.4.1.4. Perceived health benefits

In response to the question, ‘What are your associations with potatoes and a healthy diet?’ many participants stated that they were aware that potatoes contained vitamins and minerals, but were unsure of specific nutrients or amounts. A few participants in the SU groups mentioned that potatoes were a good source of potassium, but most participants felt that potatoes were nutrient-poor overall.

“I don’t know what the nutritional value is of potatoes, but I don’t think of them as particularly nutritious.” (A, Oct 28, CU)

“I think of the potato itself as kind of neutral. I don’t think it has a ton of vitamins, but it’s not bad for you.” (ST, Oct 26, CU)

Greater emphasis was placed on potatoes as a good source of starch and subsequently, carbohydrates. Participants in all four groups claimed that potatoes were high in carbohydrates and high on the glycemic index. Carbohydrates in potatoes were considered a good source of energy for fitness training but detrimental to health otherwise.

“I really like them but my doctor told me to stay away from eating them because of the high starch and carbohydrate count in them. So they’re good, but just don’t eat too many of them.” (S, Oct 26, CU)

“I do a lot of cycling and it’s a great quick carbohydrate.” (K, Oct 28, SU)

“Potatoes are associated with empty carbs a lot. There is a lot of potato guilt.” (E, Oct 28, CU)

Potatoes were recognized as a low-fat or fat-free food, but it was noted that additions like salt, butter, or sour cream negated this status. Participants across groups felt that potatoes helped to balance out a meal and should be served in addition to sources of protein (e.g. meat) and/or vitamins (e.g. vegetables) to be considered healthy.

If potatoes were eaten in excess or were the central focus of the dish (as opposed to a balancing food), this was considered unhealthy.

"I think you have to be careful what toppings you put on it." (J, Oct 26, CU)

"It's awfully tempting to take them and turn them into the main focus or add a bunch of stuff to them that pretty much negates any nutritional value." (S, Oct 28, CU)

"If you [eat potatoes] in moderation, and you combine it with other things - it could be veggies, it could be eggs, it could be meat - then it could be healthier." (L, Oct 26, CU)

"Not as a meal centerpiece. More of a side dish. And you've got to do it in balance with protein and green veggies, and not just the carbs themselves." (B, Oct 28, CU)

Potato skin was considered healthy because of its fiber content. Potato skin was also perceived as more nutritious than the flesh. Smaller potatoes were perceived as having more nutrients overall.

"I always assume that a lot of the nutrients are in the skin, so you make sure you eat the skin with the rest of it." (R, Oct 28, CU)

"The bigger, Russet, floury potatoes are not as healthy for you as the smaller, denser red potato." (N, Oct 28, CU)

Potatoes were also considered healthy because they are a natural, unprocessed, whole food. There was no mention of the antioxidant value of potatoes in any of the groups, and no group mentioned potatoes as being a good source of vitamin C.

3.4.2. Attitudes and opinions, colorful fresh market varieties

Participants in all groups had mixed reactions to the five new potato varieties they were presented with. Some participants thought their unique appearance was interesting, attractive, intriguing, and exciting. Others thought the potatoes looked unusual or strange and suspected that they were spoiled, engineered, not fully developed, or would not store well.

Participants across groups had the strongest opinions about POR03PG23-1. Opinions tended to extremes for this variety: participants either expressed that they would not buy it because it looked 'freakish' and 'unfood-like' or that they would definitely buy it because they thought it was unique and were curious to try it. Participants also suspected that the mottled appearance of POR03PG23-1 may have been due to spoilage or sun exposure.

“At first glance, I thought [POR03PG23-1] was spoiled. Like, there’s something wrong with that potato.” (A, Oct 26, CU)

“I was wondering whether [POR03PG23-1] was sun burnt.” (J, Oct 26, CU)

POR02PG26-5 was the second most debated potato. Many participants were drawn to POR02PG26-5 because it reminded them of the Yukon Gold and they expected it to be similar in flavor and texture. To others, this similarity to the Yukon Gold made it uninteresting.

“[POR02PG26-5] is appealing to me, because it reminds me of the Yukon.” (NAE, Oct 26, SU)

The reddish coloration around the eyes of POR02PG26-5 was ‘pretty’ or ‘attractive’ for some participants. For others, the rosy eyes looked dyed or reminded them of a disease.

“It reminds me of those carnations that they put the dye in the tips.” (ME, Oct 28, SU)

“[POR02PG26-5] looked like it was sitting up against something that leached red food coloring all over it.” (K, Oct 26, SU)

“The one there with the pink, I find off-putting. It looks like it has a rash or something to me.” (M, Oct 26, SU)

“[Looks] kind of like pinkeye.” (CR, Oct 26, SU)

POR01PG16-1 and POR01PG22-1 were most frequently discussed with regard to their fingerling type size and shape (small and oblong). There was a lot of concern over whether these varieties would store well. The colors of these varieties were off-putting for some (described as ‘too dark’) but were generally liked by most of the participants. To a few participants, the intensity of color indicated stronger flavor or increased nutritional content.

“[The] three really nice dark potatoes...that indicates to me that it would taste great.” (T, Oct 28, SU)

“I like the colored ones because I tend to think they have more vitamins.” (ME, Oct 28, SU)

“I like how dark it is. I know it’s nutrients. That actually makes me want to try [POR01PG16-1].” (N, Oct 28, CU)

POR03PG80-2 was a source of confusion for many because it was not easily categorized as a specialty potato. It was considered a specialty variety because of its unique purplish hue, but was also described as a Russet-type because of its large size and uniform oval shape.

“The one on the far right confuses me because it looks like a big utility potato, but then it’s blue so I don’t know if I’m supposed to bake it or...?” (M, Oct 26, SU)

3.4.3. Factors affecting purchase, colorful fresh market varieties

3.4.3.1. Positive and negative associations with appearance

Participants across all groups used the names of other foods or animals to describe the appearance of the new varieties. For example, some of the terms used to describe the appearance of POR03PG23-1 were ‘dappled cow’, ‘raw meat’, ‘marble cake’, and ‘beefsteak’. If the appearance of the potato reminded a participant of something that they had a positive association with, they were more interested in purchasing the potato. The opposite was observed if the participant had a negative association. A complete list of participant associations can be found in Table 3.2.

“The one with the reddish hue...reminds me of a pear...[and] it looks delicious. You look forward to cooking it or eating it.” (I, Oct 28, SU)

“[POR03PG23-1] reminds me of an animal. A dog, or any multicolored animal.” (ST, Oct 26, CU)

“It reminds me of a beet.” (I, Oct 28, SU)

“For [POR01PG16-1], I love that it looks like a plum...that actually makes me want to try [POR01PG16-1], but not [POR01PG22-1] because I don’t like sweet potatoes.” (N, Oct 28, CU)

“[POR03PG23-1] looks like a piece of prosciutto ham. I would not buy it. It’s too red. It really looks like meat, and I eat meat [but]...it’s a different experience I am looking for.” (NAE, Oct 26, SU)

3.4.3.2. Concerns about genetic engineering, tampering, and chemicals

Participants across all groups indicated that they thought the new potato varieties were somehow altered to achieve their unique appearance. Genetic engineering, tampering, or chemicals were mentioned as possible ways in which the potatoes were manipulated or created.

These practices were considered negative and were a concern for participants in all groups. The possibility of crossbreeding was mentioned in three of the groups and this was considered an acceptable practice.

“The other one [POR03PG23-1] looks too engineered to me. It looks scary.”
(NAE, Oct 26, SU)

“Are they genetically engineered?” (ST, Oct 26, CU)

“I almost imagine someone in a lab making that potato [POR02PG26-5]. I am going, wow, who engineered that potato?” (E, Oct 28, CU)

“I wouldn’t buy it just because of the chemicals that they would use to make the two different colors [POR03PG23-1].” (P, Oct 28, SU)

3.4.3.3. Preparation considerations

For most participants, size, shape, and skin preferences superseded color preferences as determinants of purchase because of their effect on potato preparation and utility. Some participants preferred small potatoes because they could be prepared whole, with skins on. This was especially true if consuming the skin was desirable (i.e. for increased nutrition or fiber). Larger potatoes were more desirable if the preparation required removing the skin (e.g. for mashed potatoes) or if the skin was simply not desired by the participant.

“You look at a potato and you think what you can do with it. Certain shapes lend themselves to...whatever you are going to do. The smaller it gets, that odd shape, I am thinking, how can I cut this or how can I prepare it?” (R, Oct 28, CU)

“And along with that, the question is, will you peel it or not? If they’re smaller...I am not into peeling them.” (B, Oct 28, CU)

Some participants noted that large potatoes exhibited more utility than small potatoes because small potatoes were insufficient to feed a large family. Conversely, if the preparation called for fewer potatoes or if there were less people to feed, small potatoes were preferred to large potatoes.

“I like big potatoes. You would have to buy 10 lbs of the small ones just to feed my family, so that wouldn’t work for me.” (NA, Oct 26, SU)

“I would be more interested in [POR01PG22-1] and [POR01PG16-1] because they are small and I don’t typically make things with large quantities of potatoes.” (H, Oct 26, SU)

Shape was also an important consideration, as shape could lend to specific preparations. For example, the long, cylindrical shapes of POR01PG22-1 and POR01PG16-1 were appealing because they could be easily cut into uniform pieces.

“If you’re making something like an au gratin, those [POR01PG22-1 and POR01PG16-1] would slice lovely on a mandolin and be really nice and uniform and pretty.” (I, Oct 28, SU)

Across groups, participants stated that they would cook and present the new varieties in a way that highlighted their unique colors. Showing off the color had the effect of placing the potato as the central focus of the dish, as opposed to an addition or side dish.

“Layered, cut up, because you want to show off the uniqueness of it.” (I, Oct 28, SU)

“It could be a centerpiece because of the color.” (S, Oct 26, CU)

“I would cut it long, so you could actually see the color after you prepared it. That would make an interesting presentation on a plate.” (R, Oct 28, CU)

Across groups, participants agreed that the new varieties could be used everyday, but they were especially suited for creating themed dishes for special occasions because of their unique appearance.

“[The potatoes] would be good for a Fourth of July picnic...make a potato salad...or potlucks.” (ME, Oct 28, SU)

“Like the black, [POR01PG16-1], could be used at Halloween...they are so dark and textured...you think dark or gloomy or just kind of scary.” (PA, Oct 28, CU)

“Okay, it’s Valentines Day, make pink mashed potatoes.” (PA, Oct 28, CU)

3.4.3.4. Point of sale

When asked, ‘Where would you expect to purchase these new varieties?’ participants cited specialty grocery stores, farmers markets, community supported agriculture, and cooperatives. There was no mention of conventional grocery stores. It was noted that where the potatoes were sold would affect the perception of the potato. Participants expected to see unique varieties sold at a farmer’s markets or specialty stores. If these same potatoes were sold at conventional stores, their appearance might be perceived as a defect or the result of tampering.

"If I saw something mottled like that [POR03PG23-1] at Freddy's or Safeway, I would totally think GM...something genetically modified, something tampered with. Whereas, if I found it at a farmer's market, I would think [it was] something unique: one of the 3000 varieties of potatoes from Peru. So I wouldn't trust the big stores to be able to source a specialty potato." (CR, Oct 26, SU)

"I would probably have a different reaction to it if I came across it in the grocery store or in just a bin, than I would if I came across it at a farmer's market."

"It's the difference between a feature and a bug. At the grocery store, you see it as a bug. At the farmer's market, it is a feature." (B, Oct 28, CU)

3.4.3.5. Family acceptance

Participants who had children had strong opinions about their families' acceptance of the new potato varieties. Some participants felt that their children would reject the new varieties because of their unusual appearance. Others had the opposite opinion, stating that their children would find them unique, appealing, and fun. For many participants, purchase was solely dependent on whether their children would accept the potatoes or not.

"I'm pretty sure if I showed up with those at home, the kids would go, 'I don't know what that is, but it doesn't look right'." (S, Oct 28, CU)

"My kids would love that, I know...they would think that is the coolest potato." (N, Oct 28, CU)

"I would stay away from the ones with color inside because my kids wouldn't eat it." (J, Oct 26, CU)

"I remember when I was a child I always liked foods with bright colors...so I wonder if the bright red and bright purple potatoes would be kind of interesting and fun for kids? You know, red French fries?" (S, Oct 26, CU)

3.4.3.6. Anticipated flavor

Curiosity about flavor was a motivator for purchase across all groups. Both of the SU groups noted that if the flavor was not appealing, the potatoes would not be purchased again.

"You want to know the flavor profile...I would buy it just to know what it tastes like." (N, Oct 28, SU)

"I'm a trial and error kind of person. I would buy it just once to see what the flavor is." (NA, Oct 26, SU)

"Have you [referring to moderator] tasted these potatoes? Before you go, will you tell us how you found [the potatoes] to taste?" (JU, Oct 26, CU)

"I would say that flavor is still going to be my ultimate indicator. If it's a good looking potato high in antioxidants and it tastes like dirt...then I'm not going to buy it." (CR, Oct 26, SU)

3.4.4. Effect of information on purchase intent

A one way analysis of variance (ANOVA) and Tukey's Honest Significant Difference (HSD) test at $p < 0.05$ was performed to evaluate the effect of different levels of information (raw flesh, cooked flesh, and health information) on purchase intent for each OSU variety based on participant markings on a line scale. Although many of the participants found the photos of the raw and cooked flesh to be useful information, only after receiving health information (Appendix 7), was there any significant difference in purchase intent between varieties. After health information was received, both POR01PG16-1 and POR01PG22-1 received a significantly different ($p < 0.05$) mean score for purchase intent as compared to the rest of the samples (Table 3.3). For these purple and red potatoes, the mean purchase intent score was significantly lower on the line scale, indicating higher purchase intent. It should be noted that although this result was significant for this study, this result cannot be generalized to a larger population due to the small sample size ($n=37$) of participants.

Overall, the effect of the health information changed participants' original attitudes and opinions about the colorful potatoes in a positive way, namely for POR03PG23-1, POR03PG80-2, POR01PG22-1, and POR01PG16-1. This was especially true for the CU groups, which had less experience with the colorful potatoes than the SU groups and were more suspect of the new varieties than the SU groups. After receiving the health information, participants across groups stated that they were more willing to buy the new varieties, despite any prior reservations. For many, the antioxidant benefit superseded any prior consideration or hesitation on the basis of appearance alone. For many, the health information confirmed their beliefs that the colorful varieties were in some way more nutritious than the more common varieties.

"I think that after reading that, [POR01PG16-1], the moldy looking potato...I would probably get it because it does have the antioxidants and the anthocyanins." (P, Oct 28, CU)

"I would be more tempted to buy the purple and the reds based on the information that it's more nutritious." (L, Oct 26, CU)

"I don't care about the aesthetic any more. I mean, it really has to be ugly for me to choose the aesthetic over nutrition." (NAE, Oct 26, SU)

"This just goes to show that throughout time potatoes got a bad rap...I've always loved potatoes but I didn't know why. See, I'm getting my vitamins with this. Potatoes are healthy!" (NA, Oct 26, SU)

A number of participants stated that the health information was a 'good selling point' or 'marketing campaign' for the new varieties. Most participants were surprised by the information and mentioned that they had no prior knowledge that potatoes had any antioxidant benefit at all.

"I can already see the marketing strategy: buy purple!" (LE, Oct 26, CU)

"I know everyone is big on antioxidants right now. Goji berries, blueberries, I mean it's the big word right now. If you tell them it's big, then people go for it. I mean it's all marketing. We don't really know if it's even good for us." (NAE, Oct 26, CU)

Participants in one of the CU groups stated that regardless of how they felt about the potatoes, even in light of the health information, they would not purchase them because of family considerations.

"Although I still have one caveat: for me, not for the kids." (B, Oct 28, CU)

"Sometimes when you tell your kid that it's better nutrition, it makes them even LESS likely to [eat it]." (N, Oct 28, CU).

Many participants stated that the health information was too lengthy and detailed. It was recommended that the health information be shortened to as few words as possible. Basic numerical representations of facts such as ratios (e.g. 'potato x has three times greater antioxidant levels than potato y') and percentages (e.g. '45% of daily value') were considered to have the greatest impact.

"Just give me a one-liner or whatever: what's the benefit?" (PA, Oct 28, CU)

"I like the 'total level in the purple potato is three times greater'." (A, Oct 26, SU)

"I could not recall all the things you said in here from reading it once, but I can recall 'three times greater'. I would remember that." (L, Oct 26, SU)

Most participants were familiar with the term 'antioxidant' and were aware that vitamin C was an antioxidant. Almost all the participants never heard of anthocyanins or carotenoids and were unsure of their direct benefits. It was recommended that these words be omitted.

"I think big words like 'anthocyanins', people are not going to know what that means." (H, Oct 26, SU)

One of the CU groups questioned the source of the health information, and mistrust of the food industry and conventional agriculture was expressed. The group suggested that independent sources of information like educational institutions or websites were more trusted sources of information.

"I would be more willing to buy the purple and the red based on this [health information], but at the same time I look at the USDA and it's like...where can they prosper in this kind of information?" (ST, Oct 26, CU).

3.4.5. Additional information desired by participants

In response to the question, 'What other information would you like to have about these potatoes?' most participants requested preparation instructions or recipes, information about how the varieties were developed (i.e. genetically modified or cross-bred?), and information on why the new variety was developed (i.e. what are the benefits to the consumer?).

"I'd like to see suggested preparations." (RO, Oct 28, SU)

"Before I would buy, I would talk to the farmer's market or produce guy and I would ask, is this a baking potato, is this a roasting potato? I would be curious. I would seek out the information." (JU, Oct 26, CU)

"I would want to know what is this kind of potato good for? Just like if you are going to bake with an apple. You want to make sure you have the right kind of apple for the type of desserts you're making." (JU, Oct 26, CU)

"I would like to know if they're crossed...like if it's a Russet [crossed] with a Butterball." (MI, Oct 28, CU)

"How are they bred? Again, are they genetically modified? How are they cross-bred?" (L, Oct 26, CU)

"I mean, [POR03PG23-1], why is it like that? Are they trying to say it's got more vitamin C?" (N, Oct 26, CU)

"What's wrong with the potatoes we have now? Why do we need something that's crazy as that [POR03PG23-1]?" (ST, Oct 26, CU)

3.5. CONCLUSION

Based on the findings of the focus group sessions, consumers buy fresh market potatoes because they are economical, always available, easy to prepare, versatile in application, and have an enjoyable flavor. Participants in all four groups purchased a range of varieties from a number of sources, from farmer's markets to conventional grocery stores. Varieties were more easily recognized by their color, size, and shape than by specific variety names. When purchasing fresh market potatoes, participants expected them to be inexpensive with stable prices. In sum, the participants in all four focus groups considered fresh market potatoes to be a functional commodity that fulfills a basic need.

Participants stated that specialty potatoes were different from more common varieties by their unique appearance, flavor, and culinary preparation. Participants expected specialty potatoes to be sold in unique locations (e.g. specialty stores or farmer's markets) at higher prices and with limited availability. Although specialty potatoes were expected to cost more, price was not a limiting factor because participants stated that they purchased smaller quantities of specialty potatoes and purchased them less frequently. Hence, purchase was generally use-driven instead of price-driven for specialty potatoes.

The groups revealed that they considered potatoes to be lacking in nutritional value, besides being a good source of carbohydrates, potassium, and fiber. It was mentioned that potatoes could be used to balance out the consumption of other foods (e.g. meat and vegetables). Potatoes could also be used as a source of energy due to their carbohydrate content, acting as a functional food for fitness or sports training. Potatoes were considered unhealthy when combined with other 'unhealthy' foods (e.g. sour cream or butter). Participants across all groups were not aware of the antioxidant benefits of colorful potatoes.

Some participants considered the varieties developed by OSU to be unique and exciting. For others, they aroused suspicion with regard to how and why they were developed. Purchase intent for these new varieties was affected by positive and negative associations with appearance, concerns about genetic engineering, tampering, and chemicals, preparation and presentation considerations, point of sale, family acceptance, and anticipated flavor.

Participants were interested in the photos showing the raw and cooked flesh of the potatoes, but only health information had a significant effect ($p < 0.05$) on purchase intent. Antioxidant information increased the willingness to buy for POR01PG22-1 and POR01PG16-1, though this was for a very small sample size of consumers ($n=37$) and should only be considered significant within the context of this study. Chapter 5 explores the effect of antioxidant information on purchase intent for colorful potatoes using a much larger sample size ($n=222$).

Participants desired health information to be simple and concise, without using specific nutritional terminology (e.g. 'anthocyanins' and 'carotenoids'). Additional information describing suggested preparations, how the new varieties were developed, and the direct benefit to the consumer, was also desired.

In sum, the reactions of participants to the colorful fresh market varieties developed by OSU and the factors that affect the willingness to purchase these varieties can be used to advise the future development of varieties exhibiting similar characteristics. The results of this study can also be used to develop information about colorful fresh market varieties that may influence consumer acceptance and purchase intent.

