CCAB/WSFC
Joint Strategic Planning Session

Mike Rucier
Bryant Christie Inc.

January 10, 2008

California & Northwest Working Together

- Joint board meeting in 2006 to develop a Comprehensive Industry Strategic Plan (CISP):

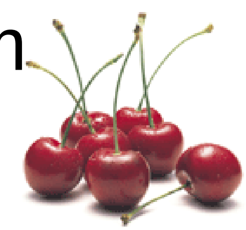
  - Outline areas where the two industries already cooperate

  - Identify objectives for future cooperation

  - Provide strategies for achieving the industry's long-term objectives

- Topics included production, trade, & sales challenges

- Final plan will help industry to ensure long-term demand in the face of growing competition



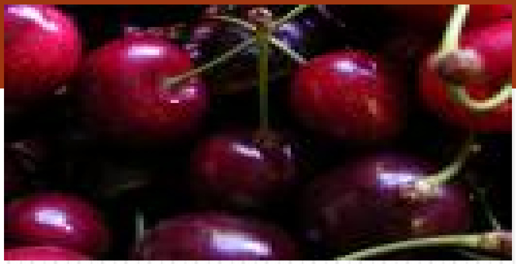
CISP: Key Findings

- Already cooperate in a number of areas, but many areas for future cooperation, particularly to address rising labor costs and increasing environmental regulation
- Exploring grant potential for mechanized harvesting
- Seeking university and grant support to explore the benefits of developing "fruiting walls"
- Develop research plan to improve quality and safety through chemical usage, orchard management, and varietal development

CISP: Key Findings (continued)

- Address retailer desire for “single source supplier” by aligning sales desks and packing shed management
- Coordinate trade policy issues between CA & NW
- Seek partnerships with Euro suppliers to better understand Euro crop situation
- ✔ Form a Nutrition Committee to develop and implement a health research plan
- ✔ Seek grants to conduct exploratory research in China, India, and Russia

Sweet Cherries and Health



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Nutrient, Carotenoid, Anthocyanin and Quercetin content of commonly consumed cherry products (per 100 grams or approx. 15 cherries)					
Nutrient /phytochemical	**Cherries, sweet**	**Cherries, tart**	**Cherries, sweet, canned**	**Cherries, sweet, frozen, sweetened**	**Maraschino**
Energy (kcal)[a]	**63**	50	46	89	165
Protein (g)[a]	**1.06**	1.0	0.8	1.15	0.22
Fat (g)[a]	**0.2**	0.3	0.13	0.13	0.21
Carbohydrate (g)[a]	**16.0**	12.2	11.8	22.4	42.0
Fiber (g)[a]	**2.1**	1.6	1.5	2.1	3.2
Glycemic Index[b]	**22**	22	22	22	Not available
Vitamin C (mg)[a]	**7**	10	2.2	1.0	0
Vitamin A (IU)[a]	**64**	1283	160	189	45
Potassium (mg)[a]	**222**	173	131	199	21
β-carotene (mg)[a]	**38**	770	96	113	27
Lutein/ Zeaxanthin (mg)[a]	**85**	85	57	85	59
Total anthocyanin (mg)[c]	**80.2**	Not available	Not available	Not available	Not available
Quercetin (mg)[c]	**2.64**	2.92	3.2	Not available	Not available

Cherries: Nutritional Highlights

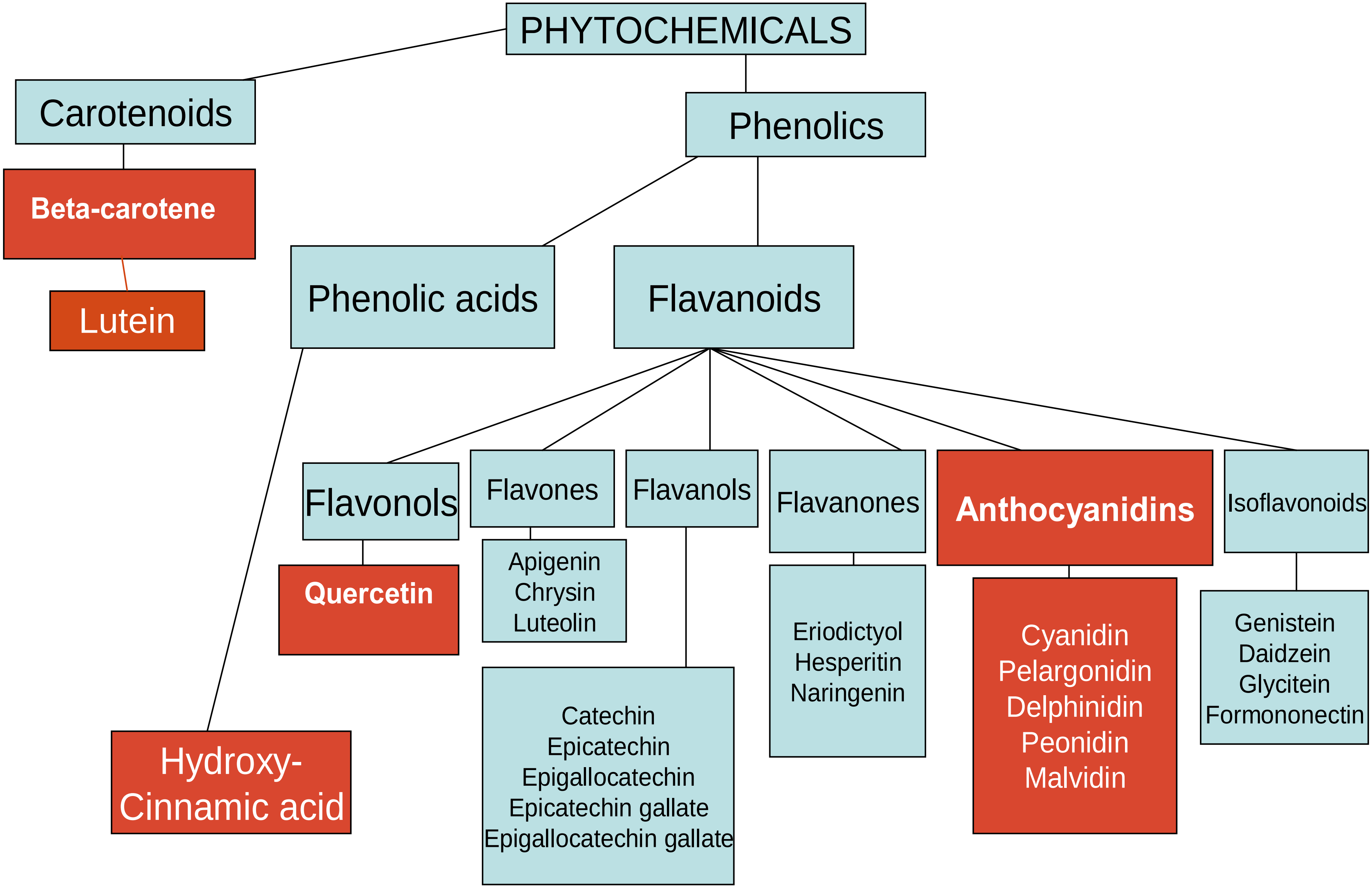
- Low calorie food
- Low fat food
- Provide 7 mg vitamin C per serving; 10% of daily requirement
- Good source of potassium
- Good source of carotenoids
- Low glycemic index (compared to most fruits)
- ALSO, good source of anthocyanin and other bioactive food compounds

Food Sources of Bioactive Food Compounds

Food Source of Select BAFC

Food	BCFA
Sweet Cherries	**Anthocyanins**
Variety of vegetables, fruit	**Carotenoids**
Cruciferous vegetables	**Indoles, isothiocyanates**
Tomato, watermelon	**Lycopene**
Citrus fruits	**Flavonoids, limonoids**
Green tea	**Polyphenols, catechins**
Pineapple	**Bromelaine**
Guava	**Polyphenol and flavonoid**
Spinach	Lutein
Red wine	Resveratrol
Onion, garlic, leeks	Allylic sulfides
Turmeric	Curcumin
Berries	Ellagic acid
Soy foods	Isoflavones/isoflavonoids

Bioactive Food Components in Sweet Cherries



Anthocyanins in Sweet Cherries and Related Plant Foods

	Anthocyanins						Total (mg)
Plant Food (1 cup)	Cyanidin (mg)	Deophinidin (mg)	Malvidin (mg)	Pelargonidin (mg)	Peonidin (mg)	Petunidin (mg)	
Cherries, Sweet	**75.2**	0	0	0.5	4.5	0	**80.2**
Cherries, Tart	6.7	0	0	0	0	0	**6.7**
Cherries, sweet, canned	0	0	0	0	0	0	**0**
Apricots	0	0	0	0		0	**0**
Peaches	1.6	0	0	0		0	**1.6**
Plums	12.0	0	0	0		0	**12.0**
Blueberries, raw	17.0	47.4	61.4	0	11.4	26.4	**163.6**
Raspberries	35.8	0.3	0.7	1.9	0	0	**38.7**
Grapes, red	1.5	3.7	34.7	.02	2.9	2.1	**44.9**
Red Wine	0.4	1.0	7	0	0.8	0.9	**10.1**

Comparison of total anthocyanins, total phenolics, and antioxidant properties of flesh, pits, and skins of different cherry cultivars (after Chavanalikit and Wrolstad, 2004).

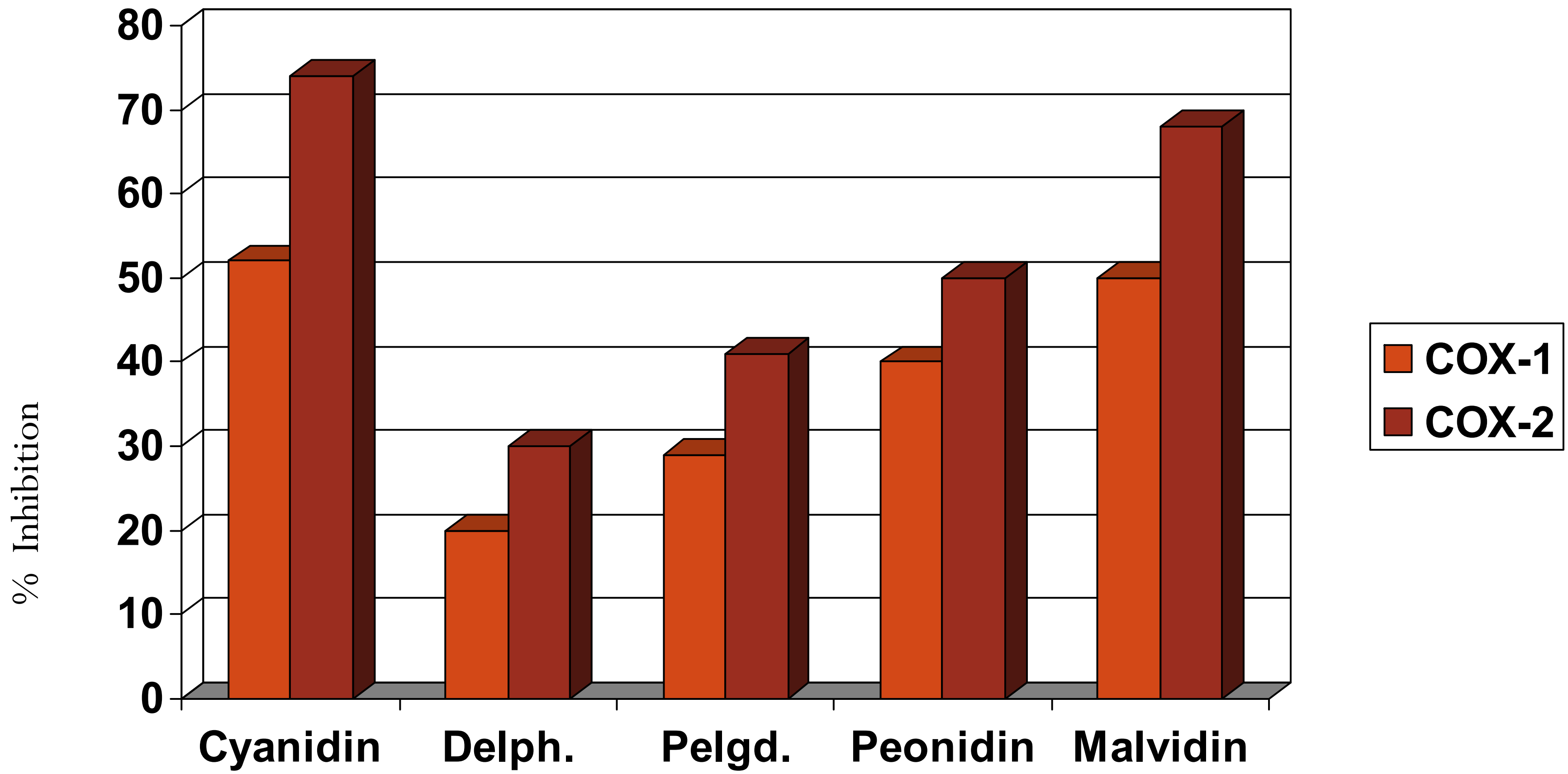
Cultivar	Portion	Anthocyanins (mg/100g fw)[Z]	Total phenolics (mg/ g fw)[Y]	ORAC (µmol TE/g fw)	FRAP (µmol TE/g fw)
Bing (sweet)	Flesh	26.0±0.7	1.34±0.18	9.07±0.35	7.28±0.24
	Pits	10.4±3.1	0.92±0.09	5.94±0.91	5.04±0.96
	Skins	60.6±2.5	3.33±0.41	28.26±1.10	21.05±0.55
Rainier (sweet)	Flesh	0.0±0.0	0.65±0.05	4.62±0.18	2.27±0.22
	Pits	0.1±0.0	0.54±0.04	3.38±0.26	2.00±0.13
	Skins	2.1±0.4	1.42±0.05	10.50±1.51	5.92±0.39
Montmorency (tart)	Flesh	0.0±0.09	3.01±0.29	15.00±1.00	13.81±0.26
	Pits	0.8±0.08	1.57±0.02	9.78±0.28	8.48±0.85
	Skins	36.5±1.6	5.58±0.33	51.02±1.97	47.96±1.33

How do these BAFC Prevent Disease?

- Anti-inflammatory response
- Anti-growth effects
- Differentiation-inducing agents
- Antioxidation / reduction in oxidative stress
- Modify insulin resistance; lower glucose levels
- Enhance drug therapies (quercetin)

Park EJ et al *Cancer Metas Rev*, 2002; Jayaprakasam, 2006; Tsuda, 2003

Anti-inflammatory Effects of Select Anthocyanins in Cell Culture



Individual Anthocyanins Evaluated in Cell Culture
40-mM concentrations

Adapted from: Seerman NP, Zhang Y and Nair MG, ***Nutr Cancer*** **2003;46(1):101-106**

Change in Biomarkers of Health associated with Cherry Feeding in Humans

- 18 healthy adults
- Design: low phenolics(8 days)—Bing cherry feeding (28 days)---no cherry (28 days)
- Measurements: CRP, IL-6, TNFα, blood lipids, glucose/insulin, NO

- Results:
  - 25% decrease in hsCRP at days 28
  - 18% decrease in NO
  - Individual variability in responsiveness was shown with 12/18 = "responders"
  - No change in serum lipid levels or glucose in "healthy" adult subjects

Kelley DS, UC Davis, 2004

Disease-specific Health Effects

- Cancer
- Cardiovascular
- Diabetes / insulin resistance
- Arthritis
- Gout
- Alzheimers Disease

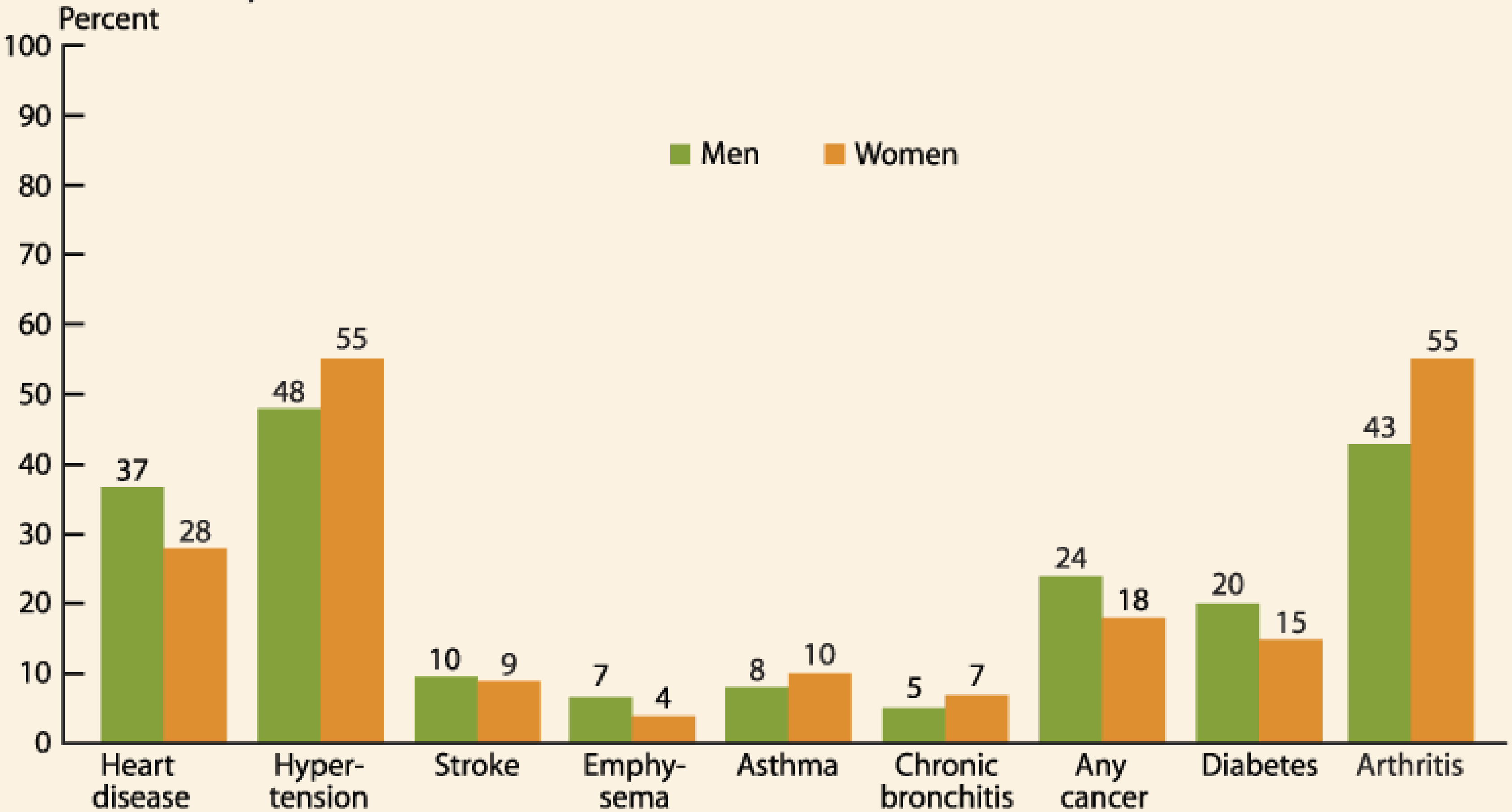
Number of Deaths for Leading Causes of Death in U.S.