-
- I. Introduction
 - A. Introduce self
 - B. Ground rules:
 - 1. Free to participate or not participate at any time
 - 2. One person speaking at a time
 - 3. Respect each others' opinions
 - C. Taping of focus group and one-way mirror
 - II. Warm-up: To get everyone acquainted and to get us all thinking about the topic of interest, please:
 - A. State your name
 - B. Briefly state your favorite way to cook potatoes at home
 - III. Initial questions
 - A. Use/purchase behavior
 - 1. What are some reasons you buy potatoes?
 - 2. What kinds of potatoes do you buy?
 - 3. Where do you buy them?
 - 4. How much do you pay?
 - B. Specialty potatoes, definition
 - 1. What characterizes a specialty potato?
 - 2. Where do you buy them?
 - 3. How much do you pay?
 - 4. How are they displayed?
 - IV. OSU specialty potato varieties, whole raw
 - A. Ballot
 - B. First impressions
 - C. Use/purchase behavior
 - 1. Are there any you would buy/not buy?
 - 2. Where would you expect to see these sold?
 - 3. How would they be displayed?
 - 4. Who would you buy them for?
 - 5. How would you prepare them?
 - V. Photo, inside raw
 - A. Ballot
 - B. First impressions
 - C. Effect on purchase intent
 - VI. Photo, inside cooked
 - A. Ballot
 - B. First impressions
 - C. Effect on purchase intent
 - VII. Potatoes and Health
 - A. Attitudes, beliefs and concerns
 - 1. What are your associations with potatoes and a healthy diet?
 - B. Health statement
 - C. Ballot
 - D. Effect on purchase intent
 - E. Information
 - 1. Is health information beneficial?
 - 2. Is this too much information? Not enough?
 - 3. What other information is desired? About health or other?
-

Figure 3.1 Focus group discussion guideline

Table 3.1 Description of potato varieties shown to focus groups

Variety Name	Sample Number	Description			
		Skin Color	Flesh Color	Size	Shape
POR03PG23-1	603	Purple/yellow, Mottled	Purple/yellow, mottled	Small-medium	Round
POR02PG26-5	254	Yellow, red eyes	Yellow	Medium-large	Round
POR01PG16-1 'Purple Pelisse'	845	Purple	Purple	Small	Fingerling
POR01PG22-1 'Ama Rosa'	567	Red	Red	Small	Fingerling
POR03PG80-2	937	Purple	Pale yellow	Large	Oblong

Table 3.2 Keywords used by focus group participants to describe potato varieties

Attribute	Variety Name	POR03PG23-1	POR02PG26-5	POR01PG16-1	POR01PG22-1	POR03PG80-2
Size		Small Medium	Medium Large	Small Medium	Small Medium	Medium Large
Shape		Round	Dimpled Plump Round Squat	Compact Dimpled Elongated Fingerling Irregular Long Lumpy Oblong Skinny	Elongated Fingerling Irregular Long Oblong Skinny Thin	Blocky Oblong Oval Wide
Color		Purple Red Tan White Yellow	Brown Pink (eyes) Red (eyes) White Yellow	Black Blue Dark Purple	Brown Dark red Pink Purple Red	Brown Blue Dark Light Purple Red White (flesh) Yellow (flesh)
Skin		Shiny Smooth	Blotchy Smooth Thin	Pearlescent Smooth Velvety	Flaky Interesting Satiny Shiny Smooth Thick Thin	Luster Shiny Smooth Thin
Flesh		Dense Firm Waxy	Creamy Dense Firm Heavy Solid	Dense Firm	Dense Firm	Dense Hard Heavy Hefty

Table 3.2 Terms used by participants to describe potato varieties (Continued)

Attribute	Variety Name	POR03PG23-1	POR02PG26-5	POR01PG16-1	POR01PG22-1	POR03PG80-2
Other		Two-tone Dalmatian Engineered Experiment Freakish Genetic Marbled Meat Mottled Multicolored Not natural Odd Polka dots Raw steak Scary Sick Cow Spoiled Spotted Sun burnt Spectacular Threatening Unique Weird Variegated	Blemish Boring Colorful Common Discolored Disease Dyed Gimmick Nutritious Ordinary Pinkeye Pretty Rash Yukon	Beet Creepy Expensive Gourmet Interesting Odd Plum Poop Rich Rocks Rotten Rustic Spoiled	Beautiful Cigar Delicate Gourmet Meat Nasty Poop Raw steak Rich Rustic Rusty Tasty Yam	Average Baker Bland Boring Dull Eggplant Generic Hearty Too many eyes Ordinary Russet Substantial Trustworthy Utility Yukon

Table 3.3 ANOVA results for mean purchase intent scores (\pm standard deviation) assessed on a 12.2 cm anchored line scale, after seeing potatoes without information, seeing a photo of raw flesh, seeing a photo of cooked flesh, and after receiving health information (n=37)

Variety Name	Skin/Flesh Color*	No Information ^{NS}	Raw Flesh ^{NS}	Cooked Flesh ^{NS}	Health Information
POR03PG23-1	P,Y/P,Y	3.94 \pm 3.28 ^a	3.81 \pm 3.95 ^a	4.45 \pm 3.63 ^a	3.12 \pm 3.37 ^{ab}
POR02PG26-5	Y/R,Y	2.74 \pm 2.63 ^a	3.51 \pm 3.07 ^a	3.75 \pm 3.35 ^a	4.16 \pm 3.19 ^a
POR01PG16-1	P/P	3.83 \pm 3.51 ^a	2.81 \pm 3.31 ^a	2.81 \pm 3.23 ^a	1.67 \pm 2.18 ^b
POR01PG22-1	R/R	3.37 \pm 3.03 ^a	3.67 \pm 3.35 ^a	3.65 \pm 3.37 ^a	2.26 \pm 2.51 ^b
POR03PG80-2	P/Y	3.84 \pm 2.34 ^a	4.19 \pm 3.07 ^a	4.78 \pm 3.41 ^a	4.32 \pm 3.04 ^a

a, b, ab – different superscript letters in each column indicate significantly different results, $p < 0.05$

NS – not a significant difference

* – P=purple, Y=yellow, R=red

4. CHAPTER 4 – EFFECT OF SENSORY PROPERTIES ON CONSUMER ACCEPTANCE OF COLORFUL FRESH MARKET POTATOES

4.1. ABSTRACT

Six colorful fresh market varieties and one commonly available variety, the Yukon Gold, were evaluated in two consumer acceptance tests with 111 participants each. Hedonic measures for overall appearance, color, size, and shape for raw potatoes and overall liking, appearance, flavor, and texture for cooked (boiled) potatoes were rated on a 9-point category scale. Consumer comments describing like/dislike of raw color, size, and shape and cooked appearance, flavor, and texture were captured. Colorful fresh market varieties received average hedonic scores on the high end of the scale for both raw and cooked attributes. For color, yellow and red varieties were accepted over purple varieties. For shape and size, larger and rounder varieties were accepted over smaller, elongated varieties. Bimodal hedonic score distributions for purple color, small size, and elongated shape were observed. Yellow varieties were accepted over the Yukon Gold for cooked attributes. Consumer comments revealed that a uniform raw and cooked appearance, a distinct flavor with no undesirable aftertaste, and a smooth, firm, and consistent texture were all desirable characteristics. Comments also revealed that preparation and serving size considerations have an effect on acceptance.

4.2. INTRODUCTION

The potato industry in Oregon could be revitalized by the introduction of new potato varieties into the fresh market. Historically, consumers have had little to choose from outside of standard Russet-type potatoes. The development of new potato varieties not only provides consumers with new and exciting choices, it also creates opportunities for growers to produce and sell value-added crops to fill market niches (Associated Press, 2007; Schmitz, 2007).

For over 20 years, researchers from the Oregon State University Department of Crop and Soil Science (OSU-CSS) have worked in collaboration with the Pacific Northwest Tri-State Potato Breeding Program to develop new potato varieties to meet the needs of the Oregon potato industry. The Tri-State Potato Breeding Program includes researchers from Washington State University, University of Idaho, and the USDA ARS in Prosser, WA and Aberdeen, ID. Five years ago, the OSU-CSS officially established the 'Potato Breeding and Genetics Program' (Oregon State University Department of Crop and Soil Science, n. d.).

The OSU Potato Breeding and Genetics Program has been very successful in developing new varieties that have physical attributes well suited for commercial potato processing, including resistance to disease, process-grade size and shape, and the ability to handle manufacturing stress and long term storage requirements. In addition to processing varieties, the program develops specialized varieties of potatoes aimed for release in the fresh market. These specialty potato varieties are characterized by unusual skin and flesh colors that result from cross breeding conventional varieties with germplasm from the Andean region of South America.

The Potato Variety Management Institute (PVMI) is a new program that makes these varieties available to growers (The Potato Variety Management Institute, 2007). The PVMI's role is to promote new varieties in Idaho, Oregon, and Washington, including the administration of licensing and royalty fees, promotion, marketing, and creating opportunities for increased variety utilization and commercialization. This effort has not been as successful for specialty varieties as for conventional processing varieties, and to this date, specialty varieties developed by OSU and released through PVMI are only a small part of the Tri-State program.

Part of the reason why specialty varieties have not been used by growers is that consumer acceptance remains unknown at the time of release. A multi-stage selection process is employed by both OSU breeders and others in the Tri-State program to ensure that the specialty varieties released through PVMI do not have any defects. This process involves multiple stages of physical and sensory evaluation and ensures that raw and cooked characteristics are on par with current fresh market quality standards (United States Department of Agriculture Agricultural Research Service, 2010). This process is performed without any consumer involvement, however, and there is no consumer testing to follow this effort.

Preference and acceptance tests have been used to assess consumer response to new varieties of crops such as sweet cherries (Dever, MacDonald, Cliff, & Lane, 1996), apples (Hampson et al., 2000), and kiwis (Wismer et al., 2005), but there is limited research for new colorful potato varieties. Sangketkit et al. (2000) investigated consumer acceptability of five new cultivars and one local cultivar of oca (*Oxalis tuberosa* Mol.), a tuber crop with yam-like qualities grown in New Zealand. A consumer-type panel evaluated appearance, flavor, and texture of raw, steamed, and baked tubers. For raw oca, panelists preferred bright red tubers, but size was also important. Flesh color, bitterness, and mealiness were important variables in the overall acceptance of steamed oca, while only flesh color and bitterness were important variables for baked oca. Cultivars which had a flesh color described as 'bright yellow', a flavor described as 'no bitter taste', and a 'very slightly mealy' texture were most preferred.

A more recent study by Jemison et al. (2008) surveyed 275 people over two years and four locations to assess fresh market potato consumption patterns in Maine and to determine how specific potato characteristics influence variety selection. White, yellow, red, and purple potatoes were evaluated whole and cut in half. Skin quality was the most important variable in influencing preference for all varieties when evaluated whole (except purple skinned varieties), whereas flesh color was the most important variable affecting variety selection for the halved potatoes.

The objective of this thesis research study was to use consumer acceptance testing methods to evaluate new colorful specialty potato varieties developed in part by the OSU Potato Breeding and Genetics Program and intended for fresh market consumption. The varieties evaluated in this study were a selection of potatoes that either performed well in the final stages of the Tri-State evaluation process or have already been released through the PVMI.

4.3. MATERIALS AND METHODS

4.3.1. Design

The study was conducted at the OSU-FIC located in Portland, Oregon. Participants tasted samples in one of 10 partitioned sensory booths equipped with computers and touch screen monitors. Participant data was collected using Compusense Five (Version 5.0, Guelph, Ontario). The study was split into two experiments that differed in test potatoes and participants, but used the same ballot. The first experiment (EXP1) tested four potatoes samples: three test samples and one Yukon Gold sample (Table 4.1). The second experiment (EXP2) tested three different test samples and the same Yukon Gold sample (Table 4.1). Test samples either had purple, red, or yellow skin and flesh, with two of the yellow samples exhibiting a reddish color around the eyes. EXP1 had 111 participants and EXP2 had 111 participants, with all 222 participants screened using the same criteria. The study was conducted over the course of four days (EXP1 on the first and fourth day and EXP2 on the second and third day), with about 60 participants scheduled each day. Test sessions were 45 minutes long and were held throughout the day.

4.3.2. Materials

Six potato cultivars developed in part by the OSU Potato Breeding and Genetics program were used in this study. Three of these cultivars were already released through the PVMI: 'Purple Pelisse' (2009), 'Ama Rosa' (2010), and 'Terra Rosa' (2010). The Yukon Gold was not developed or released by OSU, but was grown and harvested from the same location as the other test potatoes. The purpose of including the Yukon Gold was to have a commonly available all-yellow

skin and flesh sample in both experiments. The Yukon Gold samples used in this study were not characterized by the pink eyes that Yukon Gold varieties can exhibit shortly after harvest. The Yukon Gold results were analyzed in the same way as the rest of the test potatoes, but in the interpretation of the results, the Yukon Gold was treated as a 'control' against which the rest of the samples were compared.

All samples were grown as seed potatoes at the OSU Central Oregon Agricultural Research Center (COARC) in Powell Butte, Oregon and were harvested in September 2009 as part of a randomized block trial. The potatoes were stored at the experiment station for four months. They were then moved to the OSU-FIC, where they were stored at a standard storage temperature of 12°C (Brook, Fick, & Forbush, 1995) for two weeks prior to the test. One day before the test, the potatoes were removed from storage and allowed to recondition to room temperature (20±2°C). The potatoes were washed with cold water to remove excess dirt. Samples with similar appearance were selected for the test by removing extra small and extra large tubers, irregularly shaped tubers, and tubers with obvious defects or signs of disease.

4.3.3. Cooking

The potatoes in both EXP1 and EXP2 were boiled whole with skins on in unsalted water. Since there was some variation in size and shape of the tubers between potato cultivars, preliminary cooking trials were undertaken to determine the time required to cook each cultivar to doneness (internal temperature between 93-100°C). Approximately one hour before the potatoes were served to participants, four pots were filled with seven potatoes from each of the four cultivars being tested. These pots were filled with five liters of cold water each and were heated on a gas stove. The potatoes were boiled for 40 to 70 minutes (depending on the cultivar), until internal temperatures reached 93-100°C. The potatoes were then removed from the boiling water and placed in an oven set to 110°C until they were served. Potatoes were kept in the oven for a maximum hold time of 10 minutes. Just before plating, potatoes were sliced in half lengthwise and one half of each potato sample was served to each participant.

It should be noted that EXP2 suffered from experimental error introduced by the improper cooking of POR02PG37-2 during test time. Eight participants (7% of the total number of participants) received an undercooked sample of POR02PG37-2 during one test session. As a result, scores for cooked overall liking, appearance, flavor, and texture given to POR02PG37-2 by these eight participants were removed from the analysis of cooked results.

4.3.4. Participants

Based on their responses to a screener (Appendix 8), a total of 224 (112 for EXP1 and 112 for EXP2) participants were selected for participation in the study. The screener asked potential participants a variety of questions about their liking, usage, and purchase of potatoes, as well as four Likert scale (Lawless & Heymann, 1999) questions to assess their attitudes on health and food (Questions 36-39). In order to qualify for the experiment, respondents were required to like and eat potatoes (Question 3), cook potatoes at least a few times a month (Question 30), and be primarily responsible for both shopping and cooking in their household or share this responsibility with someone else (Questions 23-24). Other selection criteria included no allergies or dietary restrictions and no food industry or marketing employment history or associations.

Out of this group of potential participants, two subgroups were selected. The subgroups were participants that were frequent or 'high users' (HU) of potatoes (cooking potatoes at home at least once a week) and participants that were 'moderate users' (MU) of potatoes (cooking potatoes at home a few times a month). These subgroups were further subdivided by level of interest in health and food. Participants that responded with 'always' or 'often' to the Likert scale questions about health were categorized as having 'high health' (HH) interest and those who responded with 'sometimes' or 'rarely' were categorized as having 'moderate health' (MH) interest. Participants that responded with 'always' or 'often' to the Likert scale questions about food were categorized as having 'high food' (HF) interest and those who responded with 'sometimes' or 'rarely' were categorized as having 'moderate food' (MF) interest. Roughly the same numbers of participants were then selected, at random, from each of the following categories: HUUH, HUMH, HUHF, HUMF, MUHH, MUMH, MUHF, and MUMF.

The purpose of this screening process was to follow a stratified sampling protocol, in which a population is broken into groups on the basis of one or more exogenous characteristics, with a random sample drawn from each group (Manski & McFadden, 1981). This is done in order to get more variation in the exogenous variables (i.e. levels of usage and interest in health and food) than would be drawn at random from a limited sample, thus reducing the variance of the estimators for a given sample size (Durham, 2007).

The number of participants in the analysis was reduced from 224 to 222 (111 for EXP1 and EXP2). One participant's data was removed from EXP1 because they answered the questions on the ballot before tasting the samples, and another participant's data was removed from EXP2 because they answered questions out of order. Participant demographics are shown in Table 4.2. All participants were recruited from a list of consumers living in the Portland metropolitan area provided by the OSU-FIC. Participants were compensated \$35.

4.3.5. Procedure

Prior to the test, participants were asked to read and sign an informed consent form (Appendix 9). They were given verbal instructions regarding the use of the touch screen computers and a basic overview of the test they were about to complete. Participants were assigned to individual partitioned sensory booths for testing. All taste testing was conducted under white fluorescent light at room temperature ($20\pm 2^{\circ}\text{C}$). The test had 48 questions and was divided into four parts.

In the first part of the test, participants were passed a tray with four raw whole potato samples on paper dishes identified with random 3-digit codes (Appendix 10 and 11) and were instructed to rate their liking of overall appearance, color, size, and shape on a 9-point category scale (Figure 4.1) for each of the samples. The sample order on the computerized questionnaire was randomized according to the Williams Design (generalized Latin square that is balanced for first order carryover effects) for four treatments and participants were presented with hedonic scales for all four samples at once (Appendix 12). Participants were instructed to rate each sample in the order presented on the screen (from top to bottom). Participants were then asked to comment on what they liked and disliked about the appearance of each sample.

In the second part of the test, participants were passed a laminated card with information related to the four samples they just finished scoring for appearance. There were three versions of this card. Card 1 contained no antioxidant information, Card 2 simply stated that colored flesh potatoes are high in antioxidants without providing a scientific basis, and Card 3 stated that colored flesh potatoes are high in antioxidants based on research and as compared to other fruits and vegetables with similar health benefits (Brown et al., 2005; Brown et al., 2003; Lachman et al., 2005) (Table 4.3). Flesh color descriptions were included on all three information cards. The information on flesh color was provided to all participants so that everyone received a baseline of information, regardless of whether antioxidant information was stated or not.

Participants were instructed to read the information provided and then consider this information in answering questions about purchase. Then participants were asked to rate their probability of buying each sample at \$2.99/lb (high price), \$1.89/lb (medium price), and \$0.79/lb (low price) on a 5-point purchase intent category scale (Figure 4.2). Results from the second part of the test are analyzed and discussed in Chapter 5.

In the third part of the test, participants were presented with the same four potato samples cooked (boiled), cut in half, and placed on paper dishes with the same 3-digit codes as the raw samples (Appendix 10 and 11). The cooked potatoes were served with water and a single salt packet. Participants were instructed to first look at each sample before tasting and rate liking

of appearance for each sample on a 9-point category scale. Then participants were instructed to drink water before tasting the potatoes, and to use the same amount of salt on all four samples if they chose to use the salt packet. After tasting, participants were asked to rate overall liking, flavor, and texture for each sample on a 9-point category scale. Participants were also asked to comment on what they liked and disliked about the appearance, flavor, and texture of each of the samples.

In the fourth part of the test, participants were asked to indicate how important price was when buying fresh fruits and vegetables and to rate how informed they were about the possible benefits of eating foods high in antioxidants (Appendix 12). These questions were followed by a series of Likert scale questions for agreement and likelihood in response to statements about health and food. Results from the fourth part of the test are analyzed and discussed in Chapter 5.

4.3.6. Data analysis

All statistical analysis was performed using Compusense Five (Version 5.0, Guelph, Ontario). To assess whether there was a difference in means between hedonic scores for the potato samples, $\alpha=0.05$ was selected. Descriptive statistics were used to show the distributions of hedonic scores for each sample evaluated (Appendices 13 and 14). A one-way ANOVA was conducted to evaluate the magnitude of the differences between the hedonic scores for the four potato samples. Tukey's HSD was conducted for the one-way ANOVAs that were statistically significant ($p<0.05$) to determine the specific differences between samples (Table 4.4 and 4.7). Comments were analyzed by tabulating keywords that were used by a minimum of two participants to describe what they liked and disliked about the color, size, and shape of the raw samples, and the appearance, flavor, and texture of the cooked samples (Table 4.5, 4.6, 4.8, and 4.9).

Because cooked attributes were rated after receiving antioxidant information, an analysis was performed to assess whether receiving information influenced participant scores for overall liking, appearance, flavor, and texture. Only one potato variety (POR01PG22-1) was found to have a significant ($p<0.05$) difference between average hedonic scores for overall liking when receiving no information versus simple information. There was no significant difference for overall liking when receiving no information versus detailed information. Taken together, it was determined that antioxidant information did not have a significant effect on cooked attribute ratings.

4.4. RESULTS AND DISCUSSION

As shown in Table 4.4 and 4.7, the mean liking scores for raw and cooked attributes of all potatoes tested in EXP1 and EXP2 were between 5 ('neither like nor dislike') and 8 ('like moderately'), indicating that all of the potatoes tested were accepted by participants on average.

4.4.1. EXP1 hedonic scores

As shown in Table 4.4, the Yukon Gold and POR02PG26-5 had significantly higher ($p < 0.05$) mean liking scores for raw overall liking, shape, and size than the rest of the samples in EXP1. For color, POR01PG22-1 performed similarly to the Yukon Gold and POR02PG26-5, but POR00068-11 received a significantly lower ($p < 0.05$) mean liking score. POR01PG22-1 received a significantly lower ($p < 0.05$) mean liking score for size and for shape than the other samples.

Cooked results (Table 4.7) indicated that POR02PG26-5 and POR01PG22-1 had significantly higher ($p < 0.05$) mean liking scores for overall liking and texture than the rest of the samples. For appearance, POR02PG26-5 received a significantly higher ($p < 0.05$) mean liking score than POR00068-11. For flavor, POR02PG26-5 and POR01PG22-1 had significantly higher ($p < 0.05$) mean liking scores than the Yukon Gold.

The distribution of hedonic scores for raw overall liking, size, and shape of POR01PG22-1, and raw overall liking, shape, and color of POR00068-11 appeared bimodal, as shown in Appendix 13. As a result, it cannot be assumed that the mean liking score is a meaningful indication of central tendency for these attributes.

4.4.2. EXP1 comments

Keywords used by participants are presented in Table 4.5 for raw potatoes and Table 4.6 for cooked potatoes. Participants had mixed opinions about the color of POR02PG26-5. The yellow skin with red eyes was considered 'attractive' by some participants, and 'off-putting' by others. For some participants, the red color around the eyes seemed 'natural' and 'appealing', but for others it was 'strange' or an indicator of 'discoloration'. A few participants noted that the color of the eyes was not important since they would cut the eyes out before cooking anyway. Size was generally liked, but some participants mentioned that the size was not standard, somewhere between a medium-sized and large-sized potato. The shape was described as 'normal' or 'familiar', but the depth and number of eyes was generally disliked. POR02PG26-5 was also considered 'easy to peel' due to its 'round' and 'uniform' shape.

Participants liked the 'yellow' or 'golden' color of the cooked POR02PG26-5, with the only complaint being that it looked 'plain' as compared to its raw appearance. Cooked texture was liked, and there were many references to its 'smooth', 'creamy', and 'buttery' quality. Flavor was sweeter than expected and this was both liked and disliked. A few participants mentioned that the red eyes were less noticeable once POR02PG26-5 was cooked, and this was considered desirable.

Similar to POR02PG26-5, participants had competing comments about the skin color of POR00068-11. Some participants described the dark purple color as 'unique', 'interesting', and 'appealing'. Many participants stated that the color made them curious. Participants that didn't like the color described it as 'unappetizing', 'too unusual', or 'rotten'. The small size of POR00068-11 was generally disliked, but some participants stated that it would 'cook well whole' and was a good 'single serving' size. The round shape was liked but the irregularity in shape and the depth of eyes was disliked.

The cooked appearance of POR00068-11 received fewer negative comments than the raw color did, with the most frequent comment being that the flesh color looked 'inconsistent'. There were many comments describing the cooked texture as 'hard', 'dry', and 'grainy'. Participants also felt that the flavor was 'disappointing', not matching the intensity of the color. Other comments about flavor indicated that POR00068-11 had a 'bitter' or 'green' aftertaste.