- Heart disease: 652,486 **
- Cancer: 553,888 **
- Stroke (cerebrovascular diseases): 150,074*
- Chronic lower respiratory diseases: 121,987
- Accidents (unintentional injuries): 112,012
- Diabetes: 73,138*
- Alzheimer's disease: 65,965**
- Influenza/Pneumonia: 59,664

** cherries may provide health-related risk-reduction

Indicator 15

Percentage of people age 65 and over who reported having selected chronic conditions, by sex, 2003-2004



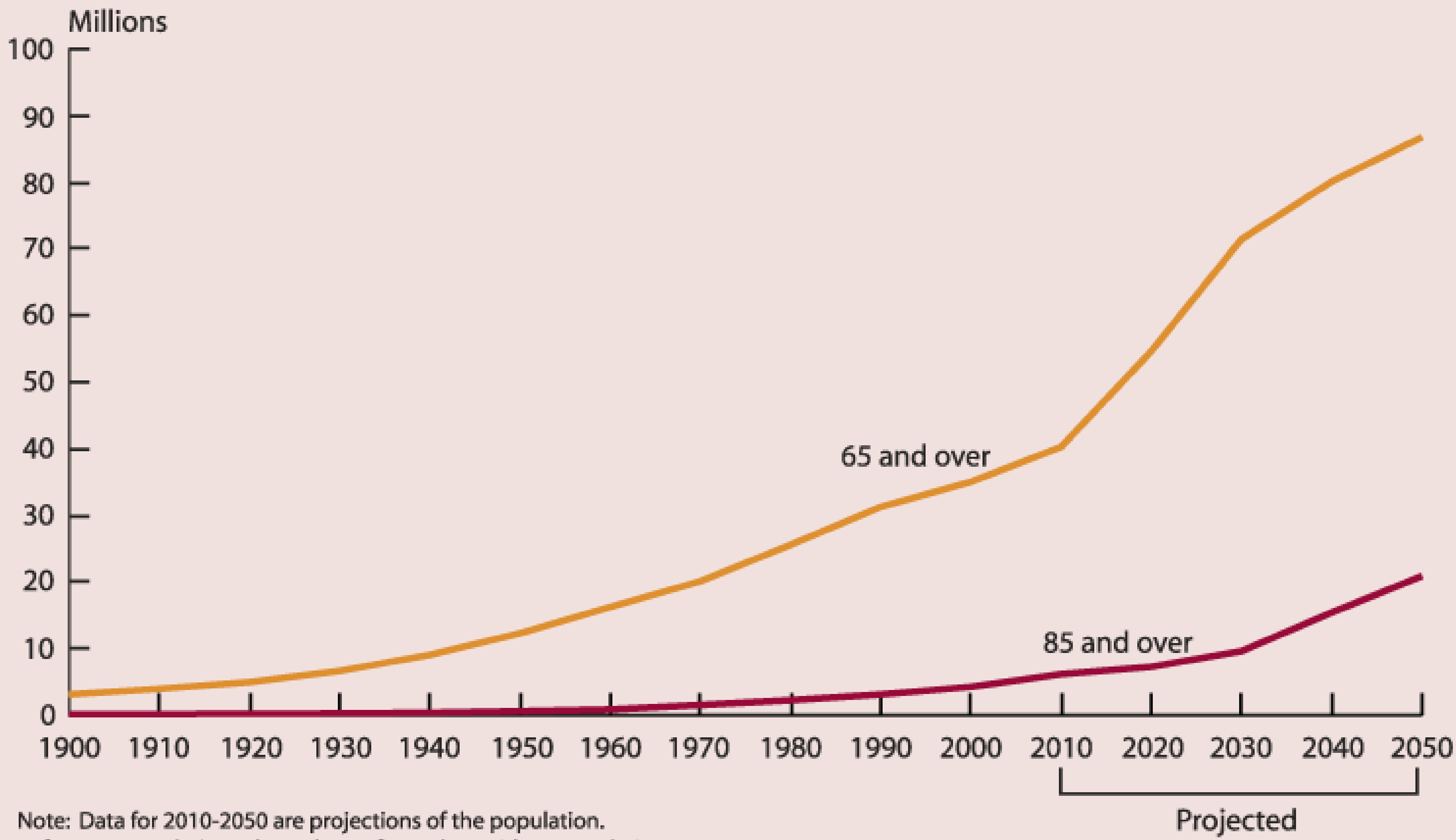
Note: Data are based on a 2-year average from 2003-2004. The question used to estimate the percentage of people who report having arthritis is "Have you EVER been told by a doctor or other health professional that you have some form of arthritis, rheumatoid arthritis, gout, lupus, or fibromyalgia?" This differs from the questions that were asked to estimate the percentage of people who report having "arthritic symptoms" in *Older Americans 2004*.

Reference population: These data refer to the civilian noninstitutionalized population.

Source: Centers for Disease Control and Prevention, National Center for Health Statistics, National Health Interview Survey.

Indicator 1 - Number of Older Americans

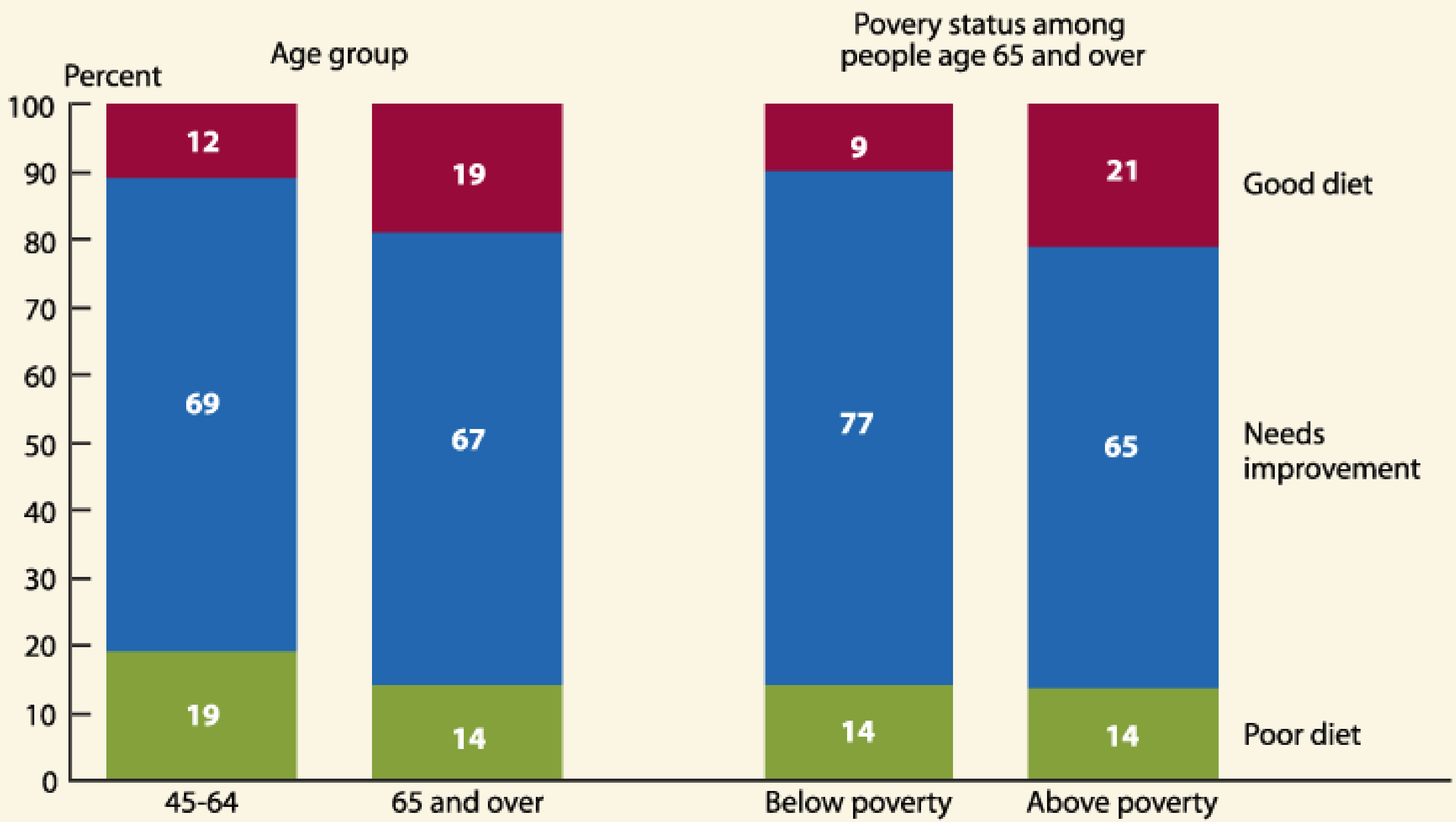
Number of people age 65 and over, by age group, selected years 1900-2000 and projected 2010-2050



Note: Data for 2010-2050 are projections of the population.
Reference population: These data refer to the resident population.
Source: U.S. Census Bureau, Decennial Census and Projections.

Indicator 23

Dietary quality ratings of people age 45 and over, as measured by the Healthy Eating Index, by age group and poverty status, 1999-2000



Note: Dietary quality was measured using the Healthy Eating Index (HEI). The HEI consists of 10 components, each representing a different aspect of a healthful diet based on the U.S. Department of Agriculture's Food Guide Pyramid and the Dietary Guidelines for Americans. Scores for each component are given equal weight and added to calculate an overall HEI score with a maximum value of 100. An HEI score above 80 indicates a good diet, an HEI score between 51 and 80 signals a diet that needs improvement, and an HEI score below 51 indicates a poor diet.

Reference population: These data refer to the civilian noninstitutionalized population.

Source: Centers for Disease Control and Prevention, National Center for Health Statistics, National Health and Nutrition Examination Survey.

Current Research Needs to Advance the Health Messaging for Cherries

- Additional studies
  - Human; beyond health volunteers
  - Larger sample size
  - Variety of investigators

- Dietary measurement
  - Instruments lack specificity
  - Seasonality of intake
  - Biomarkers of intake

- Collaborations between plant and nutritional scientitists as well as growers

Potential Funding Sources

- USDA Bioactive Food Compounds
- Fruit and Vegetable Improvement Center for Fruit and Vegetable Research (Texas A&M)
- National Cancer Institute
  - Phase I BAFC for chemoprevention
- Industry
  - Pilot studies
  - Preliminary data for larger trials

Dissemination of Research Information re: Cherries and Health

- Target Audiences
  - Dietitians, physicians, nurses, exercise physiologists
  - Health Food Stores / grocery
  - Fitness Centers / Weight Loss programs
- Mailings, web-ad (WebMD), Health care magazines (e.g. Arthritis Today, Prevention)
- Cherry websites – include pdf of papers, health facts in brief
- Media Messages
- Research programming
  - Small grants
  - Research symposia
  - Peer-reviewed publications


Questions ???

CALIFORNIA CHERRY ADVISORY BOARD

Northwest Cherries

What do we know about US consumers?

- ***Cherries are bought regularly*** - 54% of consumers buy cherries regularly during the season (29% nearly every week)
- ***Cherries are an impulse buy*** – 53% made the decision to purchase in the store
- ***Cherries appeal to kids*** - Households with children at home are more likely to plan their cherry purchase
- ***A low price motivates sales*** – 71% said a “lower everyday price” or a “sales price” was a key purchase decision factor
- ***Size doesn’t matter (much)*** – 60% said size is not important and will buy what is available

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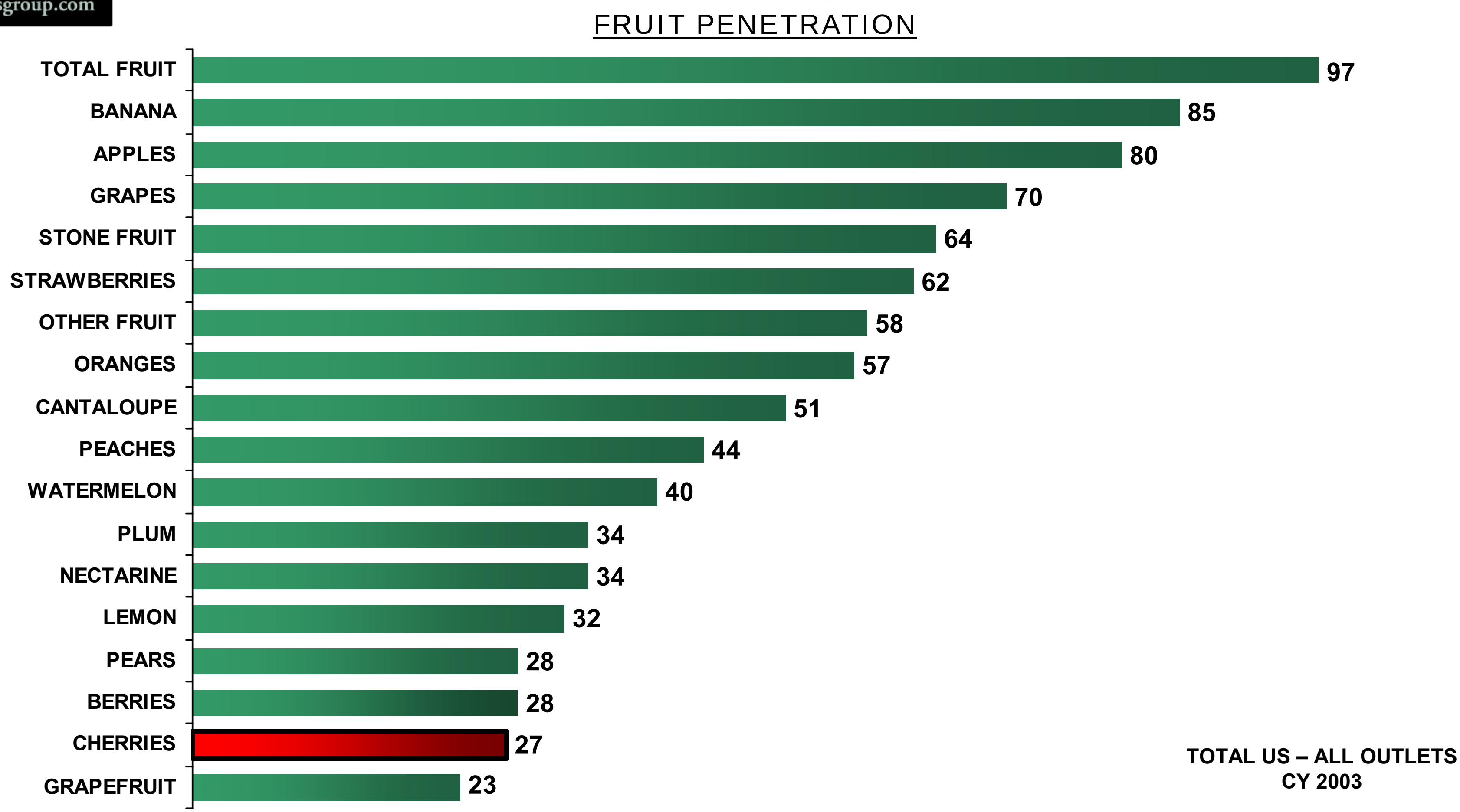
Consumer Shopping Behavior

- **Benchmarking penetration across fruit categories**
  - ***Penetration of cherries is relatively low compared to other fruits, at 27%. Less than 1 out 3 households are purchasing the cherry category annually.***

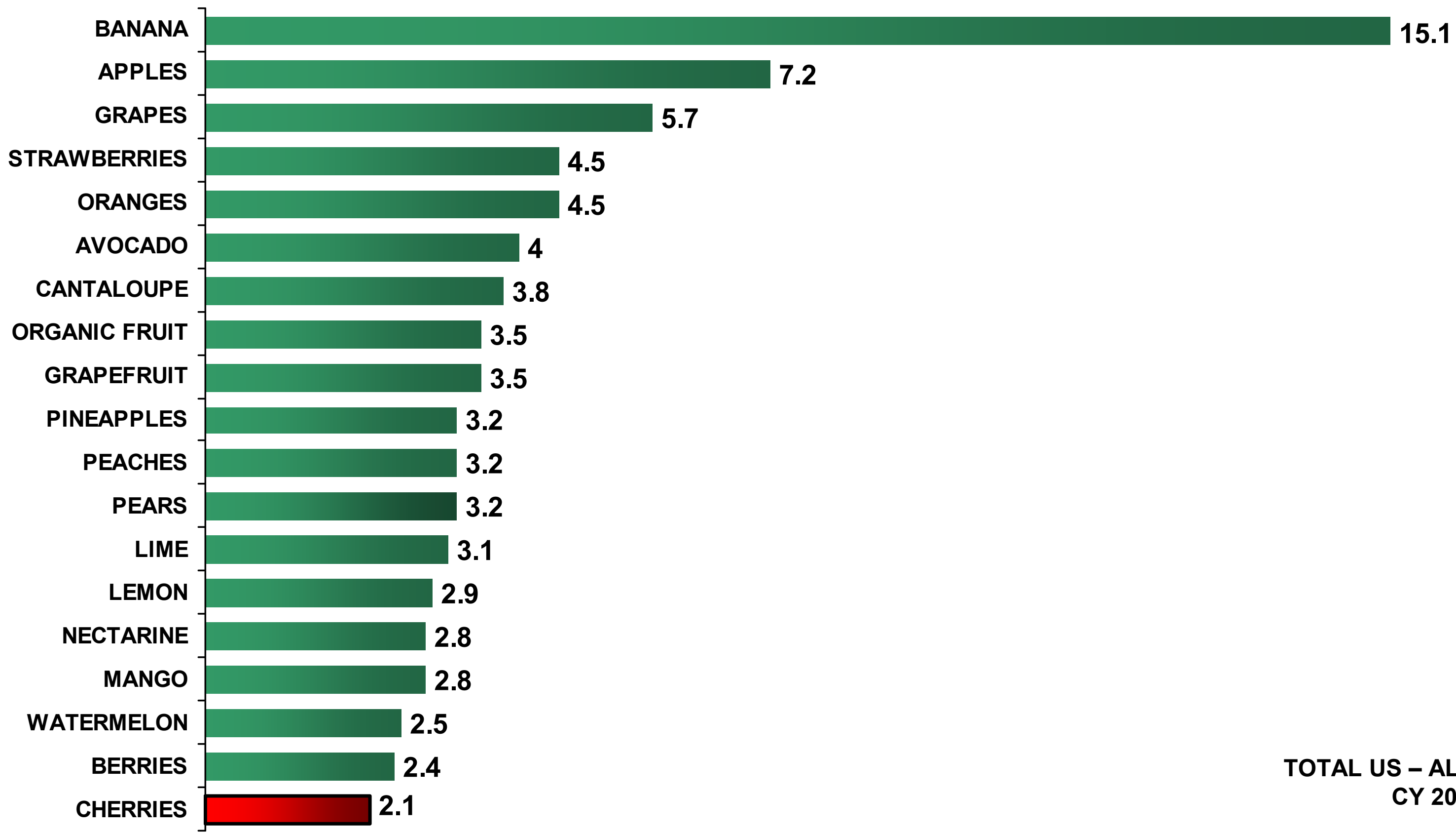


Penetration = % of HHs that purchases the product atleast once.

Consumer Shopping Behavior

- **Benchmarking frequency across fruit categories**
  - ***Cherry buyers are making roughly 2 trips per year***

FRUIT FREQUENCY



TOTAL US – ALL OUTLETS
CY 2003

Frequency = The average annual number of product purchase occasions.

Source: ACNielsen Homescan Panel Data, 2004

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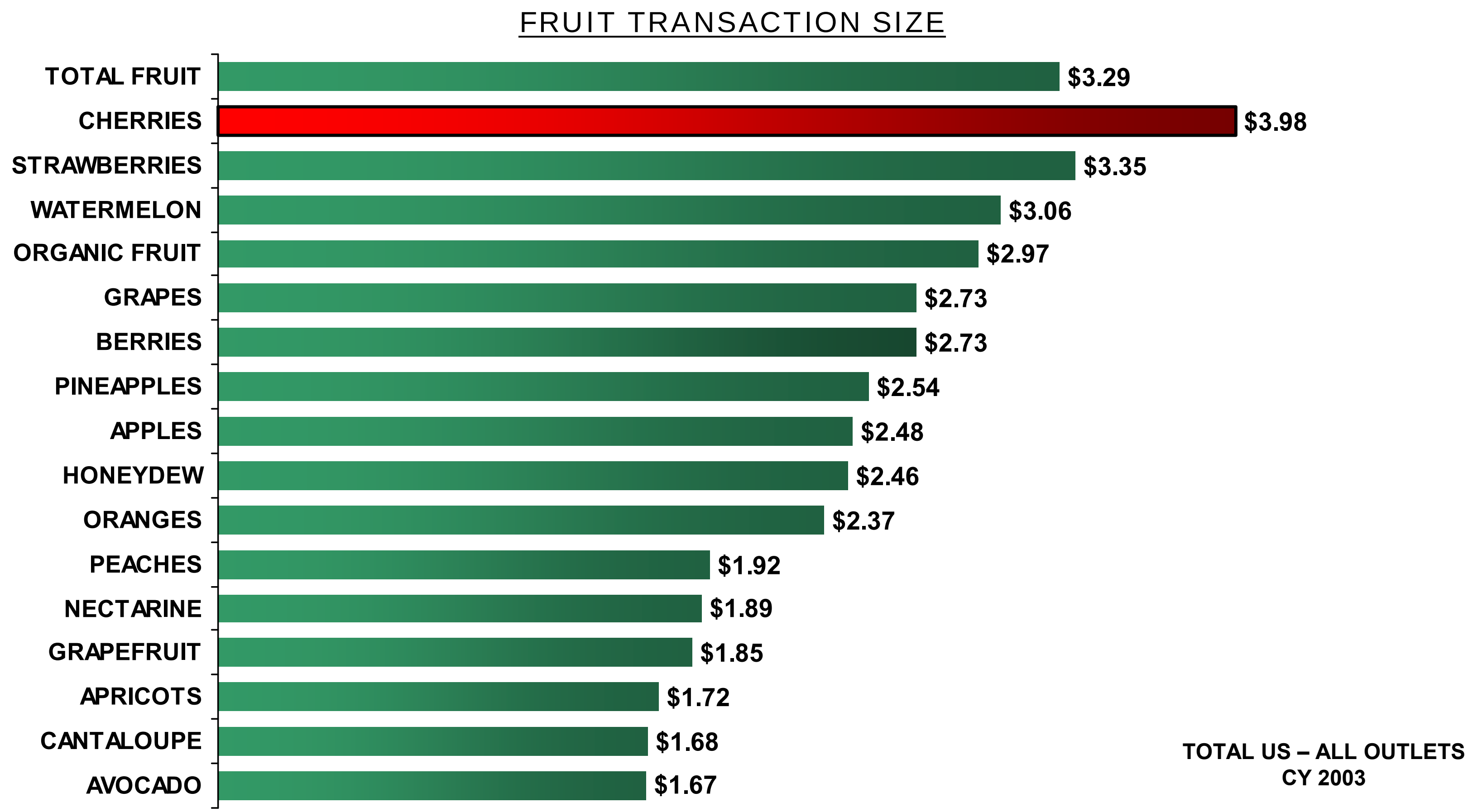
Consumer Shopping Behavior

- **Benchmarking transaction size across fruit categories**
  - ***The average cherry consumer spends $3.98 per trip, the highest of all fruits***



Dollars per Trip = The average dollars spent per product purchase occasion.

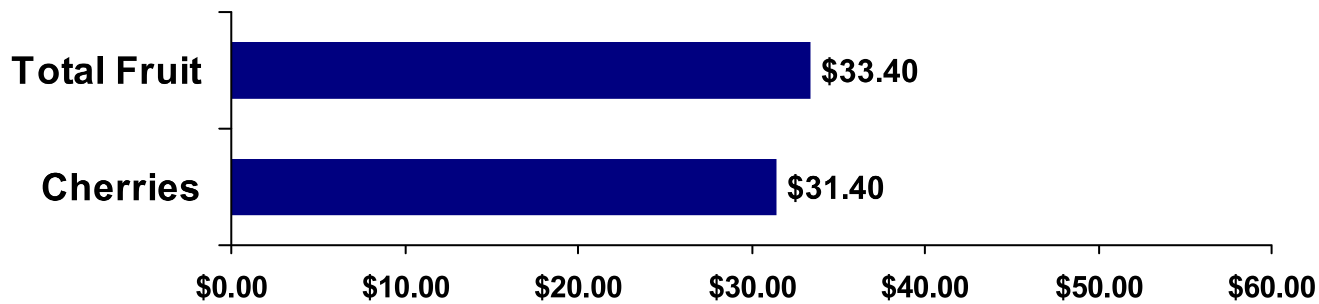
Consumer Shopping Behavior

Market Basket Size

- ***The average dollar value of the shopping basket is $52 when cherries were included. This is double the basket when cherries were absent. Cherries add significant additional shopping basket spending dollars to the retailer, even more than the average fruit.***

MARKET BASKET SIZE
When Fruit/Cherries are in Basket

MARKET BASKET SIZE
When Fruit/Cherries are Not in Basket



Source: ACNielsen Homescan Panel Data, 2004

Findings

- In terms of the <u>total produce department</u>, Cherries rank 1st in total department productivity ($/sq ft) for both years but have nearly the smallest category space allocation in total produce department

- During the season, Cherries generated nearly double the dollars per square foot of display space as the other fruit categories

- In terms of dollars generated per square foot during the season, Cherries were ranked #1 in 6 out of 7 months covered during this study
- Cherry display allocation showed a broad range through the season, but never commanded shelf space similar to other top performing seasonal fruit items. During the season, cherry space ranged from 12 square feet to very small displays of approximately one carton (1 sq. foot)

- Several key categories utilize large amounts of produce department space yet generate relatively low productivity per square foot
  - *Citrus, melons, tomatoes are examples of categories with high space allocation and low relative productivity*

CALIFORNIA CHERRY ADVISORY BOARD

Northwest Cherries

Some Questions for Discussion

- How do we increase our customer base given our low penetration and high costs?
- What role should health research play into this?
- What tools do sales desks need to motivate retailers to provide more display space for cherries?
- What should CCAB/WSFC be doing to increase consumer awareness of cherries?
- Are there any holes in the research that need filling?

Emerging Markets- Russia

- Russia is world’s largest cherry importer
- Market feasibility study conducted in summer 2007
- Major suppliers (Poland, Uzbekistan, and Turkey) account for the largest share of imported cherries
- ***Russian demand increasing*** – consumption increased 38% between ’00 and ’05; imports increased nearly 60% in last three years
- Is there room for US cherries?

Russia Recommendations

- Educate Russian importers about US cherry availability
- Educate about US cherry quality and safety
- Consider Russian trade show participation
- Conduct reverse trade missions and media tours
- Apply for grant funds to help cover costs

Other Markets?

BRYANT CHRISTIE INC.
INTERNATIONAL AFFAIRS MANAGEMENT
REPORT

CALIFORNIA CHERRY ADVISORY BOARD
WASHINGTON STATE FRUIT COMMISSION
COMPREHENSIVE INDUSTRY STRATEGIC PLAN (CISP)
WORKSHOP FINDINGS AND RECOMMENDATIONS

CALIFORNIA
CHERRY ADVISORY BOARD

Northwest Cherries

"We've all met and now trust each other and know that if we have a crisis we will be there to cover each other."

-- US Fresh Cherry Industry Member

Prepared by Bryant Christie Inc.
for the California Cherry Advisory Board and
the Washington State Fruit Commission

October 20, 2006

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I. INTRODUCTION

The California Cherry Advisory Board (CCAB) and the Washington State Fruit Commission (WSFC) representing the Northwest cherry industry agreed to develop a Comprehensive Industry Strategic Plan (CISP) for the US fresh sweet cherry industry. To initiate the plan, CCAB and WSFC board representatives met for a half-day workshop at the Benson Hotel in Portland, Oregon on March 1, 2006. The industry group hired Bryant Christie Inc. (BCI) to facilitate the workshop and draft recommendations for the CISP. Workshop participants included:

CCAB	WSFC	BCI
Jim Culbertson, Staff	B.J. Thurlby, Staff	James Christie
LaVerne Collins, Staff	Teresa Baggarley, Staff	Mike Rucier
Arnie Toso	Norm Gutzwiler	
Mike Collins	Jim Kelley	
Tom Gotelli	Kyle Mathison	
Jeff Colombini	Valerie Woerner	
Ralph Santos	Bryce Molesworth	
Lawrence Sambado	Bob Bailey	
	David Severn, staff	
	Keith Hu, Staff	

The objectives of the meeting were to:

- Review and discuss current world trade and demand for sweet cherries
- Identify and define production, sales, and trade challenges
- Identify what is already being done to address these challenges
- Outline what the California and Northwest industries can do to resolve remaining barriers

Based on the discussion during the meeting, this report includes conclusions and recommendations for the US fresh sweet cherry industry to consider as it develops a long term plan. For more information about the findings presented in this report, please contact:

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II. EXECUTIVE SUMMARY

Representatives from the California Cherry Advisory Board (CCAB) and the Washington State Fruit Commission (WSFC) representing the Northwest cherry industry held a joint meeting on March 1, 2006 to discuss challenges and opportunities facing the US fresh sweet cherry industry. The objectives of the meeting were to:

- Review and discuss current world trade and demand for sweet cherries
- Identify and define production, sales, and trade challenges
- Identify what is already being done to address these challenges
- Outline what industry can do to resolve remaining barriers

This report summarizes the group's discussion and includes conclusions and recommendations to help the US fresh sweet cherry industry formulate its Comprehensive Industry Strategic Plan (CISP).

Overall, the CCAB and WSFC representatives found that the two organizations already collaborate on a number of initiatives related to production research, trade policy, marketing, and health research. However, more can be done to strengthen these ties. In particular, CCAB and WSFC should:

- Explore grant opportunities to help fund research on the possibility of conceptualizing, developing, and testing mechanical harvesting methods
- Seek university support and grant opportunities to fund research to explore the benefits and challenges of converting existing orchards to a "fruiting wall" system to aid in harvest
- Develop a long-term research plan to improve product quality and safety through chemical usage, orchard management, and varietal development
- Continue to address retailers' desire for single-source supply-managers by considering further alliances within the industry such as sales desk consolidation and packing shed management
- Make it standard operating procedure to coordinate trade policy efforts between the two organizations
- Explore grant opportunities to conduct exploratory research in India, China, and Russia
- Seek partnerships with European suppliers to gain a better understanding of competitive factors in Europe and to help define windows of opportunity
- Share representatives and resources where is makes sense to do so
- Form a Nutritional Committee to develop and implement a health research plan

At the conclusion of the meeting, the CCAB and WSFC representatives were complimentary of this CISP process and eager to work together to ensure the long-term health of the US fresh sweet cherry industry.

III. GLOBAL SUPPLY AND DEMAND FOR SWEET CHERRIES

Cherries are commercially produced in more than 60 countries and offer some of the highest margins in retail produce sections. With their relatively short season, cherries are in high demand. In response, many of the world's top producing areas are expanding production. In fact, global cherry production has steadily increased in the last decade, rising 27% between 1994 and 2004.[1] As the world's second largest sweet cherry producer behind Turkey, the United States is poised for expansion. Primarily grown in the Western states of Washington, Oregon, and California, US sweet cherry production could increase by 50% in the next five to ten years based on current plantings. Turkey continues to set new records annually and China, while not a dominant global player currently, could account for one-third of the world's total output in the next ten to fifteen years. With production continuing to increase around the world, the US industry is seeking to address challenges to remain competitive, while exploring opportunities to expand distribution in existing and new markets. This section provides additional information about global cherry production and trade.

PRODUCTION

The United States accounts for 13% to 14% of the world's cherry production. Turkey produces a similar amount with Iran coming in a close third at 12%. Other key producers include Germany, Russia, Italy, Spain, the Ukraine, France, and Syria. The following table shows production for both tart and sweet cherries for the top ten producing countries between 2000 and 2005.