For POR01PG22-1, participants described the red skin color as 'appealing', but the small size and elongated (fingerling) shape was generally disliked. The size was considered 'too small' and 'not a typical serving size'. The shape was considered 'too thin'. Many participants anticipated that POR01PG22-1 would be 'difficult to peel' and suggested that it would be best cooked 'whole with skin on'. Participants also noted that the elongated shape could be easily cut into uniform pieces, and this was considered desirable.

As with POR00068-11, participants claimed that the cooked flavor of POR01PG22-1 did not match the intensity of its appearance, and some described it as 'bland'. The majority of participants liked the flavor, however, describing it as 'distinctive', 'nutty', 'rich', and 'earthy'. There were also some mentions of a 'sour' or 'bitter' aftertaste. Participants had mixed reactions to texture, and the keywords used to describe texture were contradictory. Many participants stated that although they disliked POR01PG22-1 in its raw state, they changed their mind after trying it cooked.

The Yukon Gold's skin color was described as 'even' or 'uniform' and as having a 'golden' hue. Participants generally liked this appearance very much and there were only a few comments that described the color as 'pale'. The same was true for cooked appearance, with the only negative comments being that it looked 'dry'. The large size was generally liked, though

some participants claimed it was 'too large'. Shape was described as 'even' or 'uniform' and this, in addition to 'few eyes', was considered desirable. Similar to POR02PG26-5, the Yukon Gold's flavor was described as 'buttery' and 'creamy', but there were many complaints of the flavor being 'bland' and having a 'sour' taste. Cooked texture was generally disliked, as many participants stated that it was too 'dry', 'grainy', 'crumbly', and 'soft'. Many participants stated that they liked the Yukon Gold because it was 'familiar' and 'normal' as compared to the other samples.

4.4.3. EXP1 discussion

For the raw samples in EXP1, participants generally liked the yellow skinned potatoes (Yukon Gold and POR02PG26-5) more than the red and purple skinned potatoes (POR01PG22-1 and POR00068-11), as those potatoes received higher mean liking scores overall. The lower mean liking score received by POR00068-11 for color could be interpreted to mean that most participants liked purple color the least, but the bimodal hedonic score distribution needs to be taken into account before drawing this conclusion.

The distribution of scores for POR00068-11 shown in Figure 13.2 in Appendix 13 reveals percentage peaks at the low end (hedonic score of 3 - 'dislike moderately') and at the high end (hedonic score of 8 - 'like very much') of the 9-point category scale. This bimodal distribution indicates that there were two subgroups of participants: one group that disliked the purple color and one that liked it. The subgroup that liked the purple color may have been more accepting of novel colors for potatoes or may have already been familiar with purple potatoes. The subgroup that disliked the purple color may have never seen a purple potato before or may have simply considered it too unusual, as was stated in many of the participant comments.

Mean liking scores for size indicated that participants generally liked larger potatoes, as the ranking of mean liking scores in this category (highest-->lowest) mirrored the size rankings for each sample (largest-->smallest). POR01PG22-1, the smallest of the samples, received the lowest mean liking score, but like POR00068-11, its score distribution for this attribute was bimodal. As shown in Figure 13.3 in Appendix 13, there were percentage peaks at the low end (hedonic score of 4 - 'dislike slightly') and at the high end (hedonic score of 8 - 'like very much').

Participants reacted in a similar way to the fingerling type shape of POR01PG22-1. Out of the four samples, this potato received the lowest mean liking score for the shape attribute. The two larger round shaped potatoes (Yukon Gold and POR02PG26-5) received the highest mean liking scores, with the small round shaped POR00068-11 falling in the middle. Again, a bimodal distribution of scores was observed, and Figure 13.4 in Appendix 13 reveals percentage peaks at the low end (hedonic score of 4 - 'dislike slightly') and at the high end (hedonic score of 8 - 'like very much').

Since POR01PG22-1 was the only small fingerling type potato out of the four samples, and both size and shape had a bimodal distribution of scores for this potato, results indicated that there were some participants who really liked small fingerling shaped potatoes. This may have been linked to preferences for specific cooked preparations. Participant comments stated that this potato would 'cook well whole' and would be 'easy to cut into uniform pieces', and hence the small size and fingerling shape may have been best suited for preferred recipes or cooking methods. Participants for whom POR01PG22-1's size and shape were undesirable complained that this potato would be 'difficult to peel' and was 'not a typical serving size', which again may have been linked to preferred preparations. As a result, the preferred preparation method of the individual consumer could have been a contributing factor in hedonic scoring of size and shape.

For the cooked samples in EXP1, participants generally liked the appearance, flavor, and texture of POR02PG26-5 and POR01PG22-1 more than the rest of the samples. This was an interesting result for POR01PG22-1, as this sample received some of the lowest mean liking scores out of the four samples for raw appearance. Participant comments reflected this result, as many participants stated that their initial negative reaction to POR01PG22-1 changed once they tasted the potato because they liked its flavor and texture.

It is surprising that the Yukon Gold did not perform as well cooked as it did raw, receiving mean liking scores that were similar to POR00068-11. One reason for this may have been that participants liked the distinct flavor and texture of POR02PG26-5 and POR01PG22-1. This was reflected in participant comments, as flavor and texture were described more favorably for POR02PG26-5 and POR01PG22-1 than for the Yukon Gold. The low mean liking score for the cooked appearance of POR00068-11 may have been a reflection of consumer dislike of purple color, as was the case for raw skin color. Another factor may have been that the flesh color was 'inconsistent', as mentioned in participant comments. This inconsistency was attributable to the streaks or patches of lighter purple (or white) color in the center of POR00068-11, which were more pronounced in some samples of this variety than others.

4.4.4. EXP2 hedonic scores

As shown in Table 4.4, mean liking scores for color were significantly higher ($p < 0.05$) for the Yukon Gold and POR01PG20-12 than the rest of the potatoes. For raw overall liking, color, size, and shape the mean liking scores for POR01PG16-1 were significantly lower ($p < 0.05$) than the rest of the samples. POR02PG37-2 received mean liking scores for size and shape that were not significantly different from the Yukon Gold and POR01PG20-12. POR02PG37-2 did receive a mean liking score that was significantly lower ($p < 0.05$) than Yukon Gold and POR01PG20-12 for overall liking and color, however.

For the cooked samples (Table 4.7), a significant difference ($p < 0.05$) was found between overall mean liking scores for POR02PG37-2 and the Yukon Gold, with POR02PG37-2 receiving a higher score. For appearance, the Yukon Gold received a mean liking score that was significantly higher ($p < 0.05$) than POR01PG16-1. For texture, POR02PG37-2 received a significantly higher ($p < 0.05$) mean liking score than the Yukon Gold. There was no significant difference between mean liking scores for flavor.

The distribution of hedonic scores for raw overall liking, color, and size for POR01PG16-1 appeared to be spread out over the 9-point category scale, as shown in Appendix 13. As a result, it cannot be assumed that the mean liking score is a meaningful indication of central tendency for these attributes.

4.4.5. EXP2 comments

Keywords used by participants are presented in Table 4.8 for raw potatoes and in Table 4.9 for cooked potatoes. Participant comments about the skin color of POR02PG37-2 were similar to the comments for POR02PG26-5 in EXP1; the yellow skin and red eyes were liked by some participants and disliked by others. Again, there was a concern over the red eyes being a sign of 'discoloration'. Unlike POR02PG26-5, however, POR02PG37-2 was described as 'green', and this was considered undesirable. Size was generally liked and was considered 'easy to peel', though some participants described it as either 'too large' or 'too small'. The shape of POR02PG37-2 was described as 'round' and 'symmetric', and these attributes made it appear 'easy to slice'. However, most participants noted that their sample was 'irregular' or 'bumpy' with 'too many eyes', making it 'difficult to peel'.

The cooked appearance of POR02PG37-2 was liked by most participants and was described as 'appealing', 'golden', and 'normal'. The only complaints about the cooked appearance were that it looked 'boring' as compared to the other samples. The cooked flavor was described as 'buttery', 'nutty', 'rich', and 'sweet', and only a few participant stated that it tasted 'average' or 'bland'. Comments describing cooked texture were contradictory, and this may have been due, in part, to experimental error (eight people received undercooked samples in one of the sessions).

Most participants liked the red skin color of POR01PG20-12, describing it as 'attractive', 'consistent', and 'deep', and many stated that the sample reminded them of other red skinned potatoes they were already familiar with. Complaints about appearance focused on the 'dry', 'flaky', and 'pocked' texture of the skin. Some participants described the size of the potato as 'perfect' and a good 'serving size', but others described it as 'too large' or 'too small'. Shape was described as 'pointed' and having 'too many eyes' by a few participants, but overall, the oblong

shape was thought to be 'uniform' and 'symmetric', making POR01PG20-12 appear 'easy to cut' and 'easy to peel'. Participant comments about the cooked appearance of POR01PG20-12 were divided. For some, the red flesh was 'beautiful', 'exotic', and 'appealing'. For others, it was 'unappetizing and too 'different'. The most frequent complaint about cooked appearance was that the flesh color was 'uneven' or 'inconsistent'. Although cooked flavor was generally liked by participants, many participants thought the potato tasted 'bland' with a 'bitter' aftertaste. Keywords used to describe texture were contradictory.

Like the purple potato in EXP1 (POR00068-11), POR01PG16-1 received mixed comments about skin color. Although many participants described it as 'interesting' and 'unique', most participants viewed it as 'unappealing', 'odd', and some participants even described it as 'unnatural'. Like POR01PG22-1 in EXP1, the size of POR01PG16-1 was considered 'too small'. For many, the fingerling type shape appeared 'good for slicing', but unlike the uniform shape of POR01PG22-1, POR01PG16-1 was described as 'uneven', and three participants stated that it looked 'shriveled'.

The cooked appearance of POR01PG16-1 was described more favorably than the raw appearance, with a wide range of keywords used by participants to describe it. These ranged from 'amazing', 'vibrant', 'gorgeous', and 'exotic' to 'ugly', 'strange', 'off-putting', and 'unreal'. Most participants liked the flavor of this potato, describing it as 'earthy', 'nutty', 'subtle', and 'rich'. Many participants stated that they expected the flavor to be as intense as the color and were surprised when it wasn't. Many participants also noted that POR01PG16-1 had a 'bitter' aftertaste. Comments about the texture of POR01PG16-1 were contradictory.

Participant comments about the skin color, size, and shape of the Yukon Gold were very similar to those in EXP1. The only negative comment about skin color was that it was 'boring' as compared to the other samples. Most participants liked its large size, and the 'round' and 'uniform' shape with 'few eyes', although some participants stated that it was 'too round' and in some cases, 'irregular'. The large size was considered 'easy to peel' and the round shape was considered 'good for slicing'.

Participants described the appearance of the cooked Yukon Gold as 'familiar', 'regular', and 'expected'. As in EXP1, the only negative comment about cooked appearance was that it looked 'dry'. Flavor was liked by most participants, with the most common complaint being that it tasted 'bland', and a few participants noted a 'bitter' aftertaste. As in EXP1, the texture was generally disliked and was described as 'crumbly', 'dry', and 'mealy'.

4.4.6. EXP2 discussion

Out of the raw samples in EXP2, the Yukon Gold and the red skinned POR01PG20-12 received the highest mean liking scores overall. This was in contrast to EXP1, where the better liked samples for raw attributes were both yellow skinned (Yukon Gold and POR02PG26-5). POR01PG20-12 also received higher mean liking scores than its red skinned counterpart in EXP1 (POR01PG22-1) for overall liking, size, and shape. This result could have been due to POR01PG20-12's size and shape being closer to a traditional potato (large and oblong), as opposed to the less common small size and fingerling shape of POR01PG22-1.

Another surprising result was the lower mean liking score for raw overall liking and color for POR02PG37-2, as compared to its yellow skinned and red eyed counterpart in EXP1 (POR02PG26-5). This may have been due to reports of a 'green' skin color. This green hue may have been a result of a condition called 'greening' that results from improper storage. Greening is caused by the development of chlorophyll pigments in chloroplasts in response to exposure to light. Greening by itself does not have an impact on food safety, but it is considered undesirable by consumers because greening has been associated with increased glycoalkaloid levels, which can be toxic to humans (Vreugdenhil, 2007). Greening is also visually unappealing for most consumers.

The purple skinned potato, POR01PG16-1, scored significantly lower ($p < 0.05$) than the rest of the samples for overall liking, color, size, and shape. Like POR00068-11 in EXP1, POR01PG16-1 received the lowest mean liking score for color. Unlike POR00068-11, however, POR01PG16-1's color scores were not bimodal. Instead, hedonic scores for color were spread out across the 9-point category scale, as shown in Figure 13.2 in Appendix 13. The large standard deviation for this attribute also reflected this spread (Table 4.7). This suggested that there was a wide range of responses to the purple color of POR01PG16-1.

Mean liking scores for the size and shape of POR01PG16-1 were very similar to the small red skinned fingerling in EXP1 (POR01PG22-1), as it also received the lowest mean liking scores for those attributes. Unlike POR01PG22-1 and POR00068-11, however, POR01PG16-1 did not exhibit a bimodal distribution of scores for size or shape.

For cooked potato attributes, both yellow fleshed potatoes (POR02PG37-2 and Yukon Gold), had higher mean liking scores than the rest of the samples (except for the texture score for the Yukon Gold, which was lower). POR01PG20-12 was not regarded as favorably cooked as when it was raw. The reason for this disparity may have been because of the inconsistent color of POR01PG20-12's flesh, as revealed by participant comments. Another possibility is that participants expected this potato to be white fleshed, since it looked similar to other red skinned,

white fleshed varieties already on the market (e.g. Red Bliss). Except for appearance, POR01PG16-1 performed better cooked than it did raw, receiving comparable liking scores to the other samples for overall liking, flavor, and texture. POR01PG16-1 performed much better cooked than its purple fleshed counterpart in EXP1, POR00068-11. This was reflected by participant comments, which were very favorable for flavor, and received fewer unfavorable comments for texture than POR00068-11.

4.5. CONCLUSION

In summary, the mean liking scores for all attributes of all potatoes tested in EXP1 and EXP2 were between 5 ('neither like nor dislike') and 8 ('like moderately'), indicating that the potatoes were acceptable to participants, on average. For skin color, participants liked the more familiar yellow potatoes more than the red or purple potatoes. Red skinned potatoes were the second most appealing, with the purple skinned potatoes least liked. Although purple skin color was generally regarded as undesirable, there was a subgroup of consumers that really liked the color. As a result, consumer acceptance of purple skinned varieties may be limited to consumers who accept or prefer purple colored foods. However, some of the red and purple skinned varieties were liked more than yellow skinned varieties once cooked, indicating that cooked attributes could be important factors in the acceptance of these varieties, and that wider acceptance may be achieved by providing tasting opportunities.

In both experiments, participants had greater liking for potatoes that resembled conventional potatoes in size (large vs. small) and shape (round or oblong vs. elongated). The liking of larger, rounder potatoes was linked to serving size and preparation. Larger potatoes were considered an ideal portion for a single serving, and were easier to peel and slice than the smaller varieties. As in the case of skin color, however, small size was appealing to a subgroup of participants. These participants liked the small round or fingerling shaped potatoes because they could be prepared whole, with skin on. In sum, it was found that acceptance of size and shape could be linked to preparation and serving size preferences.

The experiments also revealed that a consistent and uniform appearance was an important factor in the acceptance of raw potatoes. Irregularities in skin color or skin texture, inconsistent shape, or too many deep eyes were common complaints for the raw samples. Samples that exhibited these irregularities were less liked than the Yukon Gold, which exhibited a uniform skin color and skin texture, few shallow eyes, and generally a consistent round shape. A consistent and uniform appearance was also important for cooked potatoes. The samples with uniform flesh color or texture were liked more than those with inconsistencies in these areas.

Cooked flavor and texture were important in the acceptance of the samples. In both experiments, the Yukon Gold received lower scores than the other varieties because of a less pronounced flavor and a drier, mealier texture. Participants liked the 'distinct', 'rich', and 'earthy' flavor of the red and purple varieties and the 'buttery' and 'sweet' flavor of the yellow varieties with red eyes. In all cases, a sour or bitter aftertaste was undesirable.

Comments about texture for many of the samples were contradictory, so it was difficult to ascertain which texture characteristics were tied to each sample. This may have been due to the fact that texture is often a difficult attribute to characterize for untrained participants. Despite this, most of the positive comments about texture revealed that participants liked a smooth, firm, and consistent texture. The most frequently stated undesirable descriptors were: 'dryness', 'mealiness', or 'mushiness'.

Overall, the results of this study revealed that the new colorful fresh market potato varieties developed by the OSU Potato Breeding and Genetics Program were most accepted by consumers when the appearance resembled the Yukon Gold in color, size, and shape. Results also revealed that although varieties with a distinct appearance (i.e. small size, purple color, and fingerling shape) were less accepted by consumers overall, there was a distinct subgroup of consumers that liked them for these unique attributes. Most of the varieties tested also exhibited potential for acceptance based on their cooked quality (i.e. flavor and texture).

These findings indicate that there is promise for these varieties in the fresh market, with the small red and purple varieties best employed to fill specific market preferences for color, size, and shape, and the yellow varieties to be marketed next to the Yukon Gold, highlighting their superior cooked quality traits. The varieties in this study are a small sample of the possible variations of fresh market potatoes that could be introduced by the combined efforts of researchers and growers. Keeping consumer preferences in mind, the right combination of traits could lead to new market opportunities for the potato industry and increased choice for consumers.

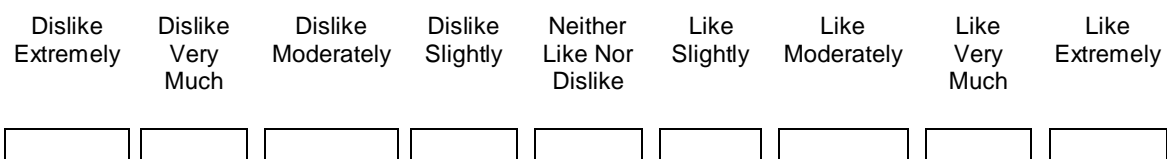


Figure 4.1 Hedonic category scale used in consumer test



Figure 4.2 Purchase intent category scale used in consumer test

Table 4.1 Description of potato varieties used in consumer test

Test	Variety Name	Sample Number	Description			
			Skin Color	Flesh Color	Size	Shape
EXP1	POR02PG26-5	485	Yellow, red eyes	Yellow	Medium-large	Round
EXP1	POR00068-11	913	Purple	Purple, white streaks	Small	Round
EXP1	POR01PG22-1 'Ama Rosa'	648	Red	Red	Small	Fingerling
EXP2	POR02PG37-2	869	Yellow, red eyes	Yellow	Medium-large	Round
EXP2	POR01PG16-1 'Purple Pelisse'	516	Purple	Purple	Small	Fingerling
EXP2	POR01PG20-12 'Terra Rosa'	372	Red	Red	Medium-large	Oblong
EXP1/ EXP2 Control	Yukon Gold	127	Yellow	Yellow	Large	Round

Table 4.2 Demographics of participants in consumer test (n=111 for EXP1 and n=111 for EXP2)

EXP1				EXP2			
Age	Females	Males	All	Age	Females	Males	All
<21 yrs	1	2	3	<21 yrs	1	1	2
21-24	3	3	6	21-24	5	4	9
25-40	31	17	48	25-40	31	19	50
41-55	14	15	29	41-55	19	12	31
>55 yrs	16	9	25	>55 yrs	12	9	21
EXP1				EXP2			
Income*	Females	Males	All	Income*	Females	Males	All
<\$20,000	12	5	17	<\$20,000	10	7	17
\$20,000-\$39,999	20	19	39	\$20,000-\$39,999	13	20	33
\$40,000-\$59,999	13	12	25	\$40,000-\$59,999	18	11	29
\$60,000-\$79,999	11	3	14	\$60,000-\$79,999	14	1	15
>\$80,000	10	6	16	>\$80,000	12	5	17
EXP1				EXP2			
Education	Females	Males	All	Education	Females	Males	All
High School	8	8	16	High School	5	9	14
Current Student, College	4	2	6	Current Student, College	4	5	9
College (2-year)	10	12	22	College (2-year)	14	10	24
College (4-year)	26	20	46	College (4-year)	28	15	43
Current Student, Advanced	1	0	1	Current Student, Advanced	2	0	2
Advanced (i.e. MS, PhD)	11	9	20	Advanced (i.e. MS, PhD)	14	5	19

* – annual income before taxes

Table 4.3 Cards with different levels of antioxidant information given to participants in the consumer test, one card per participant

Card	Amount of Information	Description*
1	None	Sample 127 has yellow flesh. Sample 913 has purple flesh. Sample 485 has yellow flesh. Sample 648 has red flesh.
2	Simple	Colored flesh potatoes are high in antioxidants. Sample 127 has yellow flesh. Sample 913 has purple flesh. Sample 485 has yellow flesh. Sample 648 has red flesh.
3	Detailed	Recent studies show that potatoes with darker yellow, red, and purple flesh have <u>high antioxidant levels</u> similar to other colored vegetables and fruits like red peppers, broccoli, and strawberries. Sample 127 has yellow flesh. Sample 913 has purple flesh. Sample 485 has yellow flesh. Sample 648 has red flesh.

* – the sample numbers listed in this table are for EXP1; EXP2 used the same cards, with only the sample numbers changed

Table 4.4 ANOVA results for mean liking scores (\pm standard deviation) assessed on a 9-point hedonic category scale for raw potatoes in EXP1 (n=111) and EXP2 (n=111)

EXP1					
Variety Name	Skin/Flesh Color*	Overall Liking	Color	Size	Shape
POR02PG26-5	Y/R,Y	7.16 \pm 1.36 ^a	7.01 \pm 1.54 ^a	7.29 \pm 1.22 ^a	7.24 \pm 1.33 ^a
POR00068-11	P/P	5.93 \pm 2.17 ^b	5.98 \pm 2.59 ^b	6.69 \pm 1.78 ^b	6.68 \pm 1.77 ^b
POR01PG22-1	R/R	6.25 \pm 1.89 ^b	7.08 \pm 1.64 ^a	5.75 \pm 2.18 ^c	5.93 \pm 2.25 ^c
Yukon Gold	Y/Y	7.38 \pm 1.23 ^a	7.05 \pm 1.44 ^a	7.34 \pm 1.34 ^a	7.20 \pm 1.42 ^a
EXP2					
Variety Name	Skin/Flesh Color*	Overall Liking	Color	Size	Shape
POR02PG37-2	Y/R,Y	6.75 \pm 1.38 ^b	6.84 \pm 1.58 ^b	7.03 \pm 1.34 ^a	6.75 \pm 1.53 ^a
POR01PG16-1	P/P	5.50 \pm 2.28 ^c	5.62 \pm 2.73 ^c	5.46 \pm 2.21 ^b	6.11 \pm 2.10 ^b
POR01PG20-12	R/R	7.22 \pm 1.24 ^{ab}	7.68 \pm 1.14 ^a	7.11 \pm 1.36 ^a	7.13 \pm 1.32 ^a
Yukon Gold	Y/Y	7.49 \pm 1.27 ^a	7.54 \pm 1.21 ^a	7.04 \pm 1.59 ^a	6.87 \pm 1.63 ^a

a, b, ab, c – different superscript letters in each column indicate significantly different results, p<0.05

* – P=purple, Y=yellow, R=red

Table 4.5 Keywords most frequently used by participants in their comments about what they liked/disliked about raw potatoes in EXP1

Variety Name	Color		Size		Shape	
	Like	Dislike	Like	Dislike	Like	Dislike
POR02PG26-5	Attractive	Indents	Fits in	Between	Easy to peel	Too many eyes
	Fresh	Off-putting	palm of hand	medium and large	Even	
	Healthy	Red discoloration	Just		Familiar	
	Natural	Strange	right		Normal	
	Pink		Single		Round	
	Pretty		serving		Uniform	
	Reddish					
	Shiny					
	Smooth					
	Yellow					
POR00068-11	Appealing	Off-putting	Cook well	Small	Good for slicing	Difficult to peel
	Dark	Rotten	whole		Round	Indented
	Different	Strange	Single			Lumpy
	Earthy	Too dark	serving			Rock
	Exotic	Ugly				
	Healthy	Unappetizing				
	Interesting	Unusual				
	Nutritious					
	Rich					
	Unique					
POR01PG22-1	Appealing	Dirty	Cook well	Difficult to peel	Cute	Long
	Dark		whole	Not a typical serving size	Easy to cut into pieces	Too thin
	Healthy			Too small	Fun	Unusual
	Reddish					
Yukon Gold	Clean	Pale	Big	Too large	Consistent	Too regular
	Even		Single		Easy to peel	
	Golden		serving		Even	
	Healthy		Large		Familiar	
	Normal				Few eyes	
	Uniform				Round	
				Uniform		

Table 4.6 Keywords most frequently used by participants in their comments about what they liked/disliked about cooked potatoes in EXP1

Variety Name	Appearance		Flavor		Texture	
	Like	Dislike	Like	Dislike	Like	Dislike
POR02PG26-5	Bright	Plain	Balanced	Bland	Buttery	Dry
	Consistent		Buttery	Too sweet	Creamy	Gritty
	Golden		Creamy	Yam-like	Firm	Mealy
	Rich		Rich		Moist	Mushy
	Uniform		Rich		Smooth	
	Vibrant		Squash		Soft	
	Yellow		Sweet	Wholesome		
POR00068-11	Appealing	Inconsistent	Earthy	Bitter	Firm	Chunky
	Beautiful	Unappealing	Mild	Bland	Meaty	Dense
	Dark		Rich	Disappointing	Moist	Dry
	purple		Sweet	Green	Smooth	Firm
	Interesting		Unique			Grainy
	Jewel					Hard
	Rich					Mushy
	Unique					Undercooked
POR01PG22-1	Appealing	Small	Distinctive	Bitter	Creamy	Chunky
	Beautiful	Weird	Earthy	Bland	Firm	Dry
	Dark red		Mild	Sour	Moist	Grainy
	Deep		Nutty	Too earthy	Normal	Hard
	Exotic		Potato-like		Smooth	Mushy
	Fun		Rich		Soft	Thick
	Gorgeous		Sweet			
	Intriguing		Tasty			
Yukon Gold	Bright	Dry	Buttery	Bland	Fluffy	Crumbly
	Even color		Creamy	Sour	Smooth	Dry
	Golden		Mild		Soft	Flaky
	Light		Sweet			Grainy
	yellow					Gummy
	Uniform					Mealy
Yellow					Soft	
					Starchy	

Table 4.7 ANOVA results for mean liking scores (\pm standard deviation) assessed on a 9-point hedonic category scale for cooked potatoes in EXP1 (n=111) and EXP2 (n=111)

EXP1					
Variety Name	Skin/Flesh Color*	Overall Liking	Appearance	Flavor	Texture
POR02PG26-5	Y/R,Y	7.19 \pm 1.55 ^a	7.32 \pm 1.28 ^a	7.25 \pm 1.60 ^a	7.46 \pm 1.49 ^a
POR00068-11	P/P	6.61 \pm 1.77 ^b	6.31 \pm 2.55 ^b	6.70 \pm 1.74 ^{ab}	6.37 \pm 1.90 ^b
POR01PG22-1	R/R	7.27 \pm 1.57 ^a	6.75 \pm 2.38 ^{ab}	7.23 \pm 1.67 ^a	7.28 \pm 1.53 ^a
Yukon Gold	Y/Y	6.62 \pm 1.80 ^b	6.83 \pm 1.41 ^{ab}	6.61 \pm 1.80 ^b	6.12 \pm 2.03 ^b
EXP2					
Variety Name	Skin/Flesh Color*	Overall Liking	Appearance	Flavor ^{NS}	Texture
POR02PG37-2**	Y/R,Y	7.50 \pm 1.25 ^a	7.35 \pm 1.21 ^{ab}	7.45 \pm 1.43 ^a	7.52 \pm 1.41 ^a
POR01PG16-1	P/P	7.13 \pm 1.59 ^{ab}	6.15 \pm 2.85 ^c	7.21 \pm 1.57 ^a	7.01 \pm 1.83 ^{ab}
POR01PG20-12	R/R	7.23 \pm 1.54 ^{ab}	6.67 \pm 2.25 ^{bc}	7.14 \pm 1.57 ^a	6.92 \pm 1.89 ^{ab}
Yukon Gold	Y/Y	6.83 \pm 1.57 ^b	7.37 \pm 1.43 ^a	6.93 \pm 1.59 ^a	6.45 \pm 2.05 ^b

a, b, ab, c – different superscript letters in each column indicate significantly different results, p<0.05

NS – not a significant difference

* – P=purple, Y=yellow, R=red

** – n=103 for POR02PG37-2 due to the removal of data for eight undercooked samples

Table 4.8 Keywords most frequently used by participants in their comments about what they liked/disliked about raw potatoes in EXP2

Variety Name	Color		Size		Shape	
	Like	Dislike	Like	Dislike	Like	Dislike
POR02PG37-2	Brown	Blemishes	Easy to peel	Large	Easy to slice	Bumpy
	Creamy	Discoloration		Small	Natural	Difficult to peel
	Golden	Green	Meaty		Round	Fat
	Light	Pink eyes	Single serving		Symmetric	Flat
	Natural	Red spots	Small			Irregular
	Pink eyes	Redness				Odd
	Red	Weird				Too many eyes
	Rose					
	Smooth					
	Yellow					
POR01PG16-1	Blue	Black	Small	Small	Good for slicing	Shriveled
	Dark	Dry			Oblong	Uneven
	Interesting	Odd			Oval	
	Intriguing	Off-putting			Pleasing	
	Purple	Old				
	Rich	Too dark				
	Shiny	Unappealing				
	Smooth	Unappetizing				
POR01PG20-12	Unique	Unnatural				
	Appealing	Dirty	Perfect	Large	Easy to cut	Average
	Appetizing	Dry	Single serving	Small	Easy to peel	Odd
	Attractive	Dull			Even	Pointed
	Beautiful	Flaky			Not many eyes	Too many eyes
	Bright	Old			Oblong	
	Consistent	Pock-marked			Oval	
	Deep				Symmetrical	
	Healthy				Uniform	
	Purple					
Yukon Gold	Red					
	Smooth					
	Appealing	Boring	Easy to peel	Large	Few eyes	Irregular
	Appetizing		Large		Good for slicing	Odd
	Beautiful		Plentiful		Round	Round
	Clean				Uniform	
	Consistent					
	Creamy					
	Even					
	Fresh					
	Golden					
	Light					
	Pleasing					
Shiny						
Smooth						
Yellow						

Table 4.9 Keywords most frequently used by participants in their comments about what they liked/disliked about cooked potatoes in EXP2

Variety Name	Appearance		Flavor		Texture	
	Like	Dislike	Like	Dislike	Like	Dislike
POR02PG26-5	Bright	Plain	Balanced	Bland	Buttery	Dry
	Consistent		Buttery	Too sweet	Creamy	Gritty
	Golden		Creamy	Yam-like	Firm	Mealy
	Rich		Mild		Moist	Mushy
	Uniform		Rich		Smooth	
	Vibrant Yellow		Squash Sweet Wholesome		Soft	
POR00068-11	Appealing	Inconsistent	Earthy	Bitter	Firm	Chunky
	Beautiful	Unappealing	Mild	Bland	Meaty	Dense
	Dark purple		Rich	Disappointing	Moist	Dry
	Interesting		Sweet	Green	Smooth	Firm
	Jewel		Unique			Grainy
	Rich					Hard
	Unique					Mushy
	Vibrant					Undercooked
POR01PG22-1	Appealing	Small	Distinctive	Bitter	Creamy	Chunky
	Beautiful	Weird	Earthy	Bland	Firm	Dry
	Dark red		Mild	Sour	Moist	Grainy
	Deep		Nutty	Too earthy	Normal	Hard
	Exotic		Potato-like		Smooth	Mushy
	Fun		Rich		Soft	Thick
	Gorgeous		Sweet			
	Intriguing Striking		Tasty			
Yukon Gold	Bright	Dry	Buttery	Bland	Fluffy	Crumbly
	Even color		Creamy	Sour	Smooth	Dry
	Golden		Mild		Soft	Flaky
	Light yellow		Sweet			Grainy
	Uniform					Gummy
	Yellow					Mealy Soft Starchy

5. CHAPTER 5 – EFFECT OF ANTIOXIDANT INFORMATION ON PURCHASE INTENT FOR COLORFUL FRESH MARKET POTATOES

5.1. ABSTRACT

The effect of information about antioxidants on purchase intent for colorful fresh market potato varieties was investigated in this study. Two hundred and twenty two participants evaluated six unreleased varieties and one commonly available variety, the Yukon Gold, in a consumer test. Overall liking of appearance for each raw uncut potato was rated on a 9-point category scale. Participants either received no antioxidant information, a simple statement, or a detailed statement. After reading this information, purchase intent was rated on a 5-point category scale for three price levels (low, medium, high). The effect of antioxidant information and other variables on the probability of purchase for red and purple potatoes was compared to yellow potatoes in a logistic regression. Other variables included hedonic (liking) rating, price, gender, age, education, income, potato usage frequency, health interest, food interest, and antioxidant knowledge. High hedonic ratings and interest in food both had a positive effect on purchase intent for both categories of potatoes. Price had a negative effect on purchase intent for both categories of potatoes. Antioxidant information and interest in health had a positive effect on purchase intent for red and purple potatoes. Detailed antioxidant information had a stronger positive effect on purchase intent than simple information. Age had a negative effect on purchase intent for red and purple potatoes, and an advanced degree of education had a negative effect on purchase intent for yellow potatoes.

5.2. INTRODUCTION

The U.S. potato industry is suffering from a decline in fresh market potato consumption (Food and Agriculture Organization (FAO), 2009). One of the ways to combat this decline is to promote new, specialty potato varieties with the hope of creating market niches that will revitalize consumer demand. Prior to introducing these new varieties, it is important to understand which factors play into consumer choice and purchase intent for fresh market potatoes.

Surveys conducted by the United States Potato Board (USPB) indicated that 57.2% of consumers considered quality, appearance, and color to be important in their potato buying decision, and only 18.2% of consumers considered price the most important factor (Olsen et al., 2003). Kezis et al. (1988) conducted a study using identically appearing round white potatoes from Maine to understand why consumers purchase new varieties over existing varieties with similar outward characteristics. The study found that consumer purchasing behavior was primarily

based on appearance and perceived quality. Cheng et al. (2001) investigated the effect of information on consumer purchase decisions for round white and Russet-type potatoes. Respondents from two eastern U.S. markets were asked to evaluate six bags of potatoes with the same appearance, size, and packaging, but different label information about origin, brand, product guarantee, and price. The study found that across regions, information about origin played a key role in consumer purchase decision. A more recent study was conducted by Jemison et al. (2008) investigating the factors influencing consumer purchase of potato varieties in Maine. The study revealed that the most important factors impacting purchase were skin quality and origin.

The potato industry is aware of these basic preferences and tries to meet the standards that consumers expect. Assuming that varieties introduced to the market meet these standards, the focus shifts to other factors that may influence purchase, and these factors can be intrinsic or extrinsic in nature (Di Monaco et al., 2007). For potatoes, intrinsic factors are those which are associated with their sensory properties (i.e. appearance, flavor, texture). Extrinsic factors lie outside of these basic characteristics, and can be in the form of information about cultivar name or origin, suggested preparations or recipes, price, packaging, nutritional properties, or potential health benefits. Out of these extrinsic factors, the impact of health benefits on purchase intent for fresh market potatoes has not been explored. This is surprising, as health is an important criterion for purchase and a parameter of quality for many consumers (Magnusson, Arvola, Koivisto Hursti, Aberg, & Sjoden, 2001; Wandel & Bugge, 1997).

A possible reason for this is that although fresh market potatoes have much to offer health conscious consumers - being nutritious, relatively low in calories, virtually free of fat and cholesterol, high in vitamin C and potassium, and high in fiber when eaten with skin on - the impact of health benefits on purchase has been overlooked because consumers typically perceive potatoes as being unhealthy (Vreugdenhil, 2007). This is largely because potatoes have been implicated in contributing to diabetes and obesity due to their high glycemic index (Camire et al., 2009).

Exploring the impact of health benefits on purchase intent becomes especially relevant for colorful potato varieties, as they exhibit unique health properties associated with their pigment. Colorful potatoes have high levels of antioxidants, including anthocyanins, carotenoids, phenolics, and vitamin C (Brown, 2005; Woolfe, 1987). Red and purple (skin and flesh) potatoes contain the highest levels of these compounds (Lachman et al., 2005). Purple fleshed potatoes have ten times the anthocyanin content of red fleshed potatoes (Lewis, Walker, Lancaster, & Sutton, 1998). Purple skinned potatoes also have high levels of phenolic acids and purple fleshed potatoes have been reported to have twice the level of flavonoids as white fleshed potatoes

(Lewis et al., 1998). Yellow (skin and flesh) potatoes have higher levels of carotenoids than white fleshed potatoes (Brown, Culley, Bonierbale, & Amoros, 2007; Brown et al., 2005; Tevini & Schonecker, 1986), and the deeper the color, the greater the antioxidant value (Iwanzik, Tevini, Stute, & Hilbert, 1983).

Previous studies have explored the effect of health information on purchase intent for a number of foods, with mixed results. Di Monaco et al. (2005) studied the effect of price on hedonic, purchase, and use intention responses to a chocolate bar in the presence of a health claim. The health claim, as well as price, decreased use intent for the chocolate bar. Kahkonen and Tuorila (1999) asked consumers to rate their hedonic response and purchase intent for frankfurters, yogurt, margarine, and chocolate bars when provided with information stating that these foods were 'regular fat' or 'reduced fat'. Hedonic response and purchase intent for chocolate bars were rated higher with regular than with reduced fat information. For margarine, reduced fat information increased hedonic ratings and purchase intent for respondents that were concerned about health. Purchase intent for frankfurters and margarine was not significantly affected.

Ginon et al. (2009) assessed the impact of label information about fiber content and general information about the long-term health benefits of fiber on purchase intent for baguettes. The study revealed that label information had a positive effect on purchase intent, but this effect was only observed when the baguette received high hedonic scores. Unlike the label information, the general information about long-term health benefits of fiber did not have a significant effect on purchase intent. A similar study by Baixauli et al. (2008) explored the effect of information about fiber on consumer acceptance and purchase intent for plain, whole meal, and fiber-enriched muffins. Fiber information did not have a significant effect on purchase intent for plain and fiber-enriched muffins, but did have a significant effect on whole meal muffins. Purchase intent for a new fat spread with a proven health benefit was compared to an established spread in a study by Bower et al. (2003). Information about the health benefits of the new fat spread had a significant effect on purchase intent, especially when combined with high hedonic scores.

The purpose of this study was to understand the effect of antioxidant information on consumer purchase intent for colorful fresh market potatoes. Using a consumer test that approximated a fresh market purchase scenario, the effect of antioxidant information was assessed for red/purple potatoes and yellow potatoes. The effect of hedonic rating and price were included in this analysis. Also, since characteristics of individual consumers such as gender, age, income, education, interest in health, and knowledge can decide how a product is perceived (R. Shepherd et al., 1996; R. Shepherd & Stockley, 1987), the effect of these factors were investigated, as well as the effect of usage frequency and interest in food.

5.3. MATERIALS AND METHODS

5.3.1. Materials, participants, and procedure

This study is part of a larger study documented in Chapter 4. The same design, participants, materials, and procedures were used for this study as in Chapter 4. The focus of this study is different, however, with analysis limited to participant responses to seeing the raw whole potatoes at the beginning of the test (9-point hedonic category scale Question 1 and 5-point purchase intent category scale Questions 6-8 in Appendix 12), the assessment of prior knowledge about the health benefits of antioxidants (Question 22), a subset of the Likert scale questions in response to statements about health and food (Table 5.1), and consumer demographic information from the screener (Appendix 8).

The intent of this study was to understand a consumer's potato purchasing decision at the point of purchase based on a message conveyed about the antioxidant benefits of colorful potatoes. The study was designed to approximate a shopping situation, in which a consumer sees colorful fresh-market potatoes side-by-side in their raw uncut state, makes an assessment of how much they like the potatoes based on appearance, reads the information that may be presented to them at the point of purchase (possibly in the form of a display sign or on packaging) and then makes a decision to buy based on price.

This was simulated in the consumer test by showing the potatoes to participants, asking them to rate how much they liked the appearance of the potatoes on a 9-point category scale (Figure 4.1), providing them with three possible levels of antioxidant information on a laminated card (Table 4.3), and asking them to rate their purchase intent for each potato on a 5-point willingness to buy category scale (Figure 4.2) at a high price, a moderate price, and a low price.

Participants were asked to rate purchase intent at three prices in order to assess how much they valued each sample. This assessment was structured similarly to contingent valuation methodology, which is based on a dichotomous choice model in which individual willingness to buy can be estimated based on responses to a market-type question (Kanninen, 1993). The price questions in this study were intended to resemble a double-bounded model where respondents are first asked if they were willing to buy at a moderate price; if the answer is yes, they are asked if they are willing to buy at a higher price; if the answer is no, they are instead asked if they are willing to buy at a lower price. Because of the limitations of the Compusense software used to create the test ballot, the double-bounded model could not be implemented, and as a result, this study presented participants with all three price points, regardless of their selections, from highest to lowest price.

Since a consumer's individual characteristics also affect their decisions at the point of purchase, usage frequency (how often they cook potatoes at home), interest in health and food, prior knowledge about the health benefits of antioxidants, and demographics (age, gender, income, and education level) were also included in the model as variables explaining purchase intent. Consumer information was gathered using a combination of questions on the ballot and on the screener.

5.3.2. Data analysis

For the purposes of this study, data from EXP1 and EXP2 were analyzed as one large study with 222 participants, six test samples, and one Yukon Gold 'control' sample. Since the Yukon Gold potato was used in both EXP1 and EXP2, this potato had 222 responses, whereas the six test samples had 111 responses each. The results for the red and purple potatoes (POR00068-11, POR01PG22-1, POR01PG20-12, and POR01PG16-1) were compared against yellow potatoes (POR02PG26-5, POR02PG37-2, Yukon Gold) using logistic regression. Logistic regression was performed using a combination of Statistical Analysis Software (Version 9.1, Cary, NC) and LIMDEP (Version 8.0, Plainville, NY).

It could be argued that POR02PG26-5 and POR02PG37-2 could fall into the red skinned category because of the red coloration around the eyes, but preliminary analysis revealed that this color did not have any effect that was significantly different from the Yukon Gold for all variables measured in this study.

5.3.3. Test variables

In this study, 14 explanatory variables were of interest for their impact on consumer purchase intent for colorful potatoes (Table 5.2). The relationship between these variables and their direct and indirect impact on the dependent variable, purchase intent, were evaluated using a logistic regression (logit) model. This model is most frequently used to analyze dichotomous (0–1) binary data and is often used in the context of consumer purchasing evaluation where the consumer is making a choice between two products, to buy or not buy (Johnston, Wessells, Donath, & Asche, 2001; Marin & Durham, 2007; Nayga, Aiew, & Nichols, 2005). During the test, consumers were asked their willingness to buy on a 5-point category scale from 'would definitely not buy' to 'would definitely buy' (Figure 4.2) instead of a 0-1 or buy/not buy situation. As a result, for the purposes of analysis, the following interpretation was applied to the purchase intent responses: 'would definitely not buy' = 0, 'would probably not buy' = 0.25, 'might not buy/might buy' = 0.50, 'would probably buy' = 0.75, and 'would definitely buy' = 1.0. Although logistic

regression is less frequently used for a fractional dependent variable than a binary one, the logit model is even more ideal for use with a fractional variable. It was originally developed to estimate a fractional response for dose-response measurement in biology (Berkson, 1944). It has also been used for fractional dependent variables to examine buying shares in agricultural economics (Durham, 2007) and to examine purchase intent in food science (Marin & Durham, 2007).

Out of the 14 possible explanatory variables for purchase intent (PINTENT), seven variables were 'dummy' variables (SINFO, DINFO, GENDER, HIGHSCH, SOMECOL, ADVEDU, and USAGE), having a value of 0 or 1. SINFO (simple antioxidant information) and DINFO (detailed antioxidant information) were 0 if the participant did not receive this information and 1 if the participant did. GENDER was 0 if female, and 1 if male. USAGE was 1 if the frequency of cooking potatoes at home was once a week or more, and 0 otherwise. HIGHSCH was 1 if the highest level of education achieved by a participant was high school. SOMECOL was 1 if the highest level of education achieved was some college (current student in a 2-year/4-year college or 2-year college degree). ADVEDU was 1 if the highest level of education achieved was an advanced degree (current advanced student or advanced degree). A 4-year college degree was chosen as the baseline case for these education scenarios because it was the most frequently observed level of education for participants (Table 4.2).