Top Ten Global Cherry Producing Countries (2000-2005)
(18-lb. boxes)

Cherries Production (18-lb. Boxes)	**Year**					
	2000	**2001**	**2002**	**2003**	**2004**	**2005**
Turkey	28,169,889	30,619,444	25,720,333	32,456,611	30,007,056	31,844,222
United States of America	22,666,962	25,599,080	20,155,433	27,299,929	31,455,355	30,619,444
Iran, Islamic Rep of	26,493,536	26,771,683	26,945,111	27,190,067	27,435,022	27,435,022
Germany	20,784,479	17,134,641	13,472,556	13,227,600	14,697,333	14,697,333
Russian Federation	10,410,611	10,778,044	10,410,611	11,023,000	12,247,778	13,472,556
Italy	17,841,583	13,595,033	15,432,200	13,360,611	11,656,088	13,218,047
Spain	13,827,741	10,484,098	14,107,235	13,224,538	7,691,604	10,937,266
Ukraine	9,332,807	6,724,030	8,879,639	9,038,860	10,447,354	9,798,222
France	8,144,037	6,807,192	8,423,899	6,225,056	7,208,920	8,940,878
Syrian Arab Republic	6,893,662	6,221,259	4,865,797	4,866,042	4,862,368	4,862,368

Source: FAO Agricultural Database

[1] Statistical database maintained by the Food and Agriculture Organization (FAO) of the United Nations. Database does not distinguish between tart and sweet cherries.

**Top Ten Global Cherry Producing Countries (2000-2005)
(20-lb. boxes)**

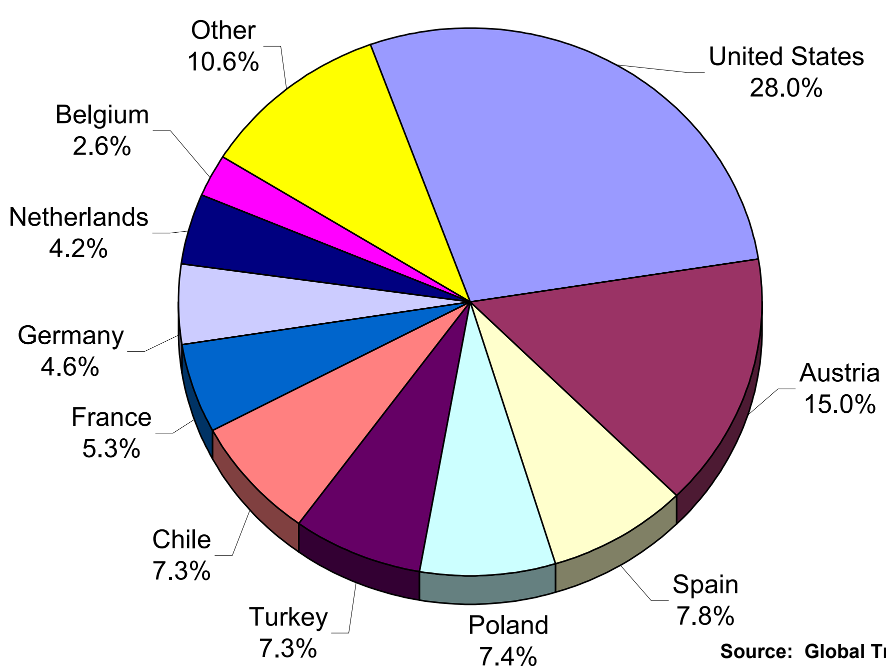
Cherries Production (20-lb. Boxes)	Year					
	2000	**2001**	**2002**	**2003**	**2004**	**2005**
Turkey	25,352,900	27,557,500	23,148,300	29,210,950	27,006,350	28,659,800
United States of America	20,400,266	23,039,172	18,139,890	24,569,936	28,309,820	27,557,500
Iran, Islamic Rep of	23,844,182	24,094,514	24,250,600	24,471,060	24,691,520	24,691,520
Germany	18,706,031	15,421,177	12,125,300	11,904,840	13,227,600	13,227,600
Russian Federation	9,369,550	9,700,240	9,369,550	9,920,700	11,023,000	12,125,300
Italy	16,057,425	12,235,530	13,888,980	12,024,550	10,490,479	11,896,242
Spain	12,444,967	9,435,688	12,696,512	11,902,084	6,922,444	9,843,539
Ukraine	8,399,526	6,051,627	7,991,675	8,134,974	9,402,619	8,818,400
France	7,329,634	6,126,473	7,581,509	5,602,550	6,488,028	8,046,790
Syrian Arab Republic	6,204,296	5,599,133	4,379,217	4,379,438	4,376,131	4,376,131

Source: FAO Agricultural Database

EXPORTS

Although Turkey and Iran are relatively large producers, they play a less dominant role in terms of exports. **The United States accounts for the largest share of the global fresh sweet cherry exports** (28%) followed by Austria (15%) and Spain (7.8%). Turkey ranks fifth with 7.3% of the world's exports while Iran does not appear to export any cherries. **Key export markets for the United States include Japan, Canada, Taiwan, the United Kingdom, and Hong Kong**. In its top three markets, the United States is by far the largest supplier. Austria and Spain's top markets are within Europe and include Germany, Belgium and the Netherlands, the United Kingdom, and Italy. The following graph illustrates the relative size of key fresh sweet cherry exporting countries. Additional information showing the destination for each country's exports is available in the appendix of this report.

Top Ten World Sweet Cherry Exporters (2004)

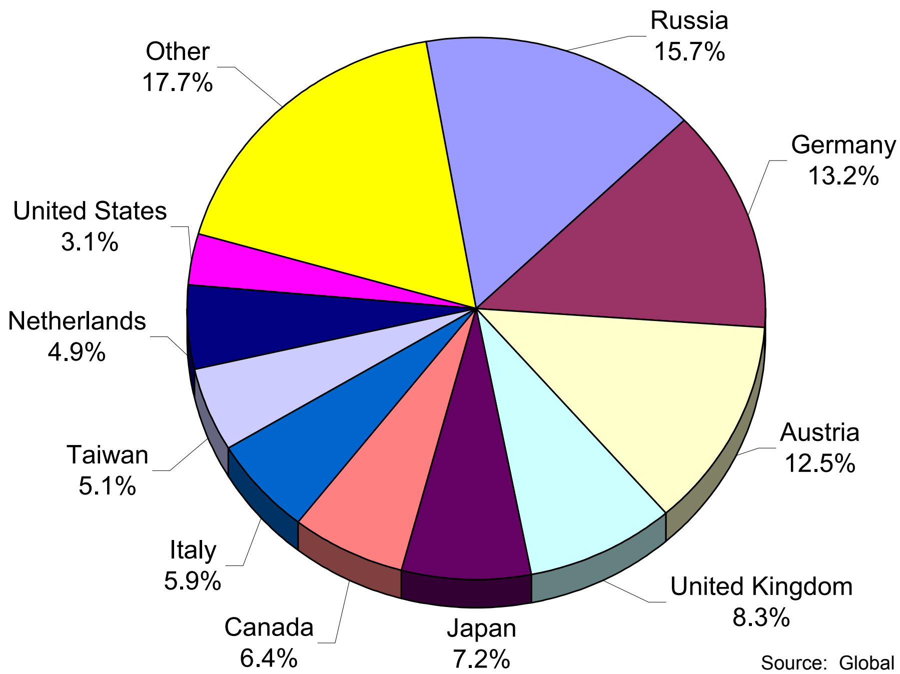


Source: Global Trade Atlas

IMPORTS

Top fresh sweet cherry importers include Russia (15.7%), Germany (13.2%), and Austria (12.5%). **While these are the world's top import markets, the United States exports little if any fresh sweet cherries to these countries**. In fact, in the last five years, US shippers exported an average of less than 100 boxes per year to Russia, fewer than 3,000 boxes to Germany, and an average of only about 150 boxes to Austria. The following graph illustrates the relative size of the world's top ten sweet cherry importers, and the appendix of this report contains details regarding suppliers to each of these countries.

Top Ten World Sweet Cherry Importers (2004)



Source: Global Trade Atlas

The large demand in Russia, Germany, and Austria would suggest an opportunity for the United States. However, **US shippers must overcome competition to succeed**. The top three exporters to Russia include Poland, Uzbekistan, and Turkey. Germany's top suppliers include Austria, Spain, and Italy. Finally, Austria gets most of its cherries from Turkey, Italy, and Germany. Based on statistics, it appears that the same countries, particularly Austria and Germany, are sending cherries back and forth. Since Germany and Austria share a border, there might be transshipments causing this statistical anomaly.

From this data, it would appear that Europe is the top market for cherries both on the import and the supply side with Turkey playing an important export role. Suppliers within this region enjoy preferential tariffs and taxes, and have much lower transportation costs compared to the United States. It is clear that Europe is an important market for cherries. However, **the United States must demonstrate characteristics other than price to attract European buyers**. For instance, European retailers often suggest that the quality of California and Northwest cherries is much better than that of cherries produced in Europe or Turkey. **US suppliers should capitalize on this quality difference to compete in European markets.**

The United Kingdom is one market where the United States is relatively competitive with European suppliers. On average, the United States represents approximately 13% of the fresh sweet cherry market in the UK. However, Spain with 28% of the market and Turkey with 29% are the top suppliers. Although the United States ranks among the top three exporters to the UK and this is the fourth largest export market for the US industry overall, California and Northwest sweet cherry suppliers ship less than half of the next largest supplier to the UK. The United States is able to demonstrate the quality differences of US fruit in many retail chains in the UK, but a lower price from other European suppliers creates significant competitive pressures.

To expand its market share in its only strong European market, **the United States must continue to differentiate itself from European competition in terms of quality**. Fortunately, a few higher-end retailers such as Marks & Spencer and Waitrose prefer to stock higher quality US fruit knowing their customers are willing to pay a premium for quality. Most of the main retail chains in the UK are starting to open higher-end "convenience" stores located in the high streets of main metropolitan areas, particularly throughout London. Such stores include Tesco Express, Sainsbury Local, Marks & Spencer's Simply Foods, among others. These chains appeal to a higher-income consumer looking for a snack during work or to pick-up a quick meal on the way home. **US suppliers of premium quality cherries have an opportunity to expand distribution to these types of retail outlets.**

IV. PRODUCTION

Much of the workshop discussion focused on production challenges facing the California and Northwest cherry industries. Workshop participants tried to determine what constraints currently impede production. Results of this discussion are outlined below.

CHALLENGES

The workshop participants covered many different production challenges, including labor, environmental regulations, transportation, packaging styles, food safety regimes, retail consolidation, and product quality. The following discusses each of these areas in greater detail.

Labor

Workshop participants were most concerned with labor issues. Like other tree fruits, the US sweet cherry industry is heavily dependent on migrant labor to assist with harvest from picking the fruit to sorting and packing. However several issues are complicating the west coast temporary labor market including immigration reform, safety regulations restrictions on the use of ladders in orchards, housing regulations for temporary workers, increasing minimum wage standards, and rising incomes in Mexico. **Addressing these labor challenges is perhaps the single most important factor to maintain the long term health of the US fresh sweet cherry industry.**

Environmental Regulations

Increasing federal and state environmental regulations are creating a growing burden on US agriculture in general. But Washington, Oregon, and California are particularly affected by some of the strictest environmental standards in the country. These standards cover a wide variety of areas including pesticide use, watershed management, spray drift restrictions, soil contamination, etc. **It has become increasingly difficult and costly to grow agricultural goods at a competitive price given the increasing environmental regulations that add significant costs to the production process.**

Transportation Challenges

The US cherry industry also faces transportation challenges. Rising fuel costs have increased trucking, shipping, and air freight rates for all producers. However, **the long distances US cherries must travel to reach foreign ports puts it at a comparative disadvantage to the competition**, particularly European suppliers in European markets. The majority of US exported fruit is air freighted which adds even greater costs compared to trucking rates. Furthermore, airline cutbacks mean fewer planes are departing for foreign ports. A lack of available cargo space puts a further premium on costs and restricts shipping flexibility. This is especially problematic around Memorial Day for California and Independence Day for the Northwest when each of the respective industries are reaching their harvest peak.

Packaging Styles

Ultimately, the goal of a seller is to create a satisfied customer, which means keeping retailers happy. Unfortunately, retailers are very picky about how their cherries are packaged. Increasingly, retailers are seeking to present their cherries in some type of consumer pack versus bulk displays. The benefits to the retailer are numerous and include a reduction of shrink, unitizing cherry sales, fewer consumer claims from falls in the produce section, less handling of the fruit, etc. However, each retailer has different demands for the types of packaging they prefer, and these preferences often change from one year to the next. Shippers are left with large inventories of packaging, must adjust machinery to accommodate different pack styles, and realize reduced profit margins due to the added cost of the packaging and shipping. Although the majority of cherries are still shipped in bulk, **increasing demands from retailers for consumer packaged cherries are driving up the costs of production for the US cherry industry**.

Food Safety Regimes

In addition to packaging styles, retailers are also becoming increasingly involved in regulatory matters, further adding to the cost of production. European retailers are now often requiring their suppliers to be certified by one or more food safety programs including EurepGAP, the British Retail Consortium (BRC), and/or Tesco's Natures Choice. Each of these programs has rigorous requirements that add a significant cost to suppliers in terms of time and labor. These requirements are particularly problematic for smaller companies that have very few staff members available to address the requirements and file the associated paperwork. Rising food safety concerns around the world almost guarantee that these regulatory programs will spread beyond Europe and will be the norm rather than the exception. **US companies will need to conform to these regimes if they want to continue exporting.**

Retail Consolidation
Retailers grow more and more powerful each year as consolidation reduces the number of players. These powerful retailers are starting to select a few suppliers in key areas to act as category managers. Therefore, one retailer might have a single distributor that ensures cherries fill their shelves as many months out of the year as possible (pulling from southern hemisphere suppliers to fill shelves during winter months). Consolidation and buying concentration pose several problems. Most importantly, such a climate greatly restricts access for smaller companies. Furthermore, if a supplier falls out of favor with one retailer, there are few alternatives.

TESCO

Product Quality
One advantage of retail consolidation for the consumer is a more consistent product. Retailers are requiring that perfect produce be on their shelves throughout the year. With so many southern hemisphere suppliers expanding distribution, gone are the days of seasonal products. Consumers expect to see apples, pears, and tree fruit 12 months out of the year, and they expect each piece of fruit to taste exactly like it did the last time they purchased that item. Retailers are fueling this consumer demand for consistency by increasing standards for quality from suppliers.

Unfortunately for the cherry industry, it is very difficult to produce consistently high quality fruit throughout the growing season. The vast number of varieties aggravates this problem. The majority of cherry growers would agree that the Bing variety offers the best color, taste, and crunch of any cherry variety. It is no coincidence that Bings are the primary sweet cherry produced. However, in an effort to extend the cherry season, growers have invested heavily in earlier and later varieties compared to Bings. These other varieties can be less appealing. For example, early fruit is often subjected to more damage from spring rains that, while having no affect on flavor, can crack the skins making the cherries unsuitable for mainstream sales.

A lack of variety definition makes it difficult for consumers to understand these quality differences. A red cherry is a red cherry. Therefore, **a consumer might have a bad experience early in a season and not buy again for some time**. California attempts to address this problem by focusing its marketing efforts solely on the Bing variety whereas the Northwest industry promotes all varieties.[2] Nevertheless, even with California's attempt to promote the "Bing as king," other red cherries are available 30 days or more before Bings hit store shelves. Consumers lack an understanding that these cherries are going to be different from those that arrive later in the season. **The wide quality differences between varieties could limit demand later in the season.**

[2] California is beginning to grow and promote more Rainier cherries. These are considered a white (or yellow) cherry and are therefore differentiated from their red cherry cousins.

SOLUTIONS

Industry's ability to overcome production challenges is somewhat limited. Labor issues will continue to impact farming communities, it is unlikely fuel costs will fall, and retailers will continue to emphasize product safety, packaging, and quality. Nevertheless, the US fresh sweet cherry industry is exploring some options to help address a few of these issues.

Labor

Reducing the need for labor is perhaps the biggest area of concern within the US fresh sweet cherry industry. Packing houses are becoming increasingly more sophisticated and are helping to lower production costs. Optical sorters are starting to replace manual labor on packing lines, and additional machinery is allowing for flexibility in pack styles. Furthermore, many of the packing sheds are starting to combine their sales forces to penetrate the increasingly consolidated retail sector. As a result, the industry is starting to consolidate and multi-state operations are becoming more common.

Despite these advancements, fresh sweet cherries are still harvested like they have been for centuries: hand picked by workers on ladders. Industry is exploring several options to reduce the labor necessary for harvest as well as improving worker safety. **Mechanical harvesting is one area under consideration** but is still in the conceptual stage. It will likely be many years before any practical application is developed. Another solution requires growers to change how they grow cherries. **There is research and experimentation with planting and pruning trees in such a way so they create a "fruiting wall."** This allows pickers to stand on a moving platform that runs between rows of the trees requiring less labor to pick the fruit and removes the need for ladders which would address increasing safety concerns. Because of the capital investment required in replanting an orchard, and the uncertainty on the affects this method would have on yields, it would be some time before an entire industry could convert to this progressive style of production.