The rest of the explanatory variables had a range of values. Overall liking for raw potato appearance (LIKING) had nine possible values (1-9), depending on the category selected on the 9-point hedonic scale, with 1 being lowest ('dislike extremely') and 9 being highest ('like extremely'). These values were transformed to be within a range of 0 to 1 by subtracting 1 from the score and then dividing by 8. The PRICE variable had three possible prices per pound ranging from \$0.79-\$2.99 and differing in increments of \$1.10. These values were based on conventional and specialty grocery store prices for fresh market potatoes sold in Portland, Oregon at the time the research was conducted (January 2010). Values for AGE were entered by participants in the screener, and these values could be any number between 0 and 100. These values were transformed by dividing by 100 to yield values between 0 and 1. For INCOME, participants selected a range in which their total household income fell. The midpoints of these ranges, divided by 100,000, were used for the model.

Responses to the health and food attitude questions at the end of the consumer test were captured by the HEALTH and FOOD variables, whose five possible values (1-5) depended on the level of agreement or likelihood selected on the Likert scale, with 1 being the least likely or true and 5 being the most likely or true. For both HEALTH and FOOD, each participant's responses were summed and this total was divided by the highest possible summation in each category (45 for HEALTH and 50 for FOOD) to get an average score between 0 and 1. Participant knowledge

of the health benefits of antioxidants were captured by the KNOW variable, which was 1 if participants felt they were not informed about this topic at all, 2 if they felt somewhat informed, and 3 if they felt very well informed. These values were transformed to be within the range of 0 to 1 by subtracting 1 from the score and dividing by 2.

In summary, PINTENT for each individual ('i') was estimated by the following model:

$$\text{PINTENT}_i = f(Z_i) = f(\text{PRICE}, \text{LIKING}, \text{SINFO}, \text{DINFO}, \text{HEALTH}, \text{FOOD}, \text{KNOW}, \text{USAGE}, \text{AGE}, \text{INCOME}, \text{GENDER}, \text{HIGHSCH}, \text{SOMECOL}, \text{ADVEDU})$$

where 'f ()' is the cumulative logistic distribution function:

$$e^{Z_i}/(1 + e^{Z_i}) = 1/(1 + e^{-Z_i})$$

in which 'e' represents the base of natural logarithms, which is approximately equal to 2.718 (Greene, 2002), and 'Z_i' is:

$$Z_i = b_0 + b_1*\text{PRICE} + b_2*\text{LIKING} + b_3*\text{SINFO} + b_4*\text{DINFO} + b_5*\text{HEALTH} + b_6*\text{FOOD} + b_7*\text{KNOW} + b_8*\text{USAGE} + b_9*\text{AGE} + b_{10}*\text{INCOME} + b_{11}*\text{GENDER} + b_{12}*\text{HIGHSCH} + b_{13}*\text{SOMECOL} + b_{14}*\text{ADVEDU} + u_i$$

where 'u_i' is an error term and b₀₋₁₄ are the parameters estimated by the model.

5.4. RESULTS AND DISCUSSION

5.4.1. Participant demographics

The gender, age, income, and education demographics for the participants in each consumer test (EXP1 and EXP2) are summarized in Table 4.2. Out of 222 participants, 59% were female and 41% were male. 44% of the participants were between the ages of 25 and 40 years and 27% of the participants were between the ages 41 and 55 years. Most of the participants fell within the income brackets of \$20,000-39,999 per year (32%) and \$40,000-\$59,999 per year (24%). Most participants (40%) completed a 4-year college degree.

Participants were selected based on a usage frequency of at least a few times a month for fresh market potatoes (Appendix 8, Question 30). 52% of the participants used potatoes once a week or more than once a week and 48% used potatoes a few times a month. Participant knowledge about the health benefits of antioxidants is shown in Figure 5.1 and was very similar

for both EXP1 and EXP2. Out of 222 participants, 35% considered themselves 'not at all informed', 63% considered themselves 'somewhat informed', and 2% considered themselves 'very well informed' on this topic.

5.4.2. Logistic regression results

PINTENT for red and purple potatoes was compared to PINTENT for yellow potatoes. The results of the logistic regression for these color categories are summarized in Table 5.3. Unlike linear regression coefficients, logistic regression coefficient estimates must be converted to marginal effects to assess their impact on the dependent variable. The marginal effect measures the percent increase or decrease in probability of buying for a one unit increase in one of the explanatory variables, taken at its average value (Marin & Durham, 2007). For the dummy (binary) variables, the marginal effect is calculated as the change in probability of purchase when the value of the binary variable changes from 0 to 1 (Marin & Durham, 2007).

For both red/purple and yellow potatoes, PRICE and LIKING had significant ($p < 0.01$) effects on PINTENT. For a one unit (\$1) increase in PRICE, there was a 22.9% lower probability of purchase for yellow potatoes. This was comparable to a 19.4% lower probability of purchase for red/purple potatoes. For a one unit increase in LIKING, there was a 56.2% higher probability of purchase for yellow potatoes. This probability was larger for red/purple potatoes, at 65.5%. This difference may be attributable to the lower base LIKING score for red/purple potatoes (0.65) than for yellow potatoes (0.77) and the declining slope of PINTENT. FOOD also had a significant effect on PINTENT for both red/purple and yellow potatoes at the $p < 0.01$ and $p < 0.10$ levels, respectively. For a one unit increase in FOOD, there was a 25.1% higher probability of purchase for yellow potatoes. This was a larger probability for the red/purple potatoes, which resulted in a 37.8% higher probability of purchase.

Both SINFO and DINFO had a significant effect on PINTENT for the red/purple potatoes at the $p < 0.05$ and the $p < 0.01$ levels, respectively. There was no significant effect of SINFO or DINFO on PINTENT for the yellow potatoes. When the value for the binary variable changed from 0 to 1 for SINFO, there was an 8.4% higher probability of purchase for red/purple potatoes. When the value for the binary variable changed from 0 to 1 for DINFO, there was a 13.3% higher probability of purchase for red/purple potatoes. The effect of information on PINTENT is further illustrated by Figure 5.2 and 5.3, which shows the cumulative distributions for PINTENT over PRICE. The downward slope in both graphs indicates a decrease in PINTENT as PRICE increases. Both graphs illustrate a higher PINTENT with information (simple or detailed) as compared to no information, but this effect was only significant for purple/red potatoes and not yellow potatoes. For example, at an average price of \$1.89/lb, the average participant had a

probability of purchase of about 60% for purple/red potatoes without information. At the same price, a participant that received detailed information had a probability of purchase of greater than 75% for red/purple potatoes. In addition, Figure 5.3 illustrates a higher PINTENT for red/purple potatoes with detailed information than with simple information. This effect was also observed for yellow potatoes (Figure 5.2), but was not significant.

HEALTH had a significant effect on PINTENT for red/purple potatoes at the $p < 0.01$ level. For a one unit increase in HEALTH, there was 43.1% higher probability of purchase for red/purple potatoes. The demographics that had a significant effect on purchase intent was AGE on red/purple potatoes at $p < 0.01$ and ADVEDU on yellow potatoes at $p < 0.10$. For a one unit increase in AGE, there was a 45.0% lower probability of purchase for red/purple potatoes. For a one unit increase in ADVEDU there was an 8.2% lower probability of purchase for yellow potatoes.

The goodness of fit for the logistic purchase intent model was assessed by both the percent of purchase intent levels the model was able to correctly predict and the likelihood ratio test. The model was able to correctly predict the purchase intent level an average of 32% of the time across the five probability categories (0, 0.25, 0.5, 0.75, and 1) for yellow potatoes and 39% of the time for red/purple potatoes. The number of correct predictions for each probability category is shown in Table 5.4 and 5.5, as indicated by the numbers in the boxed diagonal. The model generally predicted one of the next nearest probability categories when not exact (Durham, 2007). This was done 47% of the time for yellow potatoes and 48% of the time for red/purple potatoes. The number of predictions in the next nearest probability categories is indicated by the shaded areas in Table 5.4 and 5.5. The yellow potatoes received a total of 79 correct or nearly correct predictions and the red/purple potatoes received a total of 87.

The likelihood ratio test evaluates whether the parameters estimated explain the dependent variable better than a model restricting all of the parameters to equal zero (Marin & Durham, 2007). To accept the null hypothesis that the restricted model is true (the unrestricted model is not a significant improvement) the likelihood test statistic must be lower than the chi-squared critical value (Marin & Durham, 2007). The likelihood ratio test statistic for yellow potatoes was 123.7, and was 192.6 for red/purple potatoes, both far greater than the 99.9% critical value ($p < 0.001$) of 32.91 for 12 degrees of freedom, indicating that the model estimated was a good fit.

5.4.3. Discussion

Participant liking ratings for the overall appearance of the raw whole potatoes had a significant ($p < 0.01$) positive effect on the probability of purchase for both yellow and red/purple potatoes. This was not surprising, as sensory affective qualities such as appearance, taste, or smell are basic motivators for consumer willingness to try a food (Fallon & Rozin, 1983; Martins, Pelchat, & Pliner, 1997). In this case, if the participant liked the potato's overall appearance, they were more likely to purchase the potato.

Participants were asked to rate purchase intent for each potato given three different prices per pound: \$0.79, \$1.89, and \$2.99. Price had a significant ($p < 0.01$) negative effect on the probability of purchase for both yellow and red/purple potatoes. As with hedonic scores for appearance, this was not a surprising result, as probability of purchase typically decreases with increasing price and 54.5% of participants claimed that price was 'very important' when buying fresh fruits and vegetables (Figure 5.4).

Results showed that the simple and detailed antioxidant information had a significant ($p < 0.05$) positive effect on the probability of purchase for the red and purple potatoes, but not for yellow potatoes. It is likely that participants associated increased levels of antioxidants with increased color, in which case the probability of purchase for the darker colored (red and purple) potatoes were more influenced by the antioxidant information than the lighter (yellow) potatoes. Additionally, for the simple information, the meaning of the word 'colorful' was not explained, but for the detailed statement, colors indicating high antioxidant levels were stated explicitly ('darker yellow, red, and purple'). This was likely the reason why probability of purchase for the red/purple potatoes was more affected by detailed information, by solidifying the association between increased color and high antioxidant levels.

Stating that 'research studies' were involved in the 'high antioxidant levels' claim for colorful potatoes may also have increased the credibility of the detailed statement for participants. This is in contrast to the simple information, which did not provide participants with any source or background for the claim. Comparing colorful potatoes to other colorful fruits and vegetables ('red peppers', 'broccoli', and 'strawberries') may have had a similar effect, supporting the 'high antioxidant levels' claim by referencing common food items that are already familiar to consumers. Either or both of these instances of extra information may have had an effect on consumer purchase intent.

Among the variables linked to individual participants, the factors that had a significant effect on probability of purchase were food interest, health interest, age, and an advanced degree of education. If a participant had a strong interest in food (scoring higher, on average, in response

to the 'food' category of Likert scale questions in Table 5.1), this had a significant ($p < 0.01$) positive effect on probability of purchase for both yellow and red/purple potatoes. For consumers with a high food interest, sensitivity to price can be superseded by an attraction to novelty. In this case, consumers who had a strong interest in food could have been attracted to the novelty of the colors, sizes, and shapes of the potatoes tested.

A strong interest in health (scoring higher, on average, in response to the 'health' category of Likert scale questions in Table 5.1) had a significant ($p < 0.01$) positive effect on probability of purchase for red/purple potatoes, but not yellow potatoes. The Likert scale questions about health interest were a subset of the questions asked about health and were limited to assessing attitudes and behaviors related to ingredients, nutrition, and diet (Kraft & Goodell, 1993; McCluskey, Durham, & Horn, 2009). It is interesting that health interest had an effect on the purchase probability of red/purple potatoes, but not yellow potatoes. It is possible that participants with an increased interest in health were already aware of the association of stronger color with increased antioxidant levels prior to the test, and were already purchasing other colorful fruits and vegetables with the intent of consuming increased antioxidants. As a result, these participants would be more likely to purchase strongly colored potatoes regardless of the information they were given. This may have been the case for some participants, as almost two thirds of the participants considered themselves 'somewhat informed' about the health benefits of antioxidants (Figure 5.1), though there was no significant effect of antioxidant knowledge on the probability of purchase.

The older the participant, the less likely they would be to buy the red/purple potatoes. Since age only had a significant ($p < 0.01$) effect on red/purple potatoes and not on yellow potatoes, it is not price sensitivity in general that may have dissuaded older participants. Instead, the observed effect was linked to specific characteristics of the purple and red potatoes. Since the purple and red potatoes are novel in appearance, the observed effect may have been due to food neophobia, which has been found to increase with age (Meiselman, King, & Gillette, 2010). Older participants may have been less willing to purchase the red and purple varieties due to their unfamiliar coloration. Having an advanced degree or being a student in an advanced degree lowered the probability of purchase for yellow potatoes. This effect was not observed for any other levels of education or for red/purple potatoes.

5.5. CONCLUSION

This study investigated the effect of information about antioxidants on consumer purchase intent for colorful potato varieties. The study found that information about antioxidants affects purchase intent for red and purple varieties, thus providing a potential tool for

differentiation and promotion of varieties that are similar in appearance. This finding is especially relevant since red and purple potatoes receive mixed responses from consumers when evaluated on the basis of appearance alone (Jemison et al., 2008). This study also revealed that hedonic assessment and price are important factors affecting purchase intent of colorful potatoes, and these should be carefully considered when introducing new varieties to the fresh market. Consumer variables, such as age, an advanced level of education, interest in food, and interest in health also affected purchase intent for colorful potatoes, and this information can be used to identify target markets.

Since this research is limited to consumers living in the Portland metropolitan area, it is recommended that similar research be performed in other parts of the U.S. Future studies could also improve on the methodology in this study by simulating a more realistic point of purchase situation, by performing surveys at the point of sale instead of in a sensory testing facility, or by using an incentive mechanism like a Vickrey auction, in which participants are given a chance to buy the potatoes being tested by bidding on them or by choosing them against other alternatives (Combris, Bazoche, Giraud-Heraud, & Issanchou, 2009).

If additional research confirms the finding that antioxidant information is an important factor in the purchase of colorful potatoes, the potato industry may be more likely to introduce varieties that exhibit these health benefits, potentially revitalizing the fresh potato market, promoting potatoes as a healthy vegetable, and improving the long-term health of consumers.

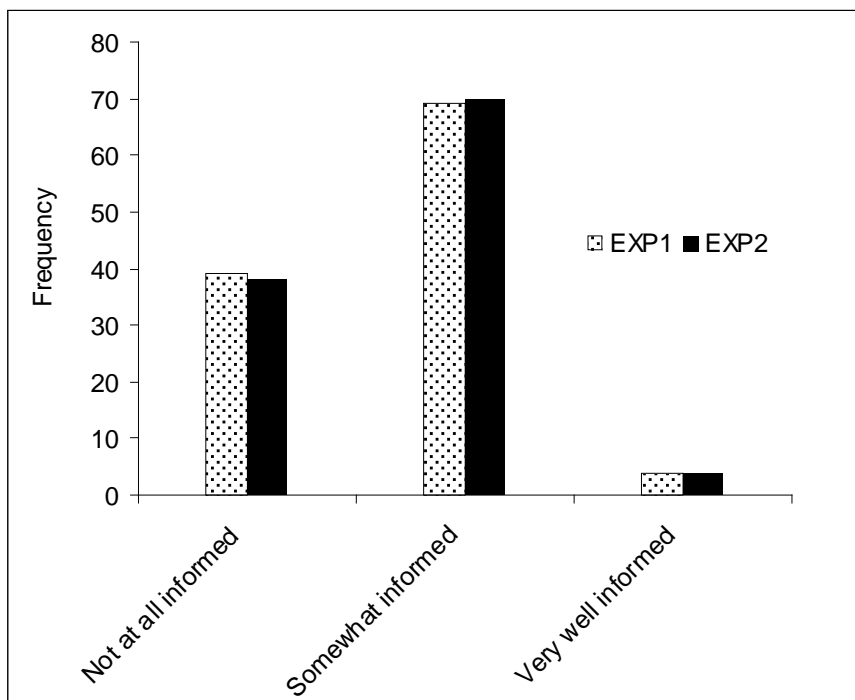


Figure 5.1 Frequency of participants that were 'not at all informed', 'somewhat informed', and 'very well informed' in response to the question: 'Do you consider yourself well informed about the possible benefits of eating foods high in antioxidants?' on the consumer test

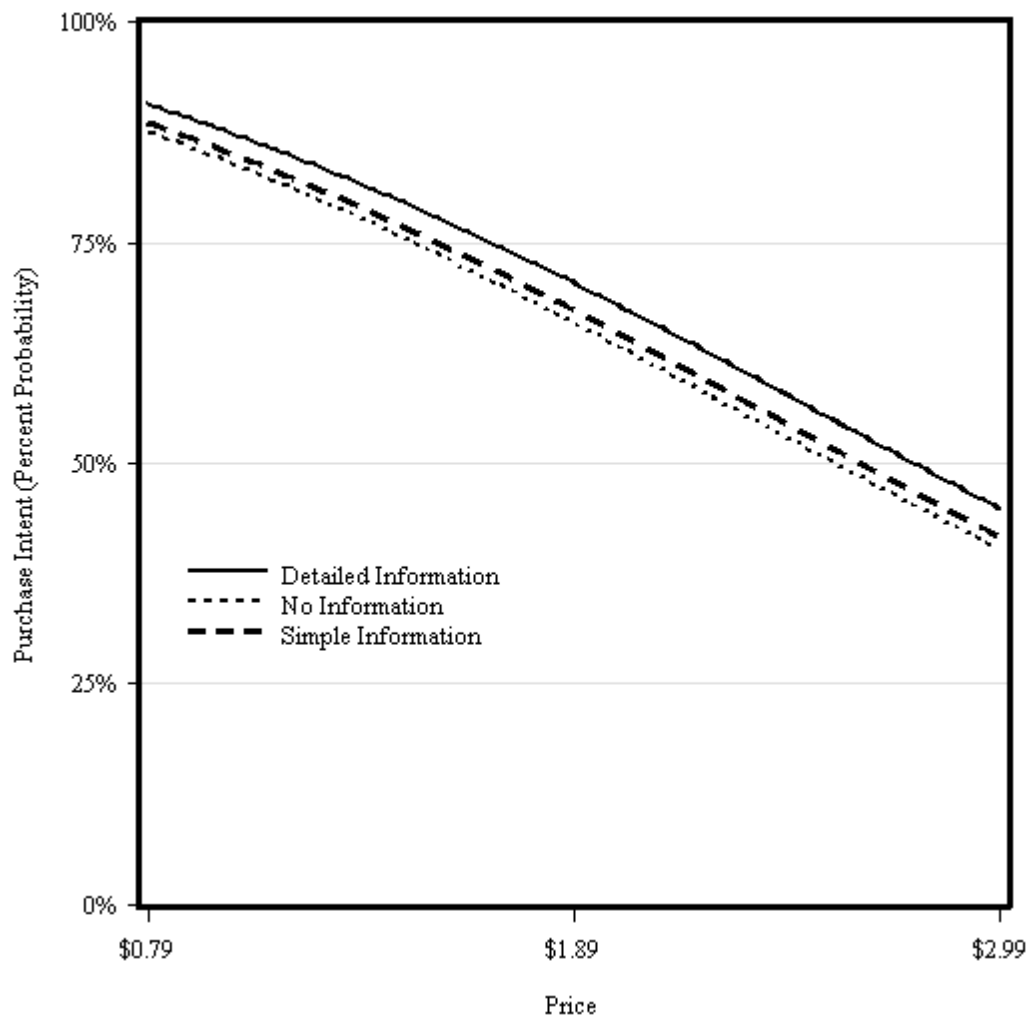


Figure 5.2 Participant purchase probability for yellow potatoes (by price) for different levels of antioxidant information for the average participant out of n=222

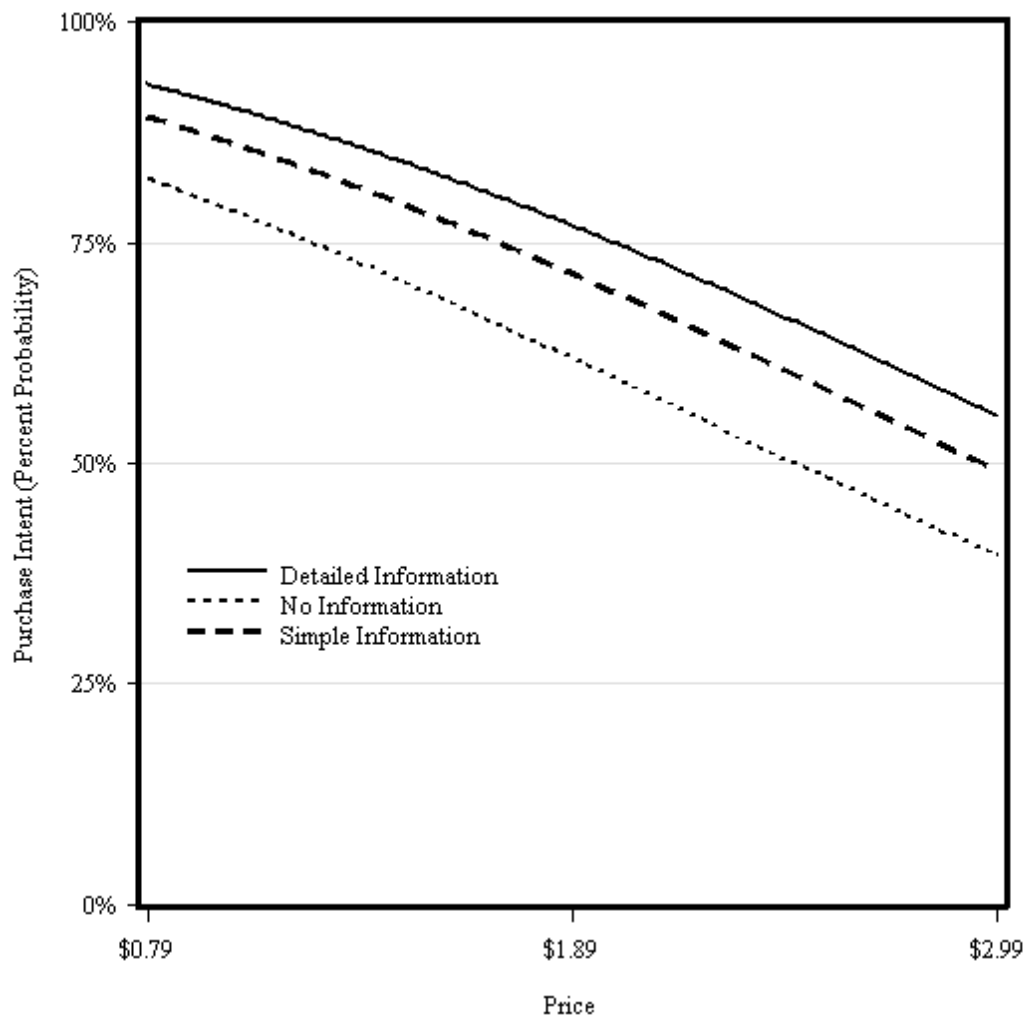


Figure 5.3 Participant purchase probability for red/purple potatoes (by price) for different levels of antioxidant information for the average participant out of n=222

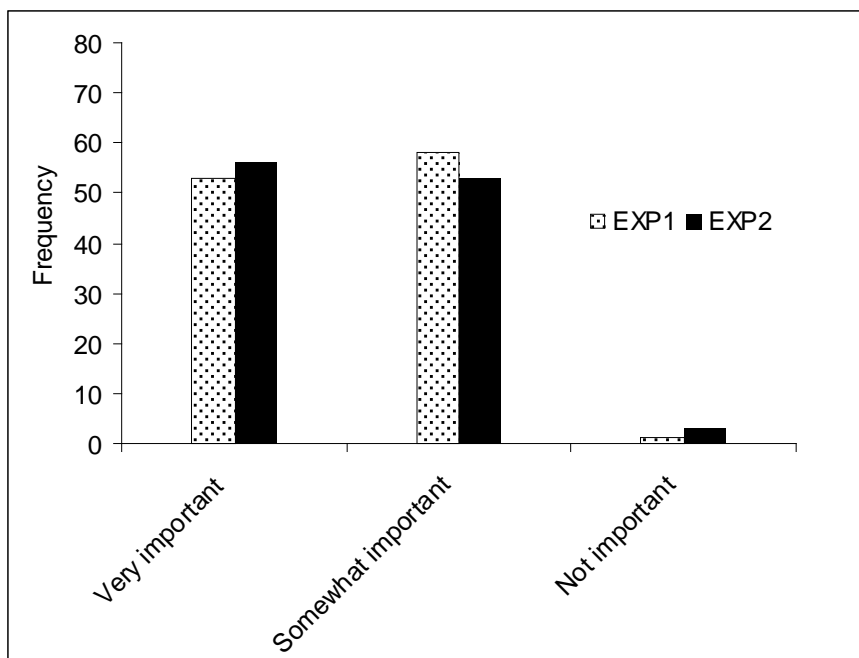


Figure 5.4 Frequency of participants that considered price 'very important', 'somewhat important', and 'not important' in response to the question: 'When buying fresh fruits and vegetables, how important is price?' on the consumer test

Table 5.1 Likert questions used to assess participant interest in food and health with likelihood scale: 1='very true', 2='often true', 3='sometimes true', 4='rarely true', 5='never true' and agreement scale: 1='strongly agree', 2='agree', 3='neither agree nor disagree', 4='disagree', 5='strongly disagree'

Statement	Interest Category	Scale (1-5)
I seek out new recipes to try at home	Food	Likelihood
I seek out seasonal and local ingredients	Food	Likelihood
I read magazines about food (e.g. Gourmet, Saveur, Bon Appetit) ^a	Food	Likelihood
I like to eat out in restaurants that feature local and seasonal food	Food	Likelihood
I look for new types of foods to try ^a	Food	Likelihood
I read articles or watch shows about food and/or cooking	Food	Likelihood
I enjoy cooking	Food	Agreement
I value new experiences and exotic flavors in food	Food	Agreement
I enjoy watching cooking shows	Food	Agreement
I place great value on the quality and flavor of food	Food	Agreement
I avoid foods from animals produced with hormones or antibiotics	Health	Likelihood
I eat foods that are high in antioxidants	Health	Likelihood
I eat five servings of fruits and vegetables a day	Health	Likelihood
Before buying a new food item, I read the ingredient listing and/or nutritional information	Health	Likelihood
I avoid foods containing nitrites or preservatives ^b	Health	Agreement
My daily diet is nutritionally balanced ^b	Health	Agreement
I am concerned about my drinking water quality ^b	Health	Agreement
I worry that there are harmful chemicals in my food ^b	Health	Agreement
I try to avoid high levels of cholesterol in my diet ^b	Health	Agreement

a – from McCluskey et al. (2009)

b – from the *Wellness Scale*, Kraft and Goodell (1993)

Table 5.2 Summary of test variables (names, response choices, model values, and statistics) used in logistic regression (n=222)

Variable	Name	Response Choices	Model Values	Mean	Std. Dev.	Min.	Max.
Purchase Intent	PINTENT	(1)=would definitely not buy, (2)=would probably not buy, (3)=might not buy/might buy, (4)=would probably buy, (5)=would definitely buy	(1)=0.0 (2)=0.25 (3)=0.5 (4)=0.75 (5)=1.0	0.58	0.34	0.0	1.0
Purchase Price	PRICE	(1)=\$0.79, (2)=\$1.89, (3)=\$2.99	(1)=0.79 (2)=1.89 (3)=2.99	1.89	0.90	0.79	2.99
Liking of Appearance	LIKING	(1)=dislike extremely, (2)=dislike very much, (3)=dislike moderately, (4)=dislike slightly, (5)=neither like nor dislike, (6)=like slightly, (7)=like moderately, (8)=like very much, (9)=like extremely	(1)=0.0 (2)=0.125 (3)=0.25 (4)=0.375 (5)=0.5 (6)=0.625 (7)=0.75 (8)=0.875 (9)=1.0	0.71	0.22	0.0	1.0
Antioxidant Information, Simple	SINFO	(1)=none, (2)=simple	(1)=0.0 (2)=1.0	0.31	0.46	0.0	1.0
Antioxidant Information, Detailed	DINFO	(1)=none, (2)=detailed	(1)=0.0 (2)=1.0	0.34	0.47	0.0	1.0
Gender	GENDER	(1)=female, (2)=male	(1)=0.0 (2)=1.0	0.43	0.49	0.0	1.0
Age	AGE	Age was input by participants	Age/100	0.41	0.14	0.19	0.75
Education, High School	HIGHSCH	(1)=high school, (2)=current student 2-year or 4-year college, (3)=2-year college, (4)=4-year college, (5)=current student advanced degree, (6)=advanced degree	(1)=1.0 (2)=0.0 (3)=0.0 (4)=0.0 (5)=0.0 (6)=0.0	0.13	0.34	0.0	1.0
Education, Some College	SOMECOL	(1)=high school, (2)=current student 2-year or 4-year college, (3)=2-year college, (4)=4-year college, (5)=current student advanced degree, (6)=advanced degree	(1)=0.0 (2)=1.0 (3)=1.0 (4)=0.0 (5)=0.0 (6)=0.0	0.27	0.45	0.0	1.0

Table 5.2 Summary of test variables (names, response choices, model values, and statistics) used in logistic regression (n=222) (Continued)

Variable	Name	Response Choices	Model Values	Mean	Std. Dev.	Min.	Max.
Education, Advanced	ADVEDU	(1)=high school, (2)=current student 2-year or 4-year college, (3)=2-year college, (4)=4-year college, (5)=current student advanced degree, (6)=advanced degree	(1)=0.0 (2)=0.0 (3)=0.0 (4)=0.0 (5)=1.0 (6)=1.0	0.19	0.39	0.0	1.0
Income	INCOME	(1)=\$0-\$19,999, (2)=\$20,000-\$39,999, (3)=\$40,000-\$59,999, (4)=\$60,000-\$79,999, (5)=\$80,000-\$99,999, (6)=\$100,000-\$120,000	(1)=0.095 (2)=0.295 (3)=0.495 (4)=0.695 (5)=0.895 (6)=1.10	0.46	0.29	0.09	1.10
Usage Frequency	USAGE	(1)=few times a month, (2)=once a week, (3)=more than once a week	(1)=0.0 (2)=1.0 (3)=1.0	0.52	0.50	0.0	1.0
Health Interest	HEALTH	(1)=strongly disagree, (2)=disagree, (3)=neither agree not disagree, (4)=agree, (5)=strongly agree --or-- (1)=never true, (2)=rarely true, (3)=sometimes true, (4)=often true, (5)=always true	Sum of responses to 9 questions/45	0.55	0.13	0.15	0.80
Food Interest	FOOD	(1)=strongly disagree, (2)=disagree, (3)=neither agree not disagree, (4)=agree, (5)=strongly agree --or-- (1)=never true, (2)=rarely true, (3)=sometimes true, (4)=often true, (5)=always true	Sum of responses to 10 questions/50	0.58	0.13	0.14	0.80
Antioxidant Knowledge	KNOW	(1)=not at all informed, (2)=somewhat informed, (3)=very well informed	(1)=0.0 (2)=0.5 (3)=1.0	0.35	0.27	0.0	1.0

Table 5.3 Logistic regression results for probability of purchase, yellow versus red/purple potatoes (n=222)

Variable	Yellow Potatoes				Red and Purple Potatoes			
	Coefficient	Marginal Effect	Marginal Effect Standard Error	Sig. ^a	Coefficient	Marginal Effect	Marginal Effect Standard Error	Sig. ^a
Constant	-0.251	-0.061	0.139		-1.432	-0.340	0.125	***
PRICE	-0.945	-0.229	0.017	***	-0.820	-0.194	0.018	***
LIKING	2.323	0.562	0.093	***	2.761	0.655	0.068	***
SINFO	0.046	0.011	0.037		0.362	0.084	0.036	**
DINFO	0.211	0.051	0.037		0.576	0.133	0.036	***
GENDER	-0.013	-0.003	0.032		0.115	0.027	0.032	
AGE	0.283	0.068	0.117		-1.898	-0.450	0.119	***
HIGHSCH	0.074	0.018	0.047		0.031	0.007	0.048	
SOMECOL	0.237	0.057	0.038		-0.036	-0.008	0.039	
ADVEDU	-0.337	-0.082	0.044	*	0.051	0.012	0.044	
INCOME	-0.187	-0.045	0.058		0.158	0.038	0.060	
USAGE	0.125	0.030	0.030		-0.030	-0.007	0.031	
HEALTH	-0.276	-0.067	0.150		1.816	0.431	0.154	***
FOOD	1.036	0.251	0.132	*	1.594	0.378	0.136	***
KNOW	-0.099	-0.024	0.065		0.191	0.045	0.067	

a – *, **, and *** indicate significance at $p < 0.10$, 0.05 , and 0.01 , respectively

Table 5.4 Predicted versus actual probabilities in logistic regression model for yellow potatoes with boxed diagonal indicating correct predictions and shaded areas indicating predictions off by one probability category

Probability Category	Actual						Total
	0.0	0.25	0.5	0.75	1.0		
Predicted	0.0	3	0	0	1	0	4
	0.25	85	93	79	25	12	294
	0.5	75	76	135	104	45	435
	0.75	19	38	91	164	236	548
	1.0	0	0	1	12	38	51
Total	182	207	306	306	331	1332	

Table 5.5 Predicted versus actual probabilities in logistic regression model for red/purple potatoes with boxed diagonal indicating correct predictions and shaded areas indicating predictions off by one probability category

Probability Category	Actual						Total
	0.0	0.25	0.5	0.75	1.0		
Predicted	0.0	26	6	2	1	0	35
	0.25	88	85	58	29	1	261
	0.5	41	79	136	86	40	382
	0.75	12	40	102	150	196	500
	1.0	0	0	1	23	130	154
Total	167	210	299	289	367	1332	

6. CHAPTER 6 – GENERAL CONCLUSION

In summary, this thesis was comprised of a critical review and three studies. In Chapter 2, a review of the literature was performed linking raw tuber characteristics to the culinary quality of fresh market potatoes. The review revealed that potato appearance was affected by greening, enzymatic browning, Maillard browning, and after-cooking darkening; cooked flavor was affected by both volatile and non-volatile compounds; and cooked texture was affected by starch content, swelling pressure due to starch gelatinization, and cell wall stability.

In Chapter 3, a qualitative study used focus groups to explore current consumer attitudes and opinions on fresh market potatoes, with a focus on specialty potato varieties. Focus group participants were presented with five colorful specialty potato varieties developed in part by the OSU Potato Breeding and Genetics Program, and were asked to rate purchase intent based on appearance alone, after being shown photos of the raw and cooked flesh of the potatoes, and after reading a statement about the health benefits of colorful potatoes.

Motivations for purchasing fresh market potatoes were economy, versatility, and flavor. Participants defined specialty potatoes as varieties characterized by a unique appearance, point of sale, culinary preparation, and flavor, as well as limited availability and a high price. Participant reactions to colorful varieties were mixed. For some, they were unique and exciting, but for others, they aroused suspicion with regard to how and why they were developed. Photos of the raw and cooked flesh did not have as strong an impact on purchase intent as information about health benefits. This study also revealed that purchase intent was influenced by positive and negative associations with appearance, concern about genetic modification, chemicals, and tampering, preparation and presentation considerations, point of sale, family acceptance, and anticipated flavor. Participants desired additional information describing suggested preparations for the new varieties, information on how the varieties were developed, and a concise statement describing the direct benefit to the consumer.

The qualitative study in Chapter 3 was followed by a quantitative consumer test described in Chapter 4. In this study, 222 participants evaluated six colorful potato varieties developed in part by OSU alongside a more commonly available variety, the Yukon Gold. Participants were shown a raw uncut potato sample from each variety and were asked to rate their liking of overall appearance, color, size, and shape. Participants then tasted each potato boiled and rated overall liking, appearance, flavor, and texture. Consumers also commented on what they liked/disliked about each raw and cooked potato.

For color, yellow and red skinned varieties were accepted over purple skinned varieties. For shape and size, larger and rounder varieties were accepted over smaller, elongated varieties. Bimodal hedonic score distributions for purple color, small size, and elongated shape suggested that varieties exhibiting these characteristics are highly accepted by some consumers and not accepted by others. Cooked flavor and texture were important factors in acceptance of the test varieties, and many were rated higher than the Yukon Gold for these attributes. Consumer comments revealed that a uniform raw and cooked appearance, a distinct flavor with no undesirable aftertaste, and a smooth, firm, and consistent texture were all desirable characteristics. Consumer comments also revealed that preparation and serving size considerations were also important for the acceptance of new varieties.

Chapter 5 used the same quantitative study described in Chapter 4 to investigate the effect of antioxidant information on purchase intent for colorful fresh market potatoes. Participants either received no information, a simple statement, or a detailed statement about antioxidants in colorful potatoes. After reading the information, participants rated purchase intent. The effect of antioxidant information on the probability of purchase for red and purple potatoes was compared to yellow potatoes. The impact of hedonic rating, price, gender, age, education, income, usage frequency, health interest, food interest, and antioxidant knowledge was also investigated.

High hedonic ratings and interest in food both had a significant positive effect on purchase intent for both categories of potatoes (red/purple and yellow). Price had a significant negative effect on purchase intent for both categories of potatoes. Antioxidant information and interest in health had a significant positive effect on purchase intent and age had a significant negative effect on purchase intent for red and purple potatoes. An advanced degree of education had a significant negative effect on purchase intent for yellow potatoes.

The results of Chapters 3-5 suggest that new colorful specialty varieties have great potential for consumer acceptance and purchase, but there are some important considerations in introducing these kinds of potatoes to the fresh market. Purple skin and flesh potatoes were the least accepted out of all the potatoes tested and results from both the focus group and the consumer test revealed that consumers were divided in opinion about this color. As a result, purple flesh and skin potatoes may not gain mass appeal, but may be very popular with consumers who like novel colors in foods. The red skin and flesh potatoes were generally well liked by participants in both their raw and cooked states. These potatoes have great potential for market success due to their familiar skin color and high antioxidant levels. The size and shape of these potatoes should be considered with care, however, as the small fingerling shaped red potato was less accepted by consumers than the larger, more conventionally shaped red potato. Based on consumer comments in the consumer test and focus group session, the appearance of

the yellow skin and flesh potatoes with red eyes received mixed reactions, but the cooked qualities of these potatoes were rated higher than the Yukon Gold. Thus, in order for this type of potato to compete with the Yukon Gold, its superior flavor and texture attributes should be highlighted.

Any information (health benefits, suggested preparations, etc.) about colorful fresh market potatoes provided to consumers at the point of purchase should be easy to understand, detailed, and concise. The best way to present this information is a topic for future research. As shown by the effect of antioxidant information on the probability of purchase for red and purple varieties, information can have an effect on purchase intent for new fresh market potatoes. Information, however, does not have as strong of an effect on purchase intent as hedonic ratings and price. Thus, developing potatoes that have intrinsic or sensory properties rated highly by consumers should be the focus of breeding efforts and the resulting potatoes should be sold at a price consumers are willing to pay. The price at which to sell new colorful potato varieties could also be a topic for future research. Lastly, consumer demographics such as age, education, and consumer interest in food and health should also be considered when identifying a target market for new colorful fresh market potato varieties.

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APPENDICES

Appendix 1 Focus Group Screener

1. A photo ID is necessary for participation. This is a requirement. Will you be able to show your photo ID on the day of the session?

Yes

No

2. Do you have any allergies to food or any food restrictions?

Yes - please answer question 3

No

3. Please describe your food allergies and/or restrictions.

4. Please enter your first name.

5. Please enter your last name.

6. Please enter the city in which you live.

7. Please enter your zip code. The first 5 digits are fine.

8. Please enter your phone number. This will be used for a confirmation call so please make sure it is correct.

9. Please enter your e-mail address. This is how we will contact you for scheduling so please make sure it is correct. We have a strict confidentiality policy and will not share your personal information with anyone.

10. Please enter your age.

11. Please select your gender.

Male

Female

12. Please select your ethnicity.

African

Asian

Hispanic

Native American

Caucasian

Other

Please specify other here:

13. What is the highest level of education you have completed?

Some high school
High school
2-year college/trade school
4-year college
Advanced degree (e.g. MA, PhD)
Currently enrolled, 2 or 4-year college/trade school
Currently enrolled, advanced degree

14. Please select your employment status.

Employed part-time
Employed full-time
Self-employed
Full-time student
Part-time student
Retired
Unemployed
Other
Please specify other here:

15. Please select your total annual household income before taxes.

Less than \$20,000
\$20,000-\$39,000
\$40,000-\$59,000
\$60,000-\$79,000
\$80,000-\$99,000
\$100,000-\$120,000
Over \$120,000

16. How many adults (18 and over) share your household with you?

None
One
Two
Three
Four
Five or more

17. How many children (under 18) share your household with you?

None
One
Two
Three
Four
Five or more

18. Do you or any member of your immediate family work for a food company or do any advertising or market research?

Yes - please answer question 19

No

19. Please explain in which industry you and/or your family works.

20. Do you like and eat potatoes?

Yes

No

21. Who in your household is most responsible for buying food?

Myself

Share the responsibility with someone else

Someone else

22. Where do you buy food at least once a month? Select all that apply.

Conventional supermarkets (e.g. Albertson's, Fred Meyer, Safeway)
Specialty grocery stores (e.g. Zupans, City Market, Market of Choice)
Natural foods stores (e.g. Whole Foods, New Seasons, Wild Oats)
Warehouse retailer (e.g. Costco, Walmart, Sam's Club)
Community supported agriculture
Food co-operative
Food delivery to my door
Convenience stores
Farmer's market
Buy direct from farm

23. Who in your household is most responsible for cooking?

Myself

Share the responsibility with someone else

Someone else

24. Do you buy raw potatoes to cook at home?

Yes - answer questions 25-29

No - skip to question 30

25. Which kind(s) of potato(es) do you buy? Select all that apply.

Brown (Russet)

Red

White

Yellow

Purple/Blue

Fingerling

Yam/Sweet Potato

Other, please specify other here:

26. Which kind of potato do you buy most often?

27. Which kind of potato do you buy second most often? (If you only buy one kind, say 'None')

28. How often do you cook potatoes at home?

More than once a week

Once a week

A few times a month

Once a month

Once every 2-3 months

Less than once every 3 months

29. How do you cook potatoes at home? Select all that apply.

Boiled

Steamed

Baked

Mashed

Microwaved

Roasted

Fried in Oil

Other

Please specify other here:

30. I read articles or watch shows about food and/or nutrition.

Always true

Often true

Sometimes True

Rarely true

Never true

31. I eat five servings of fruits and vegetables a day.

Always true

Often true

Sometimes true

Rarely true

Never true

32. I look for new types of foods to try.

Always true

Often true

Sometimes true

Rarely true

Never true

33. Before buying a new food item, I read the ingredient listing and/or nutritional information.

Always true
Often true
Sometimes true
Rarely true
Never true

34. When was the last time you participated in a taste test, focus group, or market survey at the Oregon State University Food Innovation Center?

In the last month
2 months ago
3 months ago
4 months ago
5 months ago
6-12 months ago
More than a year ago
Never

35. When was the last time you participated in a taste test, focus group, or market survey at any location?

In the last month
2 months ago
3 months ago
4 months ago
5 months ago
6-12 months ago
More than a year ago
Never

36. Please choose time(s) that are convenient for you to participate in the focus group session. There will be about 10 people per session and if selected, you will only be required to attend one session. The session will be about 90 minutes long.

Monday, October 26th 10:00 am
Monday, October 26th 2:30 pm
Wednesday, October 28th 10:00 am
Wednesday, October 28th 2:30 pm

37. Please use this space if you need to make any scheduling comments.

38. If you are not already on our e-mail list, would you like to be added to the Food Innovation Center Sensory and Consumer Group participant list?

Yes
No
Already on list

Appendix 2 Focus Group Informed Consent Document

INFORMED CONSENT DOCUMENT

Project Title: Focus Groups for Value Added Agricultural Products
Principal Investigator: Michael T. Morrissey, Superintendent, Food Innovation Center
Research Staff: Cathy Durham, Linda Wechsler, Anna Marin, Ann Colonna

PURPOSE

This is a research study. The purpose of this research study is to evaluate consumers' quality assessment of Northwest agricultural products. The results of this study will help the food industry better understand the consumer's opinion of those products.

The purpose of this consent form is to give you the information you will need to help you decide whether to be in the study or not. Please read the form carefully. You may ask any questions about the research, what you will be asked to do, the possible risks and benefits, your rights as a volunteer, and anything else about the research or this form that is not clear. When all of your questions have been answered, you can decide if you want to be in this study or not. This process is called "informed consent". You will be given a copy of this form for your records. We are inviting you to participate in this research study because you purchase and consume these products. There are a total of 40 adults who are expected to participate in this study.

PROCEDURES

During a focus group session participants are asked to share their opinions and provide feedback about particular subjects. For this study each focus group will consist of 8-10 local individuals who regularly buy agricultural products for their household. A moderator will present ideas and ask what you think about various value-added agricultural products and what you look for when shopping for food. Participants are expected to discuss what they think about the topics introduced. On some issues the moderator may ask you to first write down your ideas on a piece of paper before you discuss them. By writing it down first your first impressions of an idea will be clear and then as the discussion progresses each person in the group can offer what they first thought and then what they learned during the discussion. The focus group session will take place at the Food Innovation Center 1207 NW Naito Parkway in Portland. If you agree to take part in this study, your involvement will last for 90 minutes.