Environmental Regulations

Rising concerns regarding food safety ensures that environmental regulations for food production will only become stricter as time passes. Such regulations force industries to explore the efficacy of chemicals and growing practices deemed safer for the environment. **There are online resources to help industries to better understand regulations around the world concerning chemical usage**. One website in particular, www.mrldatabase.com, funded by the USDA's Foreign Agriculture Service (FAS), provides the maximum residue limits for chemicals that have a permanently established tolerance with the US Environmental Protection Agency on specialty crops for 76 countries in addition to tolerances for the European Union and Codex. Referring to this database allows growers to better understand what chemical products can and cannot be used when planning for export sales. Both the California and Northwest cherry industries utilize this database in their trade policy program which seeks to harmonize sweet cherry MRLs around the world with US tolerances. Such cooperation within the sweet cherry industry helps to avoid a duplication of effort and allows the US industry to speak with a common voice during trade negotiations.

In addition to trade policy work, the California and Northwest sweet cherry industries cooperate in other ways that benefit the environment. In particular, t**he industries share findings from research activities on growing and harvesting, chemical efficacy, water usage, etc**. While varied growing environments necessitate different research needs, **there is already a strong spirit of cooperation between the California and Northwest cherry industries**.

Transportation Challenges

Transportation challenges are difficult to address on an industry-wide basis. The issue of a lack of "lift" (a dearth of airfreight cargo space during the season) could be addressed by the industry through the use of chartered planes, particularly to foreign ports. The industry could easily fill entire planes during periods of heavy usage. This would guarantee shippers cargo space and could allow the entire industry to negotiate for cheaper rates. However, the challenges of timing such shipments combined with the extremely high level of coordination required, make chartered flights a difficult endeavor.

Customer Satisfaction

Industry must continue to satisfy retailers who are making more and more strict demands on food safety, packaging options, and product quality. As the number of retailers shrinks through consolidation, **suppliers must work even harder to make sure their partners remain happy, while maintaining healthy profit margins for growers**. The California and Northwest sweet cherry industries are already taking steps to improve their position with retailers with some operations **consolidating sales desks and coordinating packing shed management**. In this way, suppliers can ensure their product has a customer and industry has greater flexibility managing quality, pack styles, and supply volumes.

RECOMMENDATIONS

While the California and Northwest cherry industries already cooperate in a number of areas in respect to overcoming production challenges, there is room for additional collaboration. In particular, CCAB and WSFC should:

- Explore grant opportunities to help fund research on the possibility of conceptualizing, developing, and testing mechanical harvesting methods
- Seek university support and grant opportunities to fund research to explore the benefits and challenges of converting existing orchards to a "fruiting wall" system to aid in harvest
- Develop a long-term research plan to improve product quality and safety through chemical usage, orchard management, and varietal development
- Continue to address retailers' desire for single-source supply-managers by considering further alliances within the industry such as sales desk consolidation and packing shed management

V. TRADE POLICY

The US fresh sweet cherry industry exports an average of 29% of its annual production. Clearly, export markets are important to this industry and will remain important in light of expected production increases in the medium and long term. This section of the report outlines some of the key markets for the US industry, explains what barriers exist in those markets, what the industry is doing to overcome these barriers, and other actions the industry might consider to ensure foreign demand remains strong in the decades to come.

TARIFF AND NON-TARIFF BARRIERS

In 2005, the US fresh sweet cherry industry's top ten export markets in order of sales included (1) Japan; (2) Canada; (3) Taiwan; (4) United Kingdom; (5) China/Hong Kong; (6) Australia; (7) Korea; (8) Norway; (9) Mexico; and (10) Sweden. Noticeably absent from this list are continental European countries and Russia, which was the world's largest cherry importer. As discussed in Section III of this report: "Global Supply and Demand," US fresh sweet cherry suppliers have a comparative disadvantage when shipping to continental Europe compared to other European and Turkish suppliers. Therefore, top markets for the US remain within Asia/Oceana, North America, and parts of Europe outside of the continent. While the US is the world's top exporter, California and Northwest cherry shippers face many regulatory and market challenges that impede sales. Overcoming these challenges will help improve global demand for US fresh sweet cherries.

US fresh cherry shippers face a number of tariff and non-tariff barriers depending on the export market. The following table identifies several key markets for the US cherry industry, technical barriers in that market, and what is being done to resolve those issues.

Market	Barrier	Means of Resolution
Korea	• Tariff (24%) • Fumigation requirement	• Request tariff reduction in US-Korea Free Trade Agreement Talks (FTA) • Harmonize fumigation requirement between Korea, Australia, and Japan
Australia	• NW: Leaf and debris; powdery mildew • CA: presence of mites requiring double fumigation treatments • No access to Western Australia due to phytosanitary restrictions	• Research to mitigate problem • Harmonize fumigation requirement between Korea, Australia, and Japan; considering options for fumigation upon arrival in Australia • Work with Australia government to address phytosanitary concerns
Canada	• Revising MRL Regime (eliminating default 0.1 ppm mrl)	• Harmonize with US standards

Market	Barrier	Means of Resolution
Japan	• Fumigation requirement • Japan recently adopted its own MRL regime	• Coordinated research in California and Northwest is being done on systems approach to eliminate the need for fumigation; considering ozone as a replacement • Systems approach must address Western Cherry Fruit Fly concerns in the NW and codling moth pressure in California from walnuts • Harmonize with US standards
Thailand	• High Tariff - 40% or 33.50 THB/KG (US$0.85/KG) whichever is higher	• Seek concessions in the US-Thai FTA talks which began June 2004 but are now on hold due to political unrest in Thailand
India	• High Tariff (30%)	• No US-India FTA talks planned therefore imminent resolution is unclear
China	• Access denied for California during the 2005 and 2006 seasons; market reopened at end of 2006 season but Medfly trapping program necessary (CA only) as well as a list of approved exporters • Inspection requirement (5%)	• While APHIS continues to negotiate for the elimination of the MedFly trapping program, industry must currently comply with this requirement as well as submitting an exporter list • APHIS working to lower inspection rate
EU	• EU is currently developing an EU chemical residue regime to which all member countries must comply	• NW and CA have been monitoring to ensure trade is not disrupted
UK	• Most retailers require suppliers to conform to one or more food safety regimes (Eurepgap; BRC; Nature's Choice)	• Seek harmonization of requirements between the competing regimes
Mexico	• Market closed for CA in 2004 and 2005 due to disagreements regarding inspection rate and the need for shippers lists	• Issue resolved and market reopened for the 2006 season

RECOMMENDATIONS

The California and Northwest cherry industries work very closely with each other and with the US government to resolve technical barriers that inhibit US fresh sweet cherry exports. While many issues are specific to one growing region, the two industries ensure that the resolution of an issue in one growing region does not negatively impact access for the other region. Furthermore, the California and Northwest industries coordinate all work on issues that transcend state borders such as reducing tariffs or harmonizing maximum residue levels. Continuing this close cooperation is absolutely necessary to project a common voice in foreign markets and should become a standard operating procedure to coordinate efforts between the two organizations.

VI. MARKETING

While the California and Northwest cherry industries already work closely together on trade policy efforts, coordination on market development efforts is less defined. Differences in seasonal timing create varied marketing challenges for the two industries. These differences often require California and the Northwest to initiate diverse market development strategies. Where it makes sense to do so, California and the Northwest share representatives (such as in Australia) or share results from research studies on potential new markets. However, there are several areas where the two organizations can improve their cooperation to leverage resources to help expand demand for US cherries.

POTENTIAL MARKET DEVELOPMENT COOPERATION

During the workshop between representatives of the California Cherry Advisory Board and the Washington State Fruit Commission, meeting participants identified several areas where they would like to see coordination between the California and Northwest industries. The following table outlines such potential areas of cooperation:

Market	Potential Areas of Cooperation
China	• Research on Chinese cherry production and marketing plans to better understand competitive threat from domestic Chinese cherries • Research on promotional opportunities to identify key trade channels and to better understand consumer preferences • Coordination of reverse trade missions to bring buyers through the respective growing areas • Joint reception in China to kick off the entire US cherry season
Europe	• Exhibit in a joint booth at the annual Fruit Logistica trade show next held in Berlin, Germany February 8-10, 2007 • Establish partnerships with European suppliers to better understand their market timing each year which will help identify windows of opportunity for California and the Northwest
Australia	• Continue sharing an in-country representative and coordinating promotional messages to allow for cost sharing in merchandising, promotional material development, and evaluation research
Korea	• Coordinate promotional messages that can be communicated through a season-long public relations campaign • Develop joint promotional materials that can be used throughout the season
Russia	• Share existing information and collaborate on future research and market development activities
India	• Share existing information and collaborate on future research and market development activities

HEALTH RESEARCH

Cherries offer many unique health benefits that the world is only beginning to understand. The processed cherry industry in the Midwest has funded numerous studies on the antioxidant/anti-inflammatory benefits of eating tart cherries. The sweet cherry industry has been looking at some of these same benefits including a study completed in June 2004 that suggests eating fresh Bing cherries can help people who suffer from gout or other forms of arthritic inflammation. Subsequently, the Northwest is leading an effort through Produce-for-Better Health to conduct a literature review and to develop a plan for future health research.

Results from the research on the health benefits of eating cherries are important for future promotional campaigns. However, **the industry must better understand these benefits, particularly in relation to fresh sweet cherries before it can communicate those results in the most appropriate way for each market**. The California and the Northwest cherry industries have already started several uncoordinated initiatives. However, **industry can leverage its resources by working together to develop a comprehensive health research plan**.

A health research plan would provide many benefits, but four areas are of particular importance. First, a research plan would identify what is already known about cherry health benefits. This will provide the US sweet cherry industry with a benchmark for any future studies and serve as a foundation for the health research program. Second, a plan would help prioritize future research activities so that results provide the largest return in terms of their promotional potential. Third, it would provide industry with a plan to seek grant support to help fund additional research. Lastly, the plan would address what messages would resonate best with each of the industry's target audiences and how best to communicate those messages. **Ultimately, the cherry industry's research plan must support the industry's promotional effort**.

RECOMMENDATIONS

Based on the potential areas of cooperation that workshop participants outlined during their March meeting, the California Cherry Advisory Board and the Washington State Fruit Commission should:

- Explore grant opportunities to conduct exploratory research in India, China, and Russia
- Seek partnerships with European suppliers to gain a better understanding of competitive factors in Europe and to help define windows of opportunity
- Share representatives and resources where it makes sense to do so
- Develop and execute a health research plan for US fresh sweet cherries, potentially through the development of a Nutritional Committee consisting of representatives from the California Cherry Advisory Board, the Washington State Fruit Commission, and university research institutions

VII. CONCLUSIONS AND RECOMMENDATIONS

Developments in many areas from production technologies to retail consolidation have created an increasingly competitive global environment for fresh sweet cherry sales. California Cherry Advisory Board (CCAB) and Washington State Fruit Commission (WSFC) representatives recently held a joint meeting to better understand these developments and identify areas where the two organizations can leverage resources to ensure the long-term wellbeing of the US cherry industry. CCAB and WSFC already demonstrate a strong spirit of cooperation to coordinate production research, trade policy, marketing, and health research activities. However, more can be done to better coordinate these areas. The following summarizes the outcomes of that meeting and recommendations on how the CCAB and WSFC can strengthen the position of US fresh sweet cherry industry.

Production

CCAB and WSFC representatives cited several factors that increase the cost of production, making US cherries less competitive compared to foreign suppliers. Topics included the rising cost and shortage of labor, environmental regulations, transportation, and the growing power of retailers. To address some of these challenges, CCAB and WSFC should:

- Explore grant opportunities to help fund research on the possibility of conceptualizing, developing, and testing mechanical harvesting methods
- Seek university support and grant opportunities to fund research to explore the benefits and challenges of converting existing orchards to a "fruiting wall" system to aid in harvest
- Develop a long-term research plan to improve product quality and safety through chemical usage, orchard management, and varietal development
- Continue to address retailers' desire for single-source supply-managers by considering further alliances within the industry such as sales desk consolidation and packing shed management.

Trade Policy

CCAB and WSFC have a long history of working together to resolve technical barriers to trade. Such work has extended from seeking tariff reductions during Free Trade Agreement negotiations to working on gaining acceptance for a systems approach to offer an alternative to methyl bromide fumigation. The meeting participants recognized the need to continue working together and pledged to do so. Based on this pledge, CCAB and WSFC should make it standard operating procedure to coordinate trade policy efforts between the two organizations.

Marketing

Despite the strong spirit of cooperation in terms of the industry's trade policy work, CCAB and WSFC have rarely coordinated marketing activities. The timing of the two crops and the varied market development approaches that this timing dictates has been the main factor limiting collaboration. Nevertheless, the CCAB and

WSFC representatives outlined several areas where they could leverage resources and strengthen the global position of US cherries. In particular, the workshop participants suggested CCAB and WSFC should:

- Explore grant opportunities to conduct exploratory research in India, China, and Russia
- Seek partnerships with European suppliers to gain a better understanding of competitive factors in Europe and to help define windows of opportunity
- Share representatives and resources where it makes sense to do so

Health Research
Successfully communicating the health benefits of certain food products can significantly increase demand. Recognizing the importance of health communication in the food business, the sweet cherry industry is interested in learning more about the health benefits of eating cherries and how best to communicate those benefits to generate the greatest demand. Although CCAB and WSFC have already done some research in this area, the two organizations are interested in working more closely to develop and execute a health research plan. Based on this interest, CCAB and WSFC should form a Nutritional Committee consisting of representatives from the two organizations and university research institutions. The focus of this committee would be to help determine the direction of the health research program and to identify grant opportunities to fund such research.

Conclusion
At the end of the one day workshop, the CCAB and WSFC representatives expressed their support of the development a Comprehensive Industry Strategic Plan and most importantly, the need to work together to ensure the long-term health of the US fresh sweet cherry industry. The following are just a few of the positive comments made at the end of the meeting:

> *"We all need to work together. We should have done it a long time ago."*

> *"We've all met and now trust each other and know that if we have a crisis we will be there to cover each other."*

> *"I think we've come a long way. This is really great. I really like the honesty and it shows that we are all interested in working together."*

Clearly, the US fresh sweet cherry industry is enthusiastic and committed to working together to increase global demand for US cherries. The next step for CCAB and WSFC is to consider the recommendations outlined in this report and develop a plan for realizing these recommendations. Such a document would become the industry's Comprehensive Industry Strategic Plan.

Sweet Cherries and Health

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Nutrient, Carotenoid, Anthocyanin and Quercetin content of commonly consumed cherry products (per 100 grams or approx. 15 cherries)

Nutrient /phytochemical	Cherries, sweet	Cherries, tart	Cherries, sweet, canned	Cherries, sweet, frozen, sweetened	Maraschino
Energy (kcal)[a]	**63**	50	46	89	165
Protein (g)[a]	**1.06**	1.0	0.8	1.15	0.22
Fat (g)[a]	**0.2**	0.3	0.13	0.13	0.21
Carbohydrate (g)[a]	**16.0**	12.2	11.8	22.4	42.0
Fiber (g)[a]	**2.1**	1.6	1.5	2.1	3.2
Glycemic Index[b]	**22**	22	22	22	Not available
Vitamin C (mg)[a]	**7**	10	2.2	1.0	0
Vitamin A (IU)[a]	**64**	1283	160	189	45
Potassium (mg)[a]	**222**	173	131	199	21
β-carotene (mg)[a]	**38**	770	96	113	27
Lutein/ Zeaxanthin (mg)[a]	**85**	85	57	85	59
Total anthocyanin (mg)[c]	**80.2**	Not available	Not available	Not available	Not available
Quercetin (mg)[c]	**2.64**	2.92	3.2	Not available	Not available

Cherries: Nutritional Highlights

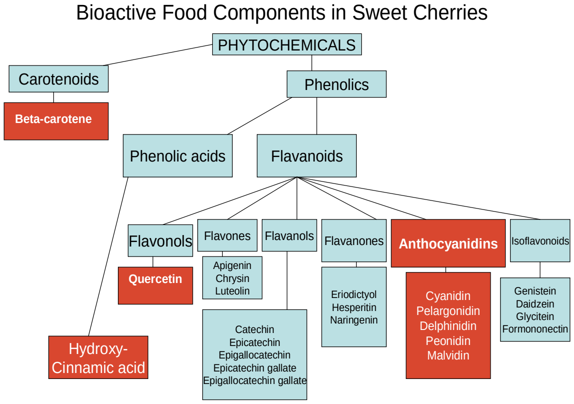
- Low calorie food
- Low fat food
- Provide 7 mg vitamin C per serving; 10% of daily requirement
- Good source of potassium
- Good source of carotenoids
- Low glycemic index (compared to most fruits)
- ALSO, good source of anthocyanin and other bioactive food compounds

Food Sources of Bioactive Food Compounds

Food Source of Select BAFC

Food	BCFA
Sweet Cherries	**Anthocyanins**
Variety of vegetables, fruit	**Carotenoids**
Cruciferous vegetables	**Indoles, isothiocyanates**
Tomato, watermelon	**Lycopene**
Citrus fruits	**Flavonoids, limonoids**
Green tea	**Polyphenols, catechins**
Pineapple	**Bromelaine**
Guava	**Polyphenol and flavonoid**
Spinach	Lutein
Red wine	Resveratrol
Onion, garlic, leeks	Allylic sulfides
Turmeric	Curcumin
Berries	Ellagic acid
Soy foods	Isoflavones/isoflavonoids

Bioactive Food Components in Sweet Cherries



Anthocyanins in Sweet Cherries and Related Plant Foods

	Anthocyanins						Total (mg)
Plant Food (1 cup)	Cyanidin (mg)	Deophinidin (mg)	Malvidin (mg)	Pelargonidin (mg)	Peonidin (mg)	Petunidin (mg)	
Cherries, Sweet	**75.2**	0	0	0.5	4.5	0	**80.2**
Cherries, Tart	6.7	0	0	0	0	0	**6.7**
Cherries, sweet, canned	0	0	0	0	0	0	**0**
Apricots	0	0	0	0		0	**0**
Peaches	1.6	0	0	0		0	**1.6**
Plums	12.0	0	0	0		0	**12.0**
Blueberries, raw	17.0	47.4	61.4	0	11.4	26.4	**163.6**
Raspberries	35.8	0.3	0.7	1.9	0	0	**38.7**
Grapes, red	1.5	3.7	34.7	.02	2.9	2.1	**44.9**
Red Wine	0.4	1.0	7	0	0.8	0.9	**10.1**

Comparison of total anthocyanins, total phenolics, and antioxidant properties of flesh, pits, and skins of different cherry cultivars (after Chavanalikit and Wrolstad, 2004).

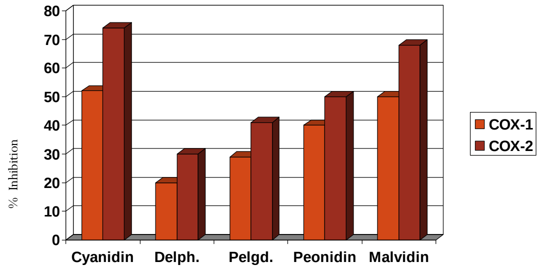
Cultivar	Portion	Anthocyanins (mg/100g fw)[Z]	Total phenolics (mg/ g fw)[Y]	ORAC (µmol TE/g fw)	FRAP (µmol TE/g fw)
Bing (sweet)	Flesh	26.0±0.7	1.34±0.18	9.07±0.35	7.28±0.24
	Pits	10.4±3.1	0.92±0.09	5.94±0.91	5.04±0.96
	Skins	60.6±2.5	3.33±0.41	28.26±1.10	21.05±0.55
Rainier (sweet)	Flesh	0.0±0.0	0.65±0.05	4.62±0.18	2.27±0.22
	Pits	0.1±0.0	0.54±0.04	3.38±0.26	2.00±0.13
	Skins	2.1±0.4	1.42±0.05	10.50±1.51	5.92±0.39
Montmorency (tart)	Flesh	0.0±0.09	3.01±0.29	15.00±1.00	13.81±0.26
	Pits	0.8±0.08	1.57±0.02	9.78±0.28	8.48±0.85
	Skins	36.5±1.6	5.58±0.33	51.02±1.97	47.96±1.33

How do these BAFC Prevent Disease?

- Anti-inflammatory response
- Anti-growth effects
- Differentiation-inducing agents
- Antioxidation / reduction in oxidative stress
- Modify insulin resistance; lower glucose levels
- Enhance drug therapies (quercetin)

Park EJ et al *Cancer Metas Rev*, 2002; Jayaprakasam, 2006; Tsuda, 2003

Anti-inflammatory Effects of Select Anthocyanins in Cell Culture



Individual Anthocyanins Evaluated in Cell Culture
40-mM concentrations

Adapted from: Seerman NP, Zhang Y and Nair MG, *Nutr Cancer* 2003;46(1):101-106

Change in Biomarkers of Health associated with Cherry Feeding in Humans

- 18 healthy adults
- Design: low phenolics(8 days)—Bing cherry feeding (28 days)---no cherry (28 days)
- Measurements: CRP, IL-6, TNFα, blood lipids, glucose/insulin, NO
- Results:
  - 25% decrease in hsCRP at days 28
  - 18% decrease in NO
  - Individual variability in responsiveness was shown with 12/18 = "responders"
  - No change in serum lipid levels or glucose in "healthy" adult subjects

Kelley DS, UC Davis, 2004

Disease-specific Health Effects

- Cancer
- Cardiovascular
- Diabetes / insulin resistance
- Arthritis
- Gout
- Alzheimers Disease

Current Research Needs to Advance the Health Messaging for Cherries

- Additional studies
  - Human; beyond health volunteers
  - Larger sample size
  - Variety of investigators
- Dietary measurement
  - Instruments lack specificity
  - Seasonality of intake
  - Biomarkers of intake
- Collaborations between plant and nutritional scientitists as well as growers

Potential Funding Sources

- USDA Bioactive Food Compounds
- Fruit and Vegetable Improvement Center for Fruit and Vegetable Research (Texas A&M)
- National Cancer Institute
  - Phase I BAFC for chemoprevention
- Industry
  - Pilot studies
  - Preliminary data for larger trials

How to Disseminate Information re: Cherries and Health

- Target Audiences
  - Dietitians, physicians, nurses, exercise physiologists
  - Health Food Stores / grocery
  - Fitness Centers / Weight Loss programs
- Mailings, web-ad (WebMD), Health care magazines (e.g. Arthritis Today, Prevention)
- Media Messages
- Research programming
  - Small grants
  - Research symposia
  - Peer-reviewed publications

SWEET CHERRIES: A RESEARCH REVIEW

Cherries like other fruits and vegetables have long been considered a healthful addition to a well-balanced diet. In 2007, the Northwest Cherry Growers commissioned a review to collect and evaluate worldwide research data on the health benefits of cherries. The study was completed by Cynthia Thomson, PhD, RD, Department of Nutritional Sciences, and Chieri Kubota, PhD, Department of Plant Sciences, at the University of Arizona.

Background: Cherries in the United States

The United States has historically been the largest exporter of cherries worldwide, followed by Turkey and Chile. U.S. cherry production has increased from 160,844 tons in 2003 to 253,286 tons in 2005, an average annual increase of 25 percent (FAO, 2007). Washington state records the highest production of sweet cherries in the U.S. (150,000 tons; USDA NASS, 2006).

The majority of sweet cherries are grown for fresh consumption, while 40 percent are processed as brined, canned, frozen, dried or used for juice. More than 50,000 tons of sweet cherries are exported annually to Canada, Japan, Taiwan, Hong Kong and other countries from the U.S.

In comparison to sweet cherries, 99 percent of tart cherries – due to their acidic flavor – are processed as frozen, canned, brined, dried, or used for juice. Processed tart cherries are primarily used in culinary service (cooking and baking). More than 10,000 tons of tart cherries are exported to Europe, Canada, Japan, Korea and other countries from the U.S. annually.

Cherry Nutrient and Phytochemical Composition

Cherries are considered a nutrient dense food, meaning that for relatively few calories, they possess a significant amount of nutrients and phytochemicals ranging from vitamin C and fiber to health-promoting bioactive food components including anthocyanins, quercetin and, to a lesser extent, carotenoids.

Nutrient, Carotenoid, Anthocyanin and Quercetin content of commonly consumed cherry products (per 100 grams or approx. 15 cherries)

Nutrient /phytochemical	Cherries, sweet	Cherries, tart	Cherries, sweet, canned	Cherries, sweet, frozen, sweetened
Energy (kcal)	63	50	46	89
Protein (g)	1.1	1.0	0.8	1.2
Fat (g)	0.2	0.3	0.1	0.1
Carbohydrate (g)	16.0	12.2	11.8	22.4
Fiber (g)	2.1	1.6	1.5	2.1
Glycemic Index	22	22	22	22
Vitamin C (mg)	7	10	2.2	1.0
Potassium (mg)	222	173	131	199
Lutein/ Zeaxanthin (µg)	85	85	57	85
Total anthocyanin (mg)	80.2	6.7	Not available	Not available
Quercetin (mg)	2.64	2.92	3.2	Not available

USDA Database for the flavonoid content of selected foods (2006). http://www.nal.usda.gov/fnic/foodcomp/Data/Flav/Flav02.pdf

Andrew Flood, PhD; Amy F. Subar, PhD; Stephen G. Hull, MS; Thea Palmer Zimmerman, MS, RD; David J. A. Jenkins, MD, PhD, DSc; Arthur Schatzkin, MD, DrPH. Methodology for Adding Glycemic Load Values to the National Cancer Institute Diet History Questionnaire Database. J Am Diet Assoc. 2006;106:393-402.

Sweet cherries are a significant source of polyphenols in the human diet. Bing cherries contain approximately 160-170 mg total polyphenols in a 100-gram serving. The primary class of phenolics in sweet cherries is hydroxycinnamates, accounting for about 40 percent of the total.

Cherries and Anthocyanins

The following table lists the specific anthocyanins (antioxidant flavonoids) found in sweet cherries and other fruits where there is evidence suggesting demonstrated health-promoting effects related to the anthocyanin and/or polyphenol content. Sweet cherries are particularly rich in cyanidin content, constituting more than 90 percent of its total anthocyanin content.

Anthocyanins in Sweet Cherries and Related Plant Foods

Plant Food (1 cup)	Total (mg)
Cherries, Sweet	80.2
Cherries, Tart	6.7
Cherries, sweet, canned	Not available
Apricots	Not available
Peaches	1.6
Plums	12.0
Blueberries, raw	163.6
Raspberries	38.7
Grapes, red	44.9
Red Wine	10.1

USDA Anthocyanin Database, accessed March 5, 2007. http://www.nal.usda.gov/fnic/foodcomp/Data/Flav/Flav02.pdf

The Health Benefits of Cherries

Introduction

Diets rich in fruits and vegetables are known to reduce the risk of chronic diseases including cancer, cardiovascular disease, diabetes, obesity or select inflammatory disorders. While data on the specific health benefits of cherries is limited, in recent years the U.S. Department of Agriculture has expanded its bioactive food component database to include an analysis of anthocyanin content of select plant foods, and sweet, fresh cherries are considered to be significant sources of anthocyanins in the human diet.

Cancer

Sweet cherries have several cancer-preventive components including fiber, vitamin C, carotenoids and anthocyanins. The potential role of sweet cherries in cancer prevention lies mostly in the anthocyanin content, especially in cyanidin. Sweet cherries are a good source of cyanidins, which appear to act as an antioxidant and in this role may reduce cancer risk. In a study by Acquaviva et al, a significant increase in free radical scavenging was demonstrated with exposure to cyanidin (Acquaviva, 2003) and a separate study using human cancer cell lines demonstrated cell cycle arrest and apoptosis of mutated cells exposed to cherry anthocyanins (Lazze, 2004; Shih, 2005). Further research suggests that the growth arrest characteristics of cyanidin are likely, at least in part, to be a result of significant inhibitory effects of these cherry components on epidermal growth factor receptors (Meirers, 2001). Finally, there is compelling evidence from basic science that cyanidin may also promote cellular differentiation and thus reduce the risk for healthy cells to transform to cancer (Serafino, 2004).

Cardiovascular Disease

The role of red wine in reducing the risk of cardiovascular disease has been studied widely for more than 20 years, and studies suggest anthocyanin found in red wine has important biological effects that reduce cardiovascular disease risk (Corder, 2006). This includes protecting lipids from oxidant damage and cardiovascular vessel plaque formation, anti-inflammation, nitric oxide formation and vascular dilation. Similarly, sweet cherries have been shown to have significant levels of anthocyanins as well as other pigments in perhaps smaller concentrations that together provide synergistic effects thought to be protective to heart and related vascular tissue (Reddy, 2005).

Diabetes

Evidence suggesting a protective role for cherries for diabetes is relatively rare, but researchers are interested in the role of anthocyanins in reducing insulin resistance and glucose intolerance. In one study, cells exposed to various glucose loads and then exposed to anthocyanins and anthocyanidins showed increased insulin production, suggesting the role of these compounds in blood glucose control should be explored further (Jayaprakasam, 2005). The study suggested that the bioactive compounds found in cherries are responsive, in terms of enhanced insulin production, to a glucose-rich environment and work to control glucose levels.

Recently the role of the glycemic index in diabetes control has gained renewed interest. Sweet cherries have an estimated glycemic index of 22, generally lower than other fruits including apricots (57), grapes (46), peaches (42), blueberries (40) or plums (39). The lower glycemic index makes sweet cherries a potentially better fruit-based snack food (as compared with many other fruits) for people with diabetes. The lower glycemic response shown in relation to cherry consumption may be the result of glucose-lowering effects of cherry phytochemicals in combination with the relatively modest fiber content of cherries.

Inflammation

An important new area for nutrition research is the role of naturally occurring compounds, primarily in plant foods, to modify the inflammatory process in humans. Low-grade inflammation is a potential risk factor for a wide range of chronic illnesses including cancer, cardiovascular disease, and arthritis. In addition, obesity has been shown to be associated with elevated inflammatory response. While Americans are often advised to take low-dose aspirin to offset this problem, researchers are looking for new ways – such as diet modification – to enhance anti-inflammatory response.

Select phytochemicals in cherries have been shown to inhibit the cyclooxygenase (COX) enzymes responsible for inflammatory response. In a cell culture study assessing COX-1 and -2 enzyme activity, the anthocyanin cyanindin, common to sweet cherries, along with malvidin, were shown to have the greatest inhibitory effects (Seernam, 2003). In relation to anti-inflammatory properties, cherries have been investigated in relation to pain control. Evidence suggesting a role of dietary constituents in reducing pain is limited, but remains an active area of research. (Tall, 2004).

Alzheimer's Disease

Flavonoids and procyanidin compounds have been shown to reduce oxidant stress and -amyloid production and may indirectly reduce the risk for Alzheimer's disease (Yoshimura, 2003; Heo, 2004). Recent studies have shown the potential role of sweet cherry phenolic compounds in protecting neuronal cells involved in neurological function. The phenolics in sweet cherries include both quercetin and hydroxycinnamic acid as well as anthocyanins. One study exposed neuronal cells to a variety of phenolic compounds found in sweet and tart cherries and showed that total phenolics, and predominantly anthocyanins, demonstrated a dose-dependent reduction in oxidant stress (Kim, 2005). Further study into possible protective effects of sweet cherry bioactive compounds in reducing risk for, or morbidity related to, Alzheimer's disease is warranted.

Other Potential Health Promoting Nutrients and Phytochemicals

Potassium

Sweet cherries are considered a good source of dietary potassium, with approximately 260 mg potassium for every cup of fresh cherries consumed (USDA MyPyramid nutrient data analysis program). In the past ten years, there has been increasing evidence of the importance of adequate potassium intake in reducing the risk for hypertension and stroke risk as well as other causes of morbidity (He, 2003). More than half of all American adults have high blood pressure levels. A diet high in potassium and calcium, and low in sodium and alcohol, is a reasonable and safe approach to promote blood pressure control.

Quercetin

Sweet cherries also contain a small amount of quercetin (Dunnick, 1992). Quercetin is among the most potent in terms of antioxidant activity. The ability of quercetin to act as a free radical scavenger suggests it could play a beneficial role in reducing reactive oxygen species (ROS) (i.e. hydrogen peroxide, superoxide anion) associated with chronic diseases such as cardiovascular disease and cancer (Johnson, 2000; Wilms, 2005).

Melatonin

Melatonin is a hormone produced by the pineal gland that in addition to antioxidant activity also plays a role in promoting healthy circadian rhythm and thus promoting healthy sleep patterns. Cherries are one plant food source of melatonin and melatonin levels have been estimated to be higher in tart cherries as compared to sweet cherries. In one study, melatonin supplementation appears to be effective in reducing jet lag (Herxheimer, 2002; Suhner, 2001). In combination with other behavioral approaches to promote sleep or reduce jet lag, sweet cherry intake in usual amounts could prove to be useful. Again, more research is needed.

Conclusion

While there is more room for study on the role of cherries in a healthy diet, the available research suggests that cherries – and especially the presence of antioxidant flavonoid anthocyanin in cherries – can play a role in reducing the risk of diseases including cardiovascular disease, diabetes, obesity and select auto-immune disorders when consumed as part of an overall plant-rich, healthy diet.