RISKS

There are no foreseeable risks to participating. Every effort will be made to be sure participants will be comfortable. Water will be provided.

BENEFITS

There are no foreseeable personal benefits from participating in this study. The researchers anticipate that, in the future, society may benefit from this study by understanding consumer's opinion of these products.

COSTS AND COMPENSATION

You will not have any costs for participating in this research project. You will be paid for being in this research project. At the end of the session, you will receive \$75 for participating in the entire 90-minute session. There will not be any compensation if you choose not to complete the session.

CONFIDENTIALITY

Records of participation in this research project will be kept confidential to the extent permitted by law. However, federal government regulatory agencies and the Oregon State University Institutional Review Board (a committee that reviews and approves research studies involving human subjects) may inspect and copy records pertaining to this research. It is possible that these records could contain information that personally identifies you. Coded names and identification numbers will be used to ensure confidentiality and only first names will be used during the session. The sessions will be video and audio-taped, however only the researchers will view and listen to the tapes. We may quote statements made by you during the session in a publication but not in a way that will identify you. All data forms will use identification code numbers not names. Videotapes will be stored in locked filing cabinets, and no later than when the project is completed in June 2010 the videotapes will be destroyed. In the event of any report or publication from this study, your identity will not be disclosed. Results will be reported in a summarized manner in such a way that you cannot be identified.

I do give my permission to be video taped and audio taped Initials: _____
 I do not give my permission to be video taped and audio taped Initials: _____

VOLUNTARY PARTICIPATION

Taking part in this research study is voluntary. You may choose not to take part at all. If you agree to participate in this study, you may stop participating at any time. You are free to skip any questions that you would prefer not to answer. If you decide not to take part, or if you stop participating at any time, your decision will not result in any penalty or loss of benefits to which you may otherwise be entitled. If you withdraw from the study before it is completed, the results you provide may be included in the study.

QUESTIONS

Questions are encouraged. If you have any questions about this research project, please contact: Michael Morrissey, 503-872-6656 and michael.morrissey@oregonstate.edu and/or Linda Wechsler, 502-872-6658, ann.colonna@oregonstate.edu. If you have questions about your rights as a participant, please contact the Oregon State University Institutional Review Board (IRB) Human Protections Administrator, at (541) 737-3437 or by e-mail at IRB@oregonstate.edu.

You may be contacted in the future to be part of other research studies. If you don't want to be contacted about future studies, just let one of the researchers know at any time.

Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

Participant's Name (printed):

(Signature of Participant)

(Date)

RESEARCHER STATEMENT

I have discussed the above points with the participant or, where appropriate, with the participant's legally authorized representative, using a translator when necessary. It is my opinion that the participant understands the risks, benefits, and procedures involved with participation in this research study.

(Signature of Researcher)

(Date)

Appendix 3 Focus Group Paper Ballot

First Name _____

Date: _____

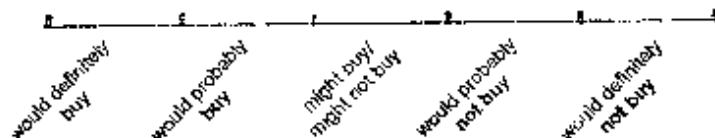
Panelist ID _____

Session: _____

Please describe each potato's appearance in your own words. Note color, size, shape, texture, weight, irregularities, and anything else that comes to mind. Then place a mark on the scale indicating how likely you would be to purchase the potato. Only spend about 1 minute on each potato.

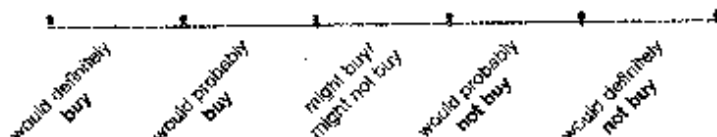
Potato 603

How likely would you be to purchase potato 603?



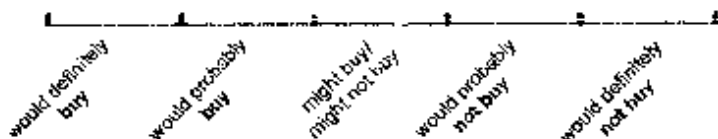
Potato 937

How likely would you be to purchase potato 937?



Potato 567

How likely would you be to purchase potato 567?



Appendix 4 Potatoes Shown to Focus Group Participants

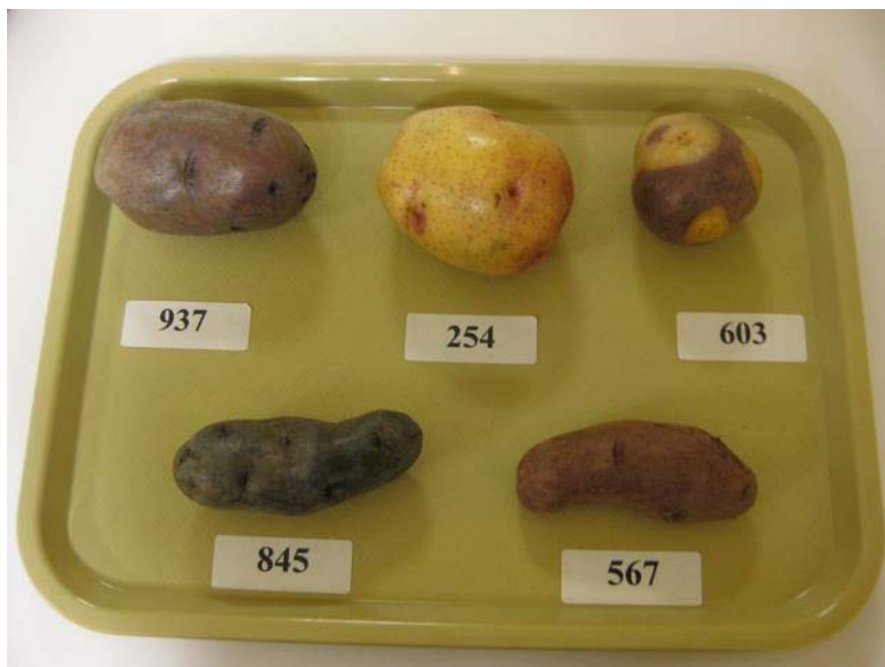


Figure 4.1 Oregon State University potato samples shown to focus groups

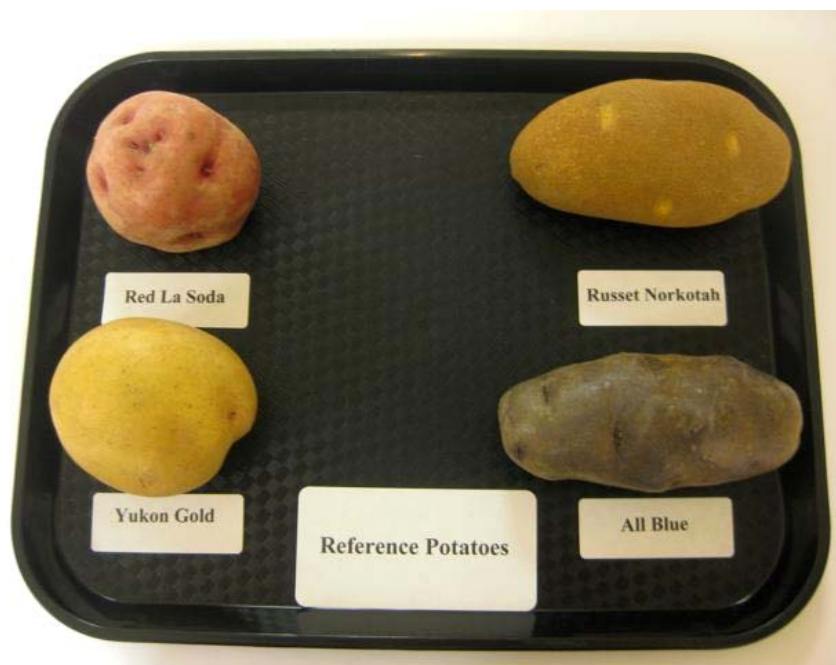
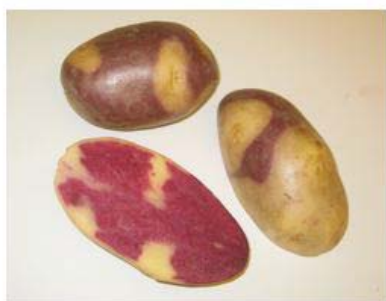


Figure 4.2 Reference potatoes shown to focus groups

Appendix 5 Laminated Card Showing Raw Interior Flesh

Raw



603



937



254



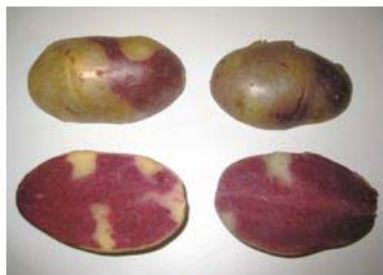
567



845

Appendix 6 Laminated Card Showing Raw and Cooked Interior Flesh

Raw and Cooked



603



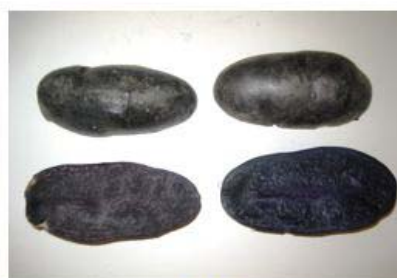
937



254



567



845

Appendix 7 Health Information Given to Focus Group Participants

Phytonutrients

Phytonutrients are components of plants that are thought to promote human health. Fruits, vegetables, grains, legumes, nuts, and teas are rich sources of phytonutrients.

Antioxidants

Antioxidants are substances or nutrients in our foods that can prevent oxidative damage to our body.

Anthocyanins

Anthocyanins are a class of phytonutrients that are responsible for blue and purple colors in fruits and vegetables and act as antioxidants (i.e. blue pigment in blueberries, purple pigment in grapes).

Carotenoids

Carotenoids are a class of phytonutrients that are responsible for red, orange, and yellow color in fruits and vegetables and act as antioxidants (i.e. orange pigment in carrots, yellow pigment in citrus fruits).

Statement

The U.S. Department of Agriculture recently included potatoes on its list of the top 20 most antioxidant-rich foods. Although Russet-type potatoes are the most common varieties consumed by Americans, red, purple, and yellow skin/flesh potatoes usually contain higher levels of antioxidants. Vitamin C is the most potent antioxidant found in potatoes. A single Russet-type potato contains 45% of the recommended daily value of Vitamin C. Yellow, red, and purple varieties contain Vitamin C plus other antioxidants called carotenoids and anthocyanins. The total antioxidant level in a purple potato is roughly three times greater than a Russet-type potato.

Appendix 8 Consumer Test Screener

1. A photo ID is a requirement for participation. Will you be able to show your photo ID on the day of the session?

Yes

No - you are not needed for this particular study, thank you

2. Do you like and eat squash (e.g. butternut squash, acorn squash, etc.)?

Yes

No

3. Do you like and eat potatoes?

Yes

No

4. Do you like and eat greens (e.g. spinach, kale, chard, etc.)?

Yes

No

5. Do you have any allergies to food or any food restrictions?

Yes - please answer question 6

No

6. Please describe your food allergies and/or restrictions.

7. Please enter your first name.

8. Please enter your last name.

9. Please enter the city in which you live.

10. Please enter your zip code. The first 5 digits are fine.

11. Please enter your phone number. This will be used for a confirmation call so please make sure it is correct.

12. Please enter your e-mail address. This is how we will contact you for scheduling so please make sure it is correct. We have a strict confidentiality policy and will not share your personal information with anyone.

13. Please enter your age.

14. Please select your gender.

Male

Female

15. Please select your ethnicity.

African
Asian
Hispanic
Native American
Caucasian
Other

Please specify other here:

16. What is the highest level of education you have completed?

Some high school
High school
2-year college/trade school
4-year college
Advanced degree (e.g. MA, PhD)
Currently enrolled, 2 or 4-year college/trade school
Currently enrolled, advanced degree

17. Please select your employment status.

Employed part-time
Employed full-time
Self-employed
Full-time student
Part-time student
Retired
Unemployed

18. Please select your total annual household income before taxes.

Less than \$20,000
\$20,000-\$39,999
\$40,000-\$59,999
\$60,000-\$79,999
\$80,000-\$99,999
\$100,000-\$120,000
Over \$120,000

19. How many adults (18 and over) share your household with you?

None
One
Two
Three
Four
Five or more

20. How many children (under 18) share your household with you?

- None
- One
- Two
- Three
- Four
- Five or more

21. Do you or any member of your immediate family work for a food company or do any advertising or market research?

- Yes - please answer question 22
- No

22. Please explain in which industry you and/or your family works.

23. Who in your household is most responsible for buying food?

- Myself
- Share the responsibility with someone else
- Someone else

24. Who in your household is most responsible for cooking?

- Myself
- Share the responsibility with someone else
- Someone else

25. Where do you buy food at least once a month? Select all that apply.

- Conventional supermarkets (e.g. Albertson's, Fred Meyer, Safeway)
- Specialty grocery stores (e.g. Zupans, City Market, Market of Choice)
- Natural foods stores (e.g. Whole Foods, New Seasons, Wild Oats, Food Co-op)
- Warehouse retailer (e.g. Costco, Walmart, Sam's Club)
- Food delivery to my door
- Convenience stores
- Farmer's market
- Buy direct from farm (e.g. farmstand, community supported agriculture)

26. Which kind(s) of squash do you buy? Select all that apply.

- Butternut
- Delicata
- Acorn
- Pumpkin
- Spaghetti
- Hubbard
- I do not buy squash
- Other
- Please specify other here:

27. How often do you cook squash at home?

More than once a week
Once a week
A few times a month
Once a month
Once every 2-3 months
Less than once every 3 months
Never

28. How do you cook squash at home?

Boiled
Steamed
Baked
Microwaved
Roasted
Fried in oil
I do not cook squash at home
Other
Please specify other here:

29. Which kind(s) of potato(es) do you buy? Select all that apply.

Brown (Russet)
Red
White
Yellow
Purple/Blue
Fingerling
Yam/Sweet Potato
I do not buy potatoes
Other
Please specify other here:

30. How often do you cook potatoes at home?

More than once a week
Once a week
A few times a month
Once a month
Once every 2-3 months
Less than once every 3 months
Never

31. How do you cook potatoes at home?

Boiled
Steamed
Baked
Microwaved
Roasted
Fried in oil
I do not cook potatoes at home
Other
Please specify other here:

32. Which kind(s) of greens do you buy? Select all that apply.

Spinach
Kale
Collard
Mustard
Dandelion
Chard
Beet
I do not buy greens
Other
Please specify other here:

33. How often do you cook greens at home?

More than once a week
Once a week
A few times a month
Once a month
Once every 2-3 months
Less than once every 3 months
Never

34. How do you cook greens at home?

Boiled
Steamed
Baked
Microwaved
Sauteed
Braised
I do not cook greens at home
Other
Please specify other here:

35. Please describe a dish you have prepared at home using squash or potatoes or greens. If you do not cook squash, potatoes, or greens at home, skip this question.

36. I read articles or watch shows about food and/or cooking.

Always true
Often true
Sometimes True
Rarely true
Never true

37. I eat five servings of fruits and vegetables a day.

Always true
Often true
Sometimes true
Rarely true
Never true

38. I look for new types of foods to try.

Always true
Often true
Sometimes true
Rarely true
Never true

39. Before buying a new food item, I read the ingredient listing and/or nutritional information.

Always true
Often true
Sometimes true
Rarely true
Never true

40. When was the last time you participated in a taste test, focus group, or market survey at the Oregon State University Food Innovation Center?

In the last month
2 months ago
3 months ago
4 months ago
5 months ago
6-12 months ago
More than a year ago
Never

41. When was the last time you participated in a taste test, focus group, or market survey at any location?

In the last month
2 months ago
3 months ago
4 months ago
5 months ago
6-12 months ago
More than a year ago
Never

42. Please choose time(s) that are convenient for you to take the test on THURSDAY, JANUARY 21st. This test will take about 45 minutes.

10:00 am
11:00 am
12:00 pm
1:30 pm
2:30 pm
3:30 pm
None of the above

43. Please choose time(s) that are convenient for you to take the test on FRIDAY, JANUARY 22nd. This test will take about 45 minutes.

10:00 am
11:00 am
12:00 pm
1:30 pm
2:30 pm
3:30 pm
None of the above

44. Please choose time(s) that are convenient for you to take the test on MONDAY, JANUARY 25th. This test will take about 45 minutes.

10:00 am
11:00 am
12:00 pm
1:30 pm
2:30 pm
3:30 pm
None of the above

45. Please choose time(s) that are convenient for you to take the test on TUESDAY, JANUARY 26th. This test will take about 45 minutes.

10:00 am

11:00 am

12:00 pm

1:30 pm

2:30 pm

3:30 pm

None of the above

46. Please use this space if you need to make any scheduling comments.

47. Would you like to be added to the Food Innovation Center Sensory and Consumer Group participant list? Please note that if you received an e-mail directly from the Food Innovation Center Sensory and Consumer group, you are already on our list.

Yes

No

Already on list

Appendix 9 Consumer Test Informed Consent Document

INFORMED CONSENT DOCUMENT

Project Title: Consumer Testing of Value Added Agricultural Products
Principal Investigator: Michael T. Morrissey, Superintendent, Food Innovation Center
Research Staff: Ann Colonna, Anna Marin, Cathy Durham

PURPOSE

This is a research study. The purpose of this research study is to evaluate consumers' quality assessment of Northwest agricultural products. The results of this study will help the food industry better understand the consumer's opinion of those products. The purpose of this consent form is to give you the information you will need to help you decide whether to be in the study or not. Please read the form carefully. You may ask any questions about the research, what you will be asked to do, the possible risks and benefits, your rights as a volunteer, and anything else about the research or this form that is not clear. When all of your questions have been answered, you can decide if you want to be in this study or not. This process is called "informed consent". You will be given a copy of this form for your records.

We are inviting you to participate in this research study because you eat these products. There are a total of 240 adults who are expected to participate in this study.

PROCEDURES

If you agree to participate, your involvement will last for approximately 45 minutes. The following procedures are involved in this study. You will be given instructions on how to take the test either on a computer or on a paper ballot. You will be assigned to go a tasting booth where you will be served the samples each labeled with a random three-digit number. The product used in this study is of the same quality that you would find in a grocery store or restaurant. You will be asked to rate how much you like each sample and reasons why.

RISKS

The risks involved in participating in this study are the same as consuming this food in your own home. You should disqualify yourself if you have any allergies to the products being tested.

BENEFITS

There are no foreseeable personal benefits from participating in this study. The researchers anticipate that, in the future, society may benefit from this study by understanding consumer's opinion of these products.

COSTS AND COMPENSATION

You will not have any costs for participating in this research project. You will be compensated for participating in this research project. At the end of the study, you will receive \$35 for completing all parts of the test. No compensation will be given unless the test is completed.

CONFIDENTIALITY

Records of participation in this research project will be kept confidential to the extent permitted by law. However, federal government regulatory agencies and the Oregon State University Institutional Review Board (a committee that reviews and approves research studies involving human subjects) may inspect and copy records pertaining to this research. It is possible that these records could contain information that personally identifies you. Coded names and identification numbers will be used to ensure confidentiality. In the event of any report or publication from this study, your identity will not be disclosed. Results will be reported in a summarized manner in such a way that you cannot be identified.

VOLUNTARY PARTICIPATION

Taking part in this research study is voluntary. You may choose not to take part at all. If you agree to participate in this study, you may stop participating at any time. You are free to skip any questions that you would prefer not to answer. If you decide not to take part, or if you stop participating at any time, your decision will not result in any penalty or loss of benefits to which you may otherwise be entitled. If you withdraw from the study before it is completed, the results you provide may be included in the study.

QUESTIONS

Questions are encouraged. If you have any questions about this research project, please contact: Michael Morrissey, 503-872-6656 and michael.morrissey@oregonstate.edu and/or Ann Colonna, 503-872-6677, ann.colonna@oregonstate.edu. If you have questions about your rights as a participant, please contact the Oregon State University Institutional Review Board (IRB) Human Protections Administrator, at (541) 737-3437 or by e-mail at IRB@oregonstate.edu.

You may be contacted in the future to be part of other research studies. If you don't want to be contacted about future studies, just let one of the researchers know at any time.

Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

Participant's Name (printed):

(Signature of Participant)

(Date)

RESEARCHER STATEMENT

I have discussed the above points with the participant or, where appropriate, with the participant's legally authorized representative, using a translator when necessary. It is my opinion that the participant understands the risks, benefits, and procedures involved with participation in this research study.

(Signature of Researcher)

(Date)

Appendix 10 EXP1 Potato Samples, Raw and Cooked



Figure 10.1 Raw uncut potato samples shown to participants



Figure 10.2 Cooked (boiled) potato samples shown to participants

Appendix 11 EXP2 Potato Samples, Raw and Cooked



Figure 11.1 Raw uncut potato samples shown to participants



Figure 11.2 Cooked (boiled) potato samples shown to participants

Question # 3.

How much do you like the size of each sample?

Sample _____

dislike extremely	dislike very much	dislike moderately	dislike slightly	neither like nor dislike	like slightly	like moderately	like very much	like extremely
----------------------	-------------------------	-----------------------	---------------------	--------------------------------	------------------	--------------------	----------------------	-------------------

--	--	--	--	--	--	--	--	--

Question # 4.

How much do you like the shape of each sample?

Sample _____

dislike extremely	dislike very much	dislike moderately	dislike slightly	neither like nor dislike	like slightly	like moderately	like very much	like extremely
----------------------	-------------------------	-----------------------	---------------------	--------------------------------	------------------	--------------------	----------------------	-------------------

--	--	--	--	--	--	--	--	--

Question # 5.

Please comment on what you like and dislike about the appearance (color, size, shape) of each sample.

You will be able to advance to the next question once you have commented on all the samples and the 'Next Question' button appears at the bottom of the screen.

Sample _____

PLEASE OPEN YOUR BOOTH DOOR

You will now receive a laminated card with information that relates to the 4 potatoes you just evaluated.

Please read the information card.

Question # 6.

Currently, specialty potatoes are selling for **\$0.79-\$2.79/lb** locally. Would you BUY each of these potatoes if their price was **\$2.99/lb**?

Sample _____

Would Definitely Not Buy	Would Probably Not Buy	Might Not Buy/Might Buy	Would Probably Buy	Would Definitely Buy
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Question # 7.

Currently, specialty potatoes are selling for **\$0.79-\$2.79/lb** locally. Would you BUY each of these potatoes if their price was **\$1.89/lb**?