For More Information

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Cherries and Health: A Review

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Cherries and in particular sweet cherries are a nutrient dense food containing bioactive food components. The U.S. produced over 253 thousand tons of sweet cherries in 2005 with the majority (60%) for the consumption of fresh fruit and the rest processed. UV concentration, degree of ripeness, post harvest storage conditions, and processing each can significantly alter amounts of bioactive components. In cherries these include amounts of anthocyanins, quercetin, hydroxycinnamates, potassium, fiber, vitamin C, carotenoids and melatonin that suggest health benefits related to cancer, cardiovascular disease, diabetes, inflammatory disease (such as gout and arthritis) and Alzheimer's disease. Cherries exhibit relatively high antioxidant activity and low glycemic index. Content of cyanidin and mylvelin have been shown to inhibit COX 1 and 2 enzyme activities and other anticarcinogenic effects in in vitro *and animal experiments The current mechanistic research findings should be further substantiated through the implementation of well designed human cherry feeding studies.*

Keywords: cherry, anthocyanin, antioxidant, cancer, diabetes, harvest, health

INTRODUCTION

Cherry is a fruit belonging to the genus *Prunus* in the Rosaceae family, which contains over several hundred species distributed across northern temperate regions. The sweet cherry (*P. avium*) is native to Europe and western Asia with the most common cultivars grown in the U.S. being Bing, which produces large black firm fruits, while the tart cherry (*P. cerasus*) is produced from the Montmorency cultivar. The cherry fruit is considered a nutrient dense food with relatively low caloric intake and a significant amount of quality nutrients and phytochemicals. These range from vitamin C and fiber to select health-promoting bioactive food components including anthocyanins, quercetin and, carotenoids. Research has demonstrated several relevant biological activities that are enhanced or inhibited by constitutive components of sweet cherries and thus hold potential for reducing cancer, cardiovascular disease, diabetes and other inflammatory diseases. The primary biological mechanisms of interest include research assessing reductions in oxidant stress, inflammation and/or tumor suppression, glucose control, and inhibition of uric acid production. This review provides information on the nutrient and bioactive food components in cherries, mechanism of action, bioactivity and associated disease risk reduction.

NUTRIENT AND BIOACTIVE FOOD COMPONENTS

Data regarding the nutrient and phytochemical content of cherries and cherry products consumed in the U.S. (Table 1) and the nutritional composition of cherries in comparison to other *Prunus* genus fruits (Table 2) illustrate that sweet cherries are comparatively a good source of fiber, potassium and anthocyanins.

Table 1. Nutrient, Carotenoid, Anthocyanin and Quercetin content of commonly consumed cherry products (per 100 grams or approx. 15 cherries)

Nutrient /phytochemical	Cherries, sweet	Cherries, tart	Cherries, sweet, canned	Cherries, sweet, frozen, sweetened	Maraschino
Energy (kcal)[a]	63	50	46	89	165
Protein (g)[a]	1.06	1.0	0.8	1.15	0.22
Fat (g)[a]	0.2	0.3	0.13	0.13	0.21
Carbohydrate (g)[a]	16.0	12.2	11.8	22.4	42.0
Fiber (g)[a]	2.1	1.6	1.5	2.1	3.2
Glycemic Index[b]	22	22	22	22	Not available
Vitamin C (mg)[a]	7	10	2.2	1.0	0
Vitamin A (IU)[a]	64	1283	160	189	45
Potassium (mg)[a]	222	173	131	199	21
β-carotene (μg)[a]	38	770	96	113	27
Lutein/ Zeaxanthin (μg)[a]	85	85	57	85	59
Total anthocyanin (mg)[c]	80.2	Not available	Not available	Not available	Not available
Quercetin (mg)[c]	2.64	2.92	3.2	Not available	Not available

[a] USDA National nutrient database for Standard Reference, Version 19 (2006).
[b] Glycemic Index database based on CSFII 96 data, National Cancer Institute (2004)
[c] USDA Database for the Flavonoid Content of Selected Foods, Release 2.1 (2007)

Potassium

Sweet cherries are considered a good source of dietary potassium with approximately 260 mg potassium for every cup of fresh cherries consumed (USDA MyPyramid nutrient data analysis program). In the past decade there has been increasing evidence of the importance of adequate potassium intake in reducing the risk for hypertension and stroke risk as well as other causes of morbidity (He, 2003). Over half of all American adults have high blood pressure levels, thus promoting diets high in potassium and calcium, as well as reduced in sodium and alcohol, is a reasonable and safe approach to promote blood pressure control.

Table 2. Nutrient composition of fruits within the genus *Prunus* (values per 100 grams or approximately 15 cherries)[a].

Nutrients	Sweet cherry	Tart cherry	Japanese sweet cherry[b]	Apricot	Plum	Peach
Energy (kcal)	63	50	60	48	46	39
Fiber (g)	2.1	1.6	1.2	2.0	1.4	1.5
Total sugars (g)	12.82	8.49	unk	9.24	9.92	8.39
Sucrose (g)	0.15	0.8	unk	5.87	1.57	4.76
Glucose (g)	6.59	4.18	unk	2.37	5.07	1.95
Fructose (g)	5.37	3.51	unk	0.94	3.07	1.53
Vitamin A (IU)	64	1283	163.33	1926	345	326
Vitamin C (mg)	7	10	10	10	9.5	6.6
Vitamin E (mg)	0.07	0.07	0.5	0.89	0.26	0.73
Potassium (mg)	222	173	unk	259	157	190
β carotene (μg)	38	770	unk	1094	190	162
Anthocyanins (mg)	80.19[d]	Not available	0.5[c]	Not available	12.02[d]	1.61[d]

Several mechanisms have been proposed and evaluated in relation to the reduction in blood pressure and stroke risk associated with potassium intake. Of particular importance is the concurrent lowering of sodium intake which is more easily achieved with the integration of high potassium fruits since most fruits, including cherries, are free of sodium. The shift from high sodium/low potassium to low sodium / higher potassium has been suggested to promote diuresis, reduce sympathetic nervous activity that leads indirectly to stimulation of angiotensin II and norepinephrine (Vaskonen, 2003).

A 2001 report in the American Journal of Hypertension, suggested that Americans consume additional potassium-rich foods to achieve an intake of 4700 mg/day, well above the estimated usual intake of 1740 mg/day among participants enrolling in the DASH dietary intervention trial (Appel, 1997). And the DASH trial supported the efficacy of such an approach (Sacks, 2001) although very high adherence may be essential to long term protective effects (Folsom, 2007). However, it is important to understand that an increase in *dietary* potassium intake alone, even in combination with sodium restriction generally is not associated with a significant improvement in blood pressure control (Davis, 1994) but a combination of higher potassium, higher calcium, lower sodium intake and weight control is efficacious in reducing blood pressure in people with hypertension (Wexler, 2006; Elmer, 2006). A recent meta-analysis suggests that these same dietary approaches are associated with a significant reduction in stroke risk (Ding, 2006).

Figure 1 illustrates the relationship among select bioactive phytochemical compounds in terms of chemical classification. Sweet cherries are a significant source of polyphenols in the human diet. Bing cherries contain an estimated 160-170 mg total polyphenols in a 100 gram serving. Table 3 provides currently available data regarding the antioxidant capacity of select cherry cultivars. The antioxidant activity associated with sweet cherry intake is largely related to the individual and synergistic antioxidant effects of nutrients such as vitamin C and bioactive food components in sweet cherries such as anthocyanins, quercetin, etc.

Anthocyanins

Both sweet cherries and tart cherries contain substantial amounts of anthocyanins and polyphenolics (e.g., Gao and Mazza, 1995), yet comparative data on sweet and tart cherry composition using the same analytical methodologies are limited (Chaovanalikit and Wrolstad, 2004). Table 3 describes the anthocyanin, phenolic and antioxidant content of select cherry cultivars. Bing sweet cherries were highest in anthocyanins, whereas Montmorency tart cherries were highest in total phenolics and antioxidant activities (Chaovanalikit and Wrolstad, 2004). Anthocyanin deposition in Bing sweet cherries is in the skins and flesh, while deposition in Montmorency tart cherries is limited to the skins. Seeram et al. (2002) reported that sweet cherries had the highest antioxidant activity followed by blueberries, and have a greater anti-inflammatory activities then Montmorency tart cherries. In contrast, ORAC and FRAP analyses showed that the edible portion of Montmorency tart cherries showed a greater antioxidant activity than those in sweet cherries (Chaovanalikit and Wrolstad, 2004). Considering issues of inconsistency regarding antioxidant activity measurements, the comparison of antioxidant activities between sweet cherries and tart cherries should be considered as inconclusive and requiring further investigation.

Table 3. Comparison of total anthocyanins, total phenolics, and antioxidant properties of flesh, pits, and skins of different cherry cultivars (after Chavanalikit and Wrolstad, 2004).

Cultivar	Portion	Anthocyanins (mg/100g fw)^{Z}	Total phenolics (mg/ g fw)^{Y}	ORAC (µmol TE/g fw)	FRAP (µmol TE/g fw)
Bing (sweet)	Flesh	26.0±0.7	1.34±0.18	9.07±0.35	7.28±0.24
	Pits	10.4±3.1	0.92±0.09	5.94±0.91	5.04±0.96
	Skins	60.6±2.5	3.33±0.41	28.26±1.10	21.05±0.55
Rainier (sweet)	Flesh	0.0±0.0	0.65±0.05	4.62±0.18	2.27±0.22
	Pits	0.1±0.0	0.54±0.04	3.38±0.26	2.00±0.13
	Skins	2.1±0.4	1.42±0.05	10.50±1.51	5.92±0.39
Montmorency (tart)	Flesh	0.0±0.09	3.01±0.29	15.00±1.00	13.81±0.26
	Pits	0.8±0.08	1.57±0.02	9.78±0.28	8.48±0.85
	Skins	36.5±1.6	5.58±0.33	51.02±1.97	47.96±1.33

^{Z} cyn-3-glu equivalent
^{Y} gallic acid equivalent
USDA Database for the Flavonoid Content of Selected Foods, Release 2.1 (2007)

Fig. 1 Bioactive Food Components in Sweet Cherries

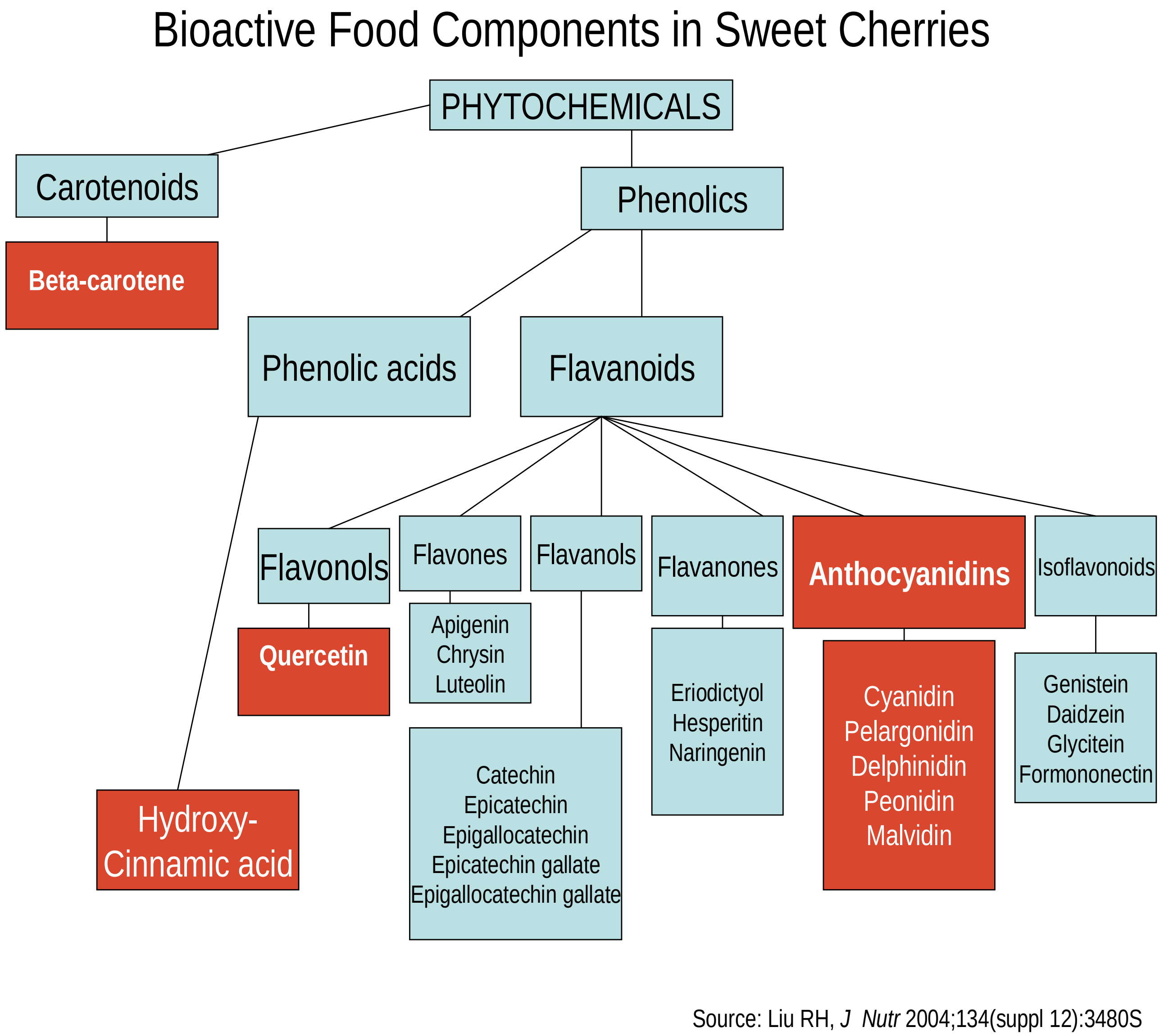

Table 4 lists the specific anthocyanins found in sweet cherries as well as other commodity fruits. The anthocyanin content of cherries is compared to other plant foods for which evidence has suggested health promoting effects related to anthocyanin and/or polyphenol content (REFS). It is noteworthy that sweet cherries are particularly rich in cyanidin content, constituting over 90% of its total anthocyanin content. The primary distinction between sweet and tart cherries in terms of phytochemical content is the greater concentration of anthocyanins in sweet cherries.

Quercetin

Sweet cherries contain quercetin, a phenolic phytochemical belonging to a class of bioflavonoids that are widely distributed in a plant-based diet (Dunnick, 1992). Quercetin is among the most potent in terms of antioxidant activity. The ability of quercetin to act as a free radical scavenger suggests it could play a beneficial role in reducing reactive oxygen species (ROS) (i.e. hydrogen peroxide, superoxide anion) associated with chronic diseases such as cardiovascular disease and cancer (Johnson, 2000; Wilms, 2005). The unique catechol structure of quercetin, which possesses two hydroxyl groups at neighboring positions, allows for a greater level of radical scavenging activity as compared with most antioxidants (Murota, 2003). High doses of quercetin (10-100uM) have been shown to diminish malondialdehyde concentration (Alia, 2005 epub), and *in vitro* pre-treatment of human lymphocytes with quercetin (low concentrations 1-10uM quercetin) is very effective in preventing induced oxidative DNA damage in a concentration-dependent manner (Wilms, 2005).

Table 4. Anthocyanins in Sweet Cherries and Related Plant Foods

	Anthocyanins						**Total (mg)**
Plant Food (1 cup)	Cyanidin (mg)	Deophinidin (mg)	Malvidin (mg)	Pelargonidin (mg)	Peonidin (mg)	Petunidin (mg)	
Cherries, Sweet	75.2	0	0	0.5	4.5	0	80.2
Cherries, Tart	6.6	Not available	Not available	Not available	Not available	Not available	Not available
Peaches	1.6	0	0	0	0	0	1.6
Plums	12.0	0	0	0	0	0	12.0
Blueberries, raw	17.0	47.4	61.4	0	11.4	26.4	163.6
Raspberries	35.8	0.3	0.7	1.9	0	0	38.7
Grapes, red	1.5	3.7	34.7	.02	2.9	2.1	44.9
Red Wine	0.4	1.0	7	Not available	0.8	0.9	Not available

In relation to cardiovascular disease risk reduction both oxidative stress and antiplatelet effects of quercetin have been evaluated. Human studies focused on quercetin feeding have shown mixed results on oxidative stress levels both supporting (Boyle, 2003; McAnlis, 1999; Lean, 1999) and not supporting (Beatty, 2000) a statistically relevant effect. A supplementation trial conducted among 27 healthy adults showed no significant improvement if platelet aggregation or lipid levels after consuming 1 gram/day for 28 days (Conquer, 1998); however, oxidant stress biomarkers were not assessed and selection of a healthy population may have limited the opportunity to modify existing biomarker levels. Further, concentrations of quercetin used in *in vitro* studies which support anti-platelet effects are likely not plausible in human feeding studies (Janssen, 1998). In a comprehensive review by Prior (2003) the bioavailability and antioxidant capacity of quercetin *in vivo* (as compared to *in vitro*) was reduced in relation to conjugation with glucuronide or sulfate and short half-life. Therefore, while significant antioxidant effects can occur and have been demonstrated in humans, sufficient and repeated “dosing” may be necessary in order to achieve sustained biological affects.

Studies investigating the modulation of inflammatory vascular biomarkers in relation to quercetin specifically are limited. In rat *in vivo* studies, quercetin was shown to have vasorelaxant effects (Woodman, 2004). In addition, a review of flavonoid effects on cyclooxygenase-2 supports strong inhibitory effects (O'Leary, 2004). One of the more promising studies on the health-promoting effects of quercetin in humans was a 1999 trial in which 30 males with prostatitis were randomly assigned to placebo or 500 mg quercetin twice daily for 30 days (Shoskes, 1999). Results showed a significant reduction in NIH chronic prostatitis symptom score in those randomized to quercetin ($P = 0.003$). No follow up trials have been conducted to further support this initial research. This daily dose is well above what could be achieved via the promotion of sweet cherry consumption.