Sample _____

Would Definitely Not Buy	Would Probably Not Buy	Might Not Buy/Might Buy	Would Probably Buy	Would Definitely Buy
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Question # 8.

Currently, specialty potatoes are selling for **\$0.79-\$2.79/lb** locally. Would you BUY each of these potatoes if their price was **\$0.79/lb**?

Sample _____

Would Definitely Not Buy	Would Probably Not Buy	Might Not Buy/Might Buy	Would Probably Buy	Would Definitely Buy
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

PLEASE OPEN YOUR BOOTH DOOR

PASS YOUR TRAY AND INFO CARD TO THE SERVER

You will now look at the same 4 potatoes COOKED.

Please rate each sample in the order presented on the screen (top to bottom).

Question # 12.

How much do you like the texture of each sample?

Sample _____

dislike extremely	dislike very much	dislike moderately	dislike slightly	neither like nor dislike	like slightly	like moderately	like very much	like extremely
----------------------	-------------------------	-----------------------	---------------------	--------------------------------	------------------	--------------------	----------------------	-------------------

--	--	--	--	--	--	--	--	--

Question # 13.

Please comment on what you like and dislike about the appearance, flavor, and texture of each sample.

You will be able to advance to the next question once you have commented on all the samples and the 'Next Question' button appears at the bottom of the screen.

Sample _____

Question # 14.

Please describe the appearance of each cooked sample in a few words.

You will be able to advance to the next question once you have commented on all the samples and the 'Next Question' button appears at the bottom of the screen.

Sample _____

Question # 15.

Now that you know how each potato tastes, would you BUY each potato if their price was **\$2.99/lb?**

Sample _____

Would
Definitely
Not Buy

Would
Probably
Not Buy

Might Not
Buy/Might
Buy

Would
Probably
Buy

Would
Definitely
Buy

Question # 16.

Now that you know how each potato tastes, would you BUY each potato if their price was **\$1.89/lb?**

Sample _____

Would
Definitely
Not Buy

Would
Probably
Not Buy

Might Not
Buy/Might
Buy

Would
Probably
Buy

Would
Definitely
Buy

Question # 17.

Now that you know how each potato tastes, would you BUY each potato if their price was **\$0.79/lb?**

Sample _____

Would
Definitely
Not Buy

Would
Probably
Not Buy

Might Not
Buy/Might
Buy

Would
Probably
Buy

Would
Definitely
Buy

Question # 18.

If sold at a price you were willing to pay, how often would you BUY each sample?

Sample _____

More than once a week
 Once a week
 2-3 times a month
 Once a month
 9-11 times a year
 6-8 times a year
 4-5 times a year
 1-3 times a year
 Once a year
 Less than once a year
 Never

Question # 19.

Aside from taste, what is most important to you (1=most important, 10=least important) when purchasing potatoes?

<u>Rank</u>	<u>Concept</u>
_____	Health Benefits
_____	Price
_____	Quality
_____	Color (e.g. skin, flesh)
_____	Packaging
_____	Purpose (e.g. intended recipe, occasion)
_____	Certified Organic
_____	Local/Seasonal
_____	Size
_____	Shape (e.g. round, fingerling, oval)

Question # 20.

When buying fresh fruits and vegetables, how important is price?

Very important
 Somewhat important
 Not important

Question # 21.

What percentage of the household shopping do you do?

- 0-5%
- 6-25%
- 26-49%
- 50-75%
- 76-95%
- 96-100%

Question # 22.

Do you consider yourself well informed about the possible benefits of eating foods high in antioxidants?

- Very well informed
- Somewhat informed
- Not at all informed

Please indicate how well the following statements describe your attitudes on food and health.

Question # 23.

I seek out new recipes to try at home.

- Always true
- Often true
- Sometimes true
- Rarely true
- Never true

Question # 24.

I seek out seasonal and local ingredients.

- Always true
- Often true
- Sometimes true
- Rarely true
- Never true

Question # 25.

I avoid foods from animals produced with hormones or antibiotics.

- Always true
- Often true
- Sometimes true
- Rarely true
- Never true

Question # 26.

I eat foods that are high in antioxidants.

- Always true
- Often true
- Sometimes true
- Rarely true
- Never true

Question # 27.

I read magazines about food (e.g. Gourmet, Savuer, Bon Appetit).

- Always true
- Often true
- Sometimes true
- Rarely true
- Never true

Question # 28.

I like to eat out in restaurants that feature local and seasonal food.

- Always true
- Often true
- Sometimes true
- Rarely true
- Never true

Question # 29.

I am interested in information about my health.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Question # 30.

I avoid foods containing nitrites or preservatives.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Question # 31.

I try to exercise at least 30 minutes a day, 3 days a week.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Question # 32.

I use the internet to find recipes and answer questions about food.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Question # 33.

My daily diet is nutritionally balanced.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Question # 34.

I try to avoid stressful situations.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Question # 35.

I regularly participate in outdoor activities (walking, biking, etc).

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Question # 36.

I read more health related articles than I did 3 years ago.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Question # 37.

I enjoy cooking.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Question # 38.

My health is outside my control.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Question # 39.

I'm concerned about my drinking water quality.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Question # 40.

It's the doctor's job to keep me well.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Question # 41.

I value new experiences and exotic flavors in food.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Question # 42.

Good health takes active participation on my part.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Question # 43.

I worry that there are harmful chemicals in my food.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Question # 44.

I exercise more than I did 3 years ago.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Question # 45.

I enjoy watching cooking shows.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Question # 46.

I am concerned about my health all the time.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Question # 47.

I place great value on the quality and flavor of food.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Question # 48.

I try to avoid high levels of cholesterol in my diet.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

THANK YOU!
Please collect your belongings
and see the receptionist.

Appendix 13 Hedonic Score Distributions for Raw Potato Samples

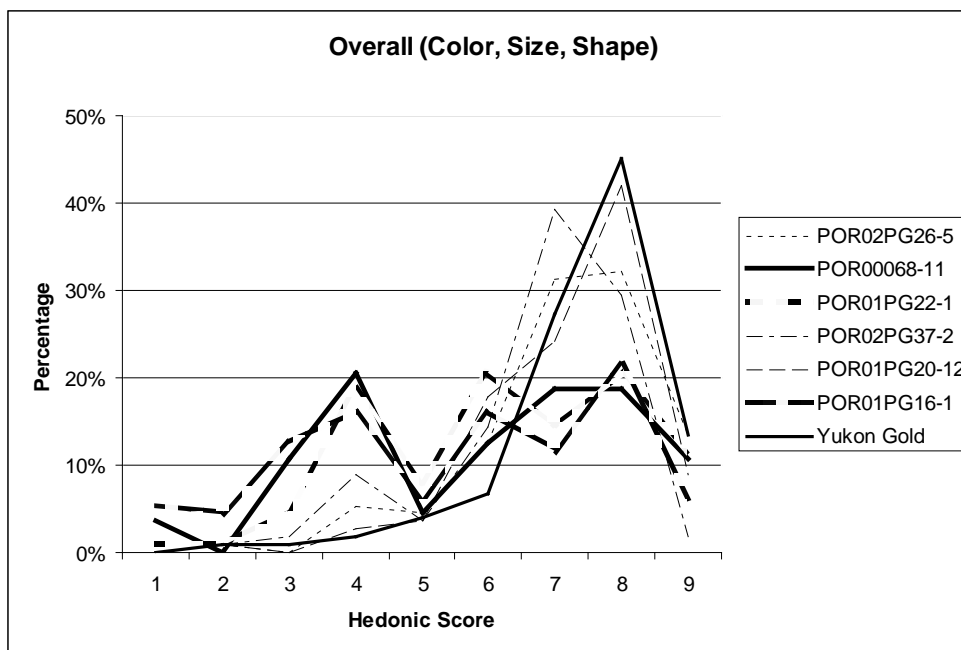


Figure 13.1 Percentage of hedonic score ratings (1-9) for overall liking (n=222)

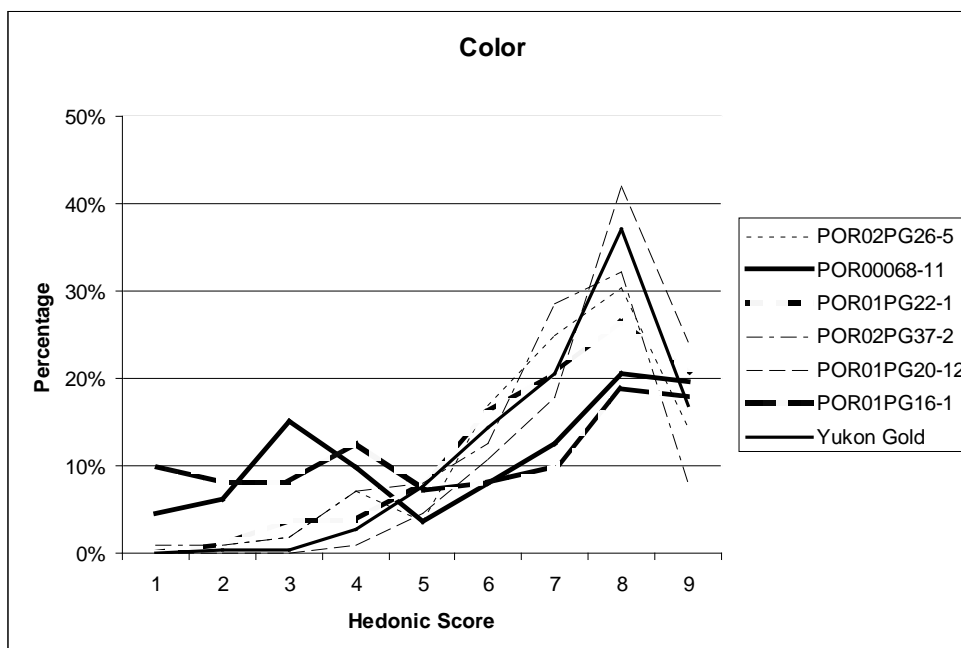


Figure 13.2 Percentage of hedonic score ratings (1-9) for color (n=222)

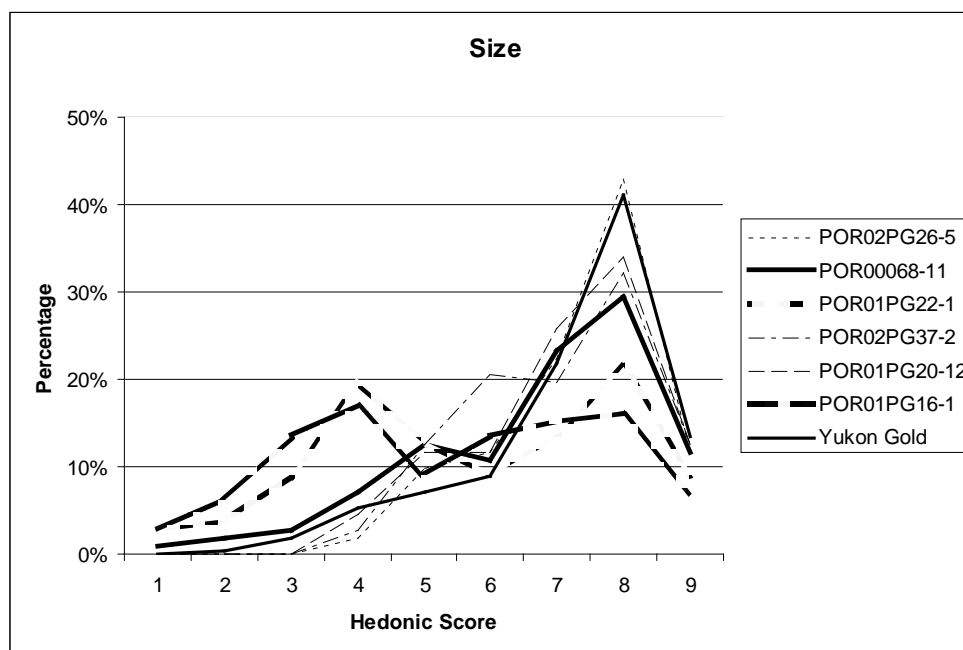


Figure 13.3 Percentage of hedonic score ratings (1-9) for size (n=222)

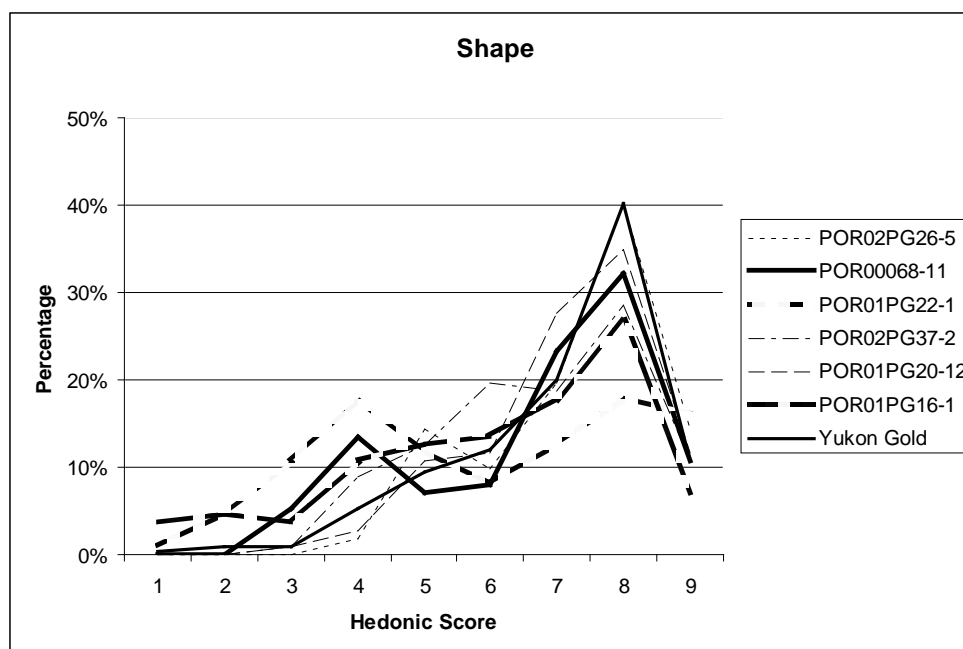


Figure 13.4 Percentage of hedonic score ratings (1-9) for shape (n=222)

Appendix 14 Hedonic Score Distributions for Cooked Potato Samples

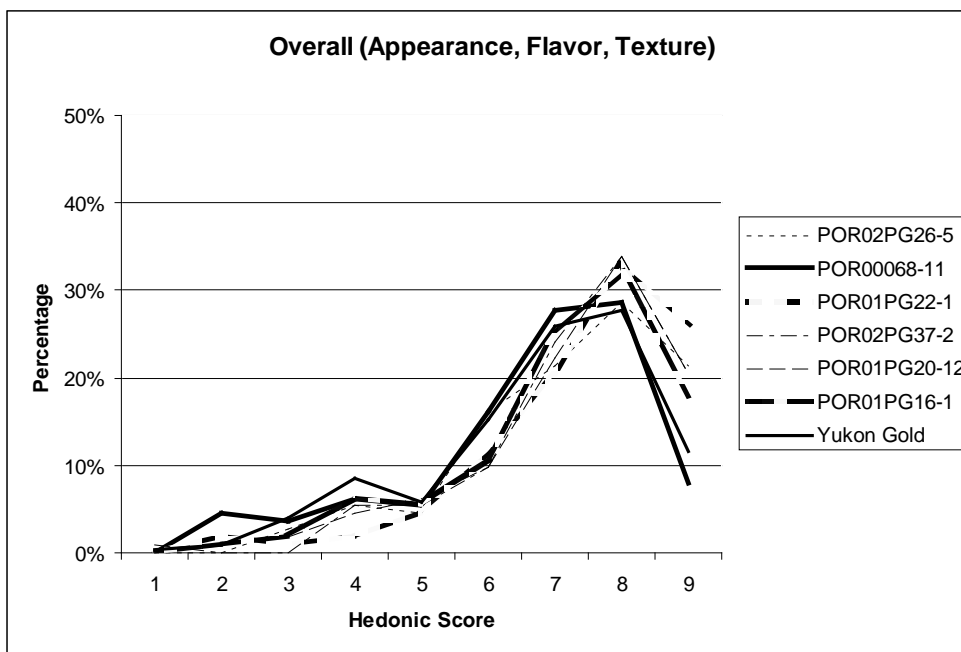


Figure 14.1 Percentage of hedonic score ratings (1-9) for overall liking (n=222)

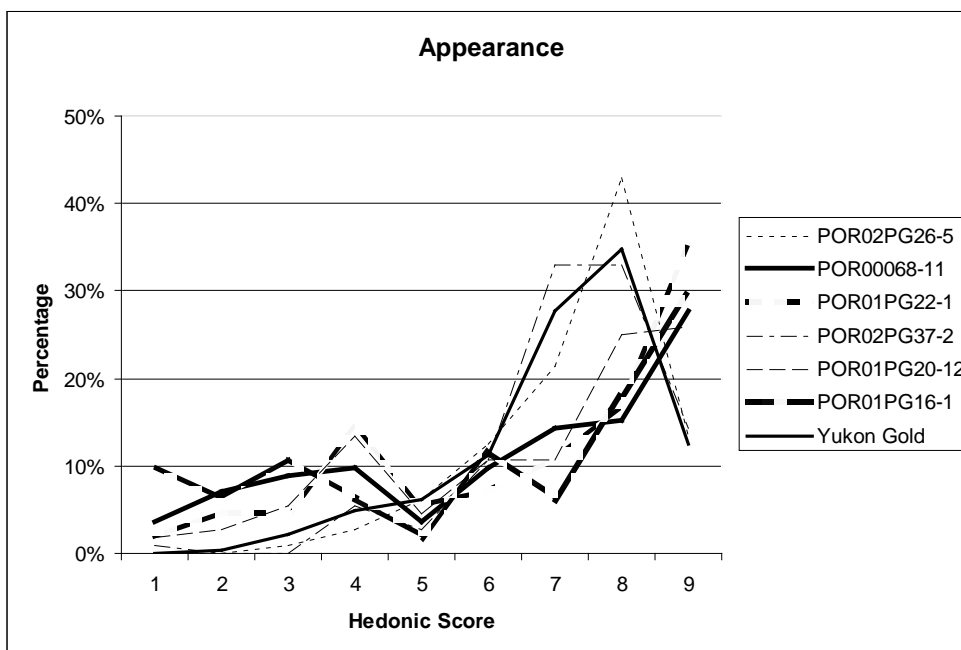


Figure 14.2 Percentage of hedonic score ratings (1-9) for appearance (n=222)

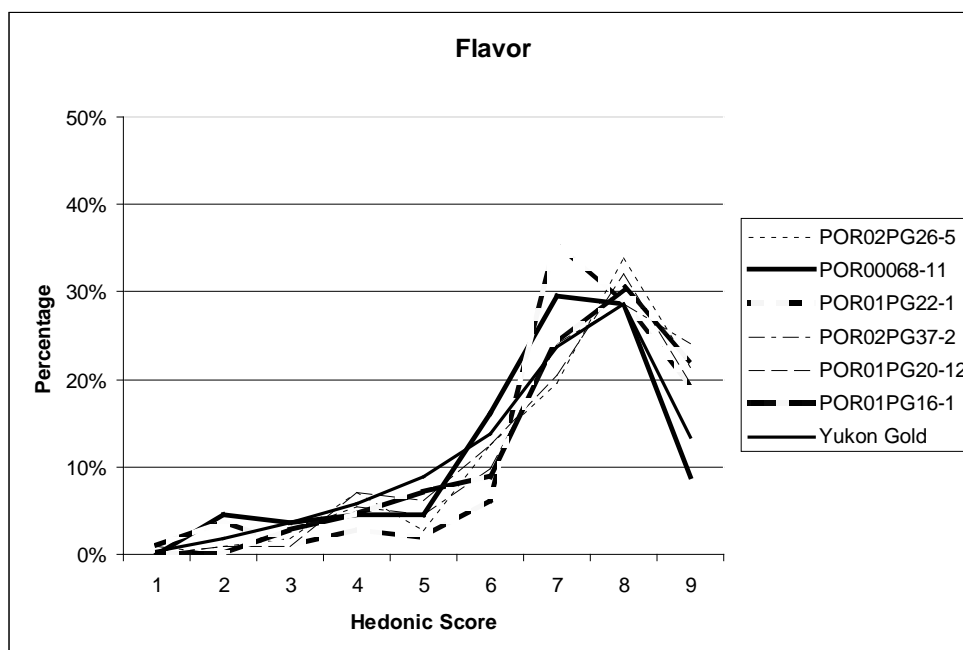


Figure 14.3 Percentage of hedonic score ratings (1-9) for flavor (n=222)

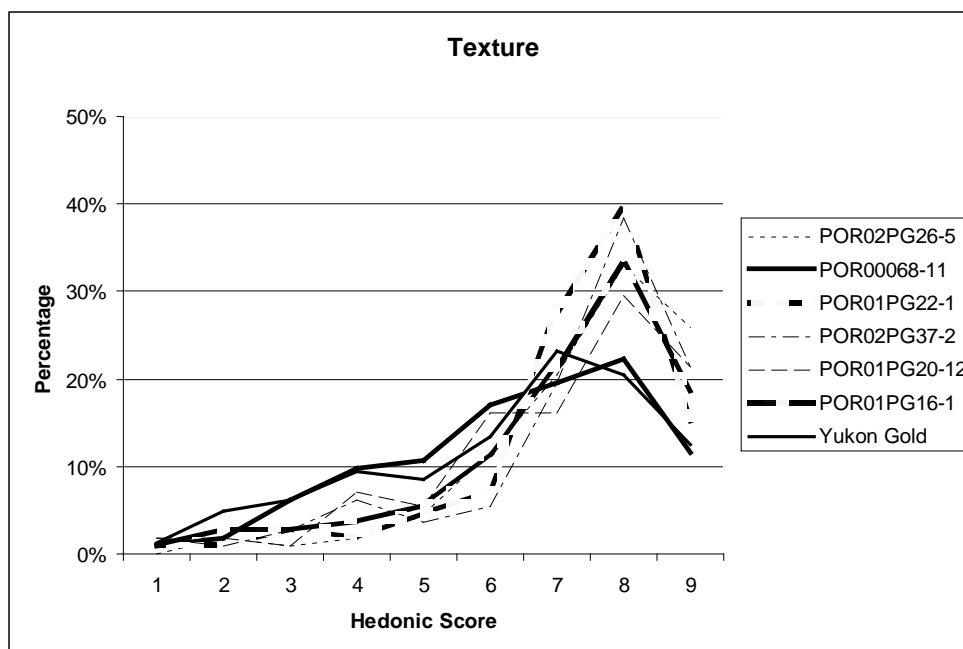


Figure 14.4 Percentage of hedonic score ratings (1-9) for texture (n=222)