It is important to note that the quercetin content alone in an average serving of cherries is insufficient to expect any significant effect on oxidant stress or inflammatory biomarkers, but in conjunction with other antioxidant and anti-inflammatory phytochemicals modulation of this biomarkers may be observed. Further, while sweet cherries are available source of quercetin in the human diet, citrus fruits and onions, among other fruits and vegetables, are considerable higher in quercetin content. Well controlled feeding studies are needed to assess more clearly the role of sweet cherries in modifying oxidant stress and inflammation, perhaps even a study designed to compare the modulation of these biomarkers in relation to cherry intake versus isolated quercetin.

Hydroxycinnamate

The primary class of phenolics in sweet cherries is hydroxycinnamates, comprising approximately 40% of the total (REF). Significant evidence for the role of phenolics in health has been published (REF), yet limited data regarding the health promoting effects specific to hydroxycinnamates is available. Analytical assays have been developed to qualify hydroxycinnamate levels in human urine samples (Nielsen, 2003; Bourne, 1998) and plasma (Cremin, 2001), suggesting that evaluating the relevance of these compounds in terms of health-promoting potential of cherry intake is possible.

SELECT HEALTH BENEFITS

Cancer

Sweet cherries have several cancer-preventive components including fiber, vitamin C, carotenoids and anthocyanins. The role of sweet cherries in cancer prevention lies predominantly in the anthocyanin content. While cherries are a fair source of dietary fiber and dietary fiber has been associated with reduced risk for select cancers including colorectal cancer, this association remains inconclusive (Rock, 2007). Also, the amount of fiber in a single serving of sweet cherries (2.1 grams/15 cherries) would be insufficient to modify risk if cherries were the sole source of fiber in the diet. However, certainly the added fiber associated with fresh sweet cherry intake contributes to the possibly cancer-preventive recommended dietary intake level of 30 or more grams daily (ACS, 2006). Cherries also provide a reasonable source of lutein and beta-carotene in the diet, although not near the levels associated with consumption of green leafy vegetables and orange-yellow vegetables such as carrots and sweet potatoes. Again, the presence of beta-carotene likely contributes to the total antioxidant effects of cherries, but not to any significant degree.

Of primary interest in terms of health promotion are the anthocyanins and in particular the anthocyanin cyanidin. Sweet cherries are a good source of cyanidin and the presence of cyanidin appears to have particular importance in terms of reducing cancer risk. Anthocyanins are responsible for the red-purple color inherent to fresh sweet cherries. Anthocyanin concentration is one factor that differentiates the sweet cherry from the tart cherry in that while both contain anthocyanins, sweet cherry concentrations are more than 10-fold higher, particularly in relation to cyanidin content (USDA, 2006). Thus, while literature exists suggesting that the anthocyanin content of tart cherries is health promoting, in all likelihood this evidence would be even stronger for the sweet, dark red cherry varieties given the higher anthocyanin content.

Using a mouse model of colorectal cancer, a multiple regime feeding trial was conducted. Mice were fed one of the following: 1) a cherry diet, 2) anthocyanins, 3) cyaniding, 4) control diet or 5) control diet with added sulidac (anti-inflammatory) to determine the effects of these diets on tumor development (Kang, 2003). Results suggested that mice assigned to any of the three test diets showed significantly fewer and smaller volume cecal tumors, but not colonic tumors, than control or sulindac supplemented mice. These data suggest that the bioactivity of cyanidin is responsible for inhibiting cecal tumors, but this anti-tumor effect is specific to the cecal and not colonic tumors. Similar cancer-protective effects of cyaniding glucosides have been demonstrated in studies employing cancer cell lines (Chen, 2005) including apoptotic effects via G2/M growth cycle arrest.

Further, cyanidin has also been shown to act as a potent antioxidant in research employing cell culture models. In a study by Acquaviva et al. a significant increase in free radical scavenging was demonstrated with exposure to cyanidin (Acquaviva, 2003) and a separate study using cancer cell lines from humans also demonstrated cell cycle arrest and apoptosis of mutated cells exposed to cherry anthocyanins (Lazze, 2004; Shih, 2005). Further research suggests that the growth arrest characteristics of cyanidin are likely, at least in part, to be a result of significant inhibitory effects of these cherry components on epidermal growth factor receptor (Meirers, 2001). Finally, there is compelling evidence that cyanidin may also promote cellular differentiation and thus reduce the risk for transformation of ephithelial cells to cancer (Serafino, 2004).

Wang showed potent inhibition of tumor necrosis factor alpha in relation to quercetin treatment, a bioflavonoid found in sweet cherries, and at the same time this same compound was induced by anthocyanins (also found in sweet cherries), suggesting counter-regulatory effects on cancer growth may be associated with sweet cherry consumption (Wang, 2002).

To date, no human intervention trials assessing the role of cherries and / or cherry bioactive food compounds have been completed to assess the efficacy of a cherry-enriched diet or cherry phytochemical enriched diet on cancer outcomes. In addition, while available epidemiological data suggest fruits are protective against select cancers, no data specific to cherry intake patterns are available to test hypotheses specific to cherry intake and cancer risk. Based on the ever-expanding mechanistic research from cell culture and animal models, human cherry feeding trials should be pursued to test efficacy of cherries and cherry bioactive constituents in modulating intermediate biomarkers of cancer risk.

Cardiovascular disease

The role of red wine in cardiovascular disease risk reduction has been investigated broadly for over two decades and suggests that the content of anthocyanin from red wine exerts important biological effects that reduce cardiovascular disease risk (Corder, 2006). These effects or activities include protecting lipids from oxidant damage and ensuing cardiovascular vessel plaque formation, anti-inflammation, nitric oxide formation and vascular dilation. Similarly, sweet cherries have been shown to have significant levels of anthocyanins as well as other pigments in perhaps smaller concentrations that together provide synergistic effects thought to be protective to heart and related vascular tissue (Reddy, 2005).

As with anti-cancer effects, much of the research suggesting cardio-protective effects of cherry constituents lies in well-designed cell culture models. In one study endothelial cells were removed from bovine arteries and exposed to cyanidin-3-glycoside for several hours. This treatment was associated with a significant increase in nitric oxide output and thus could be associated with a significant reduction in local oxidant stress to the cardiac tissue (Xu, 2004). Both plaque formation and blood pressure control would be expected to result from this biological activity of cyanidin-3-glycoside. In a study using tart cherry seed extract, rat hearts were subjected to ischemic injury (which generally results in irregular and rapid heart beats and possibly heart attack) and exposed to the cherry extract at variable doses. Extract at moderate doses was associated with reduced incidence of irregular and rapid heart rates as well significantly less cardiac damage as a result of heart attacks that did occur (Bak, 2006). Repetition of this model system to test cardioprotective effects specific to sweet cherries is indicated; similar effects would be expected.

Expanding on this evidence, in 2002 Frank and colleagues investigated the role of the anthocyanin, cyanidin-3-O-glucoside, common to the cherry fruit in reducing lipid levels in rats. While anthocyanin supplementation in the diet (in this study derived from blackcurrant and elderberry and not specifically sweet cherry) did not reduce serum cholesterol levels, it did modify vitamin E levels in vital organs, suggesting an overall and indirect antioxidant effect (Frank, 2002). In another animal study, investigators targeted the cholesterol transport pathways in assessing the role of anthocyanins in reducing cardiovascular disease risk. The study isolated foam cells, key players in plaque formation within vessel walls, from mice and then exposed them to variable doses of cyanidin-3-O-β-glucoside. Results suggested that there was a dose-dependent removal of cholesterol from macrophages and their associated foam cells, illustrating a protective effect of this anthocyanin in reducing cardiovascular risk (Xia, 2005).

Clearly, this preliminary evidence suggests that the role of cherries and cherry bioactive components in protection against cardiovascular disease is an area ripe for focused research. Given the expected tolerance and acceptance of cherries in human populations, human feeding trials assessing effects of cherry intake on heart health are an important next step toward advancing our understanding. Feeding studies would also provide important information as to the appropriate "dose" of cherries to optimize cardiovascular risk reduction, should evidence from basic and animal models translate to human cardiovascular disease.

Diabetes

Evidence suggesting a protective role of cherries and cherry components in the setting of diabetes is relatively sparse. Yet, mechanistic studies in cancer and cardiovascular disease targeting common biological pathways for disease promotion, including both antioxidant and anti-inflammatory effects of cherries/cherry components point to diabetes as another potential disease target to assess the health-promoting effects of cherries.

Current evidence lies in the role of anthocyanins in reducing insulin resistance and glucose intolerance. In a cell culture study, anthocyanins and anthocyanidins in cherry fruit were combined with various glucose loads to result in a significant insulin production by anthocyanin and anthocyanidin-enriched cells (Jayaprakasam, 2005). This suggests that these bioactive compounds found in cherry fruit are responsive, in terms of enhanced insulin production, to a glucose-rich environment and work to control glucose levels. Reportedly traditional Chinese literature has illustrated the use of cherry fruit to control blood glucose for centuries (Yamahara, 1981).

In a few studies using mouse models of hyperglycemia, similar glucose-lowering effects were demonstrated in relation to feeding of either cherry anthocyanins (Jayaprakasam, 2006) or 3-o-β-d-glucoside specifically (Tsuda, 2003). In both studies, high fat diets were used to induce obesity and hyperglycemia and then supplemental feedings of cherry-specific bioactive components were provided. Protective effects were shown including reduced triglyceride synthesis as well as reduced glucose and leptin levels. Recent work by Seymour et al. (2007) found rat diets enriched with tart cherries significantly reduced levels of triglyceride, total cholesterol, insulin and markers of oxidative stress.

Recently the role of glycemic index in diabetes control has gained renewed interest. Sweet cherries have an estimated glycemic index of 22, generally lower than other fruits such as apricot (57), grapes (46), peach (42), blueberry (40) or plum (39) (Foster-Powell, et al. 2002). The lower glycemic index makes sweet cherries a potentially more appropriate fruit-based snack food (as compared with many other fruits) for people with diabetes. The lower glycemic response shown in relation to cherry consumption may be the result of glucose-lowering effects of cherry phytochemicals in combination with the fiber content of cherries.

Inflammation

An important new area for nutrition research is the role of naturally-occurring compounds in the food supply (primarily plant foods) to modify the inflammatory process in humans. It has been well recognized that low grade inflammation is a potential risk factor for a wide range of chronic illnesses including cancer, cardiovascular disease, and arthritis. Further, obesity itself has been shown to be associated with elevated inflammatory response. To reduce inflammation many Americans with or at risk for chronic inflammatory related illnesses are adviced to take low-dose aspirin or non-steroidal anti-inflammatory medications. However, these medication-based approaches are not without undesirable side-effects and thus more tolerable approaches, such as dietary modification to enhance anti-inflammatory response, are warranted.

Cherries, and the constitutive phytochemicals, have been demonstrated to inhibit the cyclooxygenase (COX) enzymes responsible for inflammatory response. In a cell culture study assessing COX-1 and -2 enzyme activity, the anthocyanin cyanindin, common to sweet cherries, along with malvidin, were shown to have the greatest inhibitory effects (Seernam, 2003). The research also indicated that cyanidin had greater anti-inflammatory activity via COX enzyme inhibition than polyphenols found in green tea. The strong inhibitory potential of cyanidin is thought to be the result of the chemical structure which exhibits a hydroxyl group positioned in the B ring of the compound. These data provide evidence of anti-inflammatory effects that should be investigated in human feeding studies using fresh cherries as the dietary intervention and examining COX 2 activity as well as select inflammatory biomarker outcomes.

These results are further substantiated by another cell-culture study comparing the anti-inflammatory effects of cyanidin alone, anthocyanins from a wide variety of cherries and common anti-inflammatory medications (Seeram, 2001). The results of this study show that sweet cherries (Montmorency) inhibited COX-1 enzyme activity by an average 30% and COX-2 activity by 48%. This inhibitory response on inflammatory enzyme activity was approximately 60% of the Cox-1 inhibition demonstrated for the anti-inflammatory medications tested (ibuprofen and naproxen), and, in fact, sweet cherries exhibited about 5% greater COX-2 inhibition than these medications. Similarly, data from the laboratory of Hou also indicate a significant COX-2 inhibitory effect of anthocyanin constituents found in sweet cherries and further demonstrate that these effects are related to down-stream inhibition of mitogen-activated protein kinase (MAPK)(Hou, 2005).

The anti-inflammatory effects of cherries have also been investigated in animal models of arthritis, a primary inflammatory disease affecting over 43 million Americans (CDC, 2006). In a study conducted by He at al, using induced arthritis model, male Sprague Dawley mice were fed 40, 20 or 10 mg/kg of total cherry anthocyanins daily in mouse chow for 28 days or standard un-enriched mouse chow (He, 2006). Anti-inflammatory response was assessed through the measurement of serum tumor necrosis factor alpha and prostaglandin E2 levels in paw tissue. Results suggested that, as expected, the induction of arthritis was successful as illustrated by elevated serum TNFα levels. Feeding at the highest dose of anthocyanins resulted in a significantly lower TNFα level as compared to standard feeding, but lower doses were not therapeutic in this regard. PGE2 levels in paw tissue samples showed a significant rise with induction of arthritis and a dose-responsive effect of anthocyanin feedings, in that while all doses reduced PGE2 levels as compared to standard feeding, this effect was greatest at the 40 mg/kg dose, followed by the 20 mg/kg dose and finally the 10 mg/kg dose. This study provides preliminary evidence of the potential role of cherries in reducing inflammatory response in those with inflammation-related chronic illness. It is important to consider that extrapolation of the doses used in this mouse study would suggest that a 70 kg man would need to eat 2800 mg anthocyanins daily for several weeks. This is the equivalent of over 400 cups of fresh tart cherries or 35 cups of sweet cherries daily, amounts unobtainable in human feeding studies. While bioavailability differences are likely variable across species, the only real way to assess dose-response would be a well-designed cherry feeding study with standardized exposure in terms of anthocyanin content (dose).

In a pilot study investigating the effects of sweet cherry consumption on inflammatory markers in humans, 18 healthy adults (age 45-61 years) were fed 280 grams or approximately 2.5 cups of sweet cherries daily for 4 weeks (Kelley, 2006). Inflammation was assessed by repeat measures of serum C-reactive protein (CRP) levels. CRP levels were reduced by 8 and 25% at Day 14 and 28 cherry feeding, respectively as compared to CRP levels prior to daily cherry consumption, indicating a significant drop only at the 28 day time point ($P < 0.05$). After cherry feeding was discontinued, CRP levels rose in the study population by an average of 10% in 34 days, although this rise did not reach statistical significance. Interleukin 6 levels were not changed in relation to sweet cherry intake and this was also true for several *ex vivo* secretion levels of IL-6 and TNFα. While of interest, these results need to be replicated. It would also be of value to evaluate the anti-inflammatory effects of sweet cherry feeding in study populations demonstrating baseline elevations in inflammatory status (obese, those with chronic inflammation-related illness) and to incorporate a broader range of inflammatory outcome markers.

In relation to the anti-inflammatory properties of sweet cherry components, cherries have been investigated in relation to pain control. Evidence suggesting a role of dietary constituents in reducing pain is expanding (Tall, 2004). In a novel study testing the role of tart cherry anthocyanins in pain control in rats, Tall and colleagues showed that anthocyanins provided at a dose of 400 mg/kg resulted in a significant reduction in paw withdrawal from heat-induced pain stimuli and von Frey filament exposure.

Gout, an inflammation associated disease which affects over 4.3 million Americans, particularly those who are male and obese, manifests as a consistent and significant elevation in plasma urate levels. Thus, to assess the pain-reducing potential of cherries, a pilot study was conducted among ten healthy women, age 22-40 years who were fed a single dose of 280 grams of de-pitted sweet cherries (Jacob, 2003). Blood samples to assess urate levels were collected before cherry feeding and 1.5, 3 and 5 hours post feeding. Results demonstrated a significantly lower mean serum urate level 5 hours after cherry feeding, a protective effect note shown with grape, strawberry or kiwi fruit feeding. This single-dose cherry feeding did not modify plasma CRP or nitric oxide as was suggested with longer term feeding (28 days) (Kelley, 2006).

Alzheimer's disease

Flavonoids and procyanidin compounds have been shown to reduce oxidant stress and β-amyloid production and thus may indirectly reduce the risk for Alzheimers disease (Yoshimura, 2003; Heo, 2004). Only recently has there been published evidence of the potential role of sweet cherry phenolic compounds in protecting neuronal cells involved in neurological function. The phenolics in sweet cherries include both quercetin and hydroxycinnamic acid as well as anthocyanins. In a recent cell culture study in which neuronal cells were exposed to a variety of sweet and tart cherry phenolic compounds, total phenolics and predominantly anthocyanins, demonstrated a dose-dependent reduction in oxidant stress (Kim, 2005). This preliminary evidence should provide impetus for further investigation into the potential protective effects of sweet cherry bioactive compounds in reducing risk for or morbidity related to Alzheimers disease.

Sleep and Jet Lag

Melatonin is a hormone produced by the pineal gland that in addition to antioxidant activity also plays a role in promoting healthy circadian rhythm and thus promoting healthy sleep patterns. Cherries are one plant food source of melatonin and melatonin levels have been estimated to be higher in tart cherries as compared to sweet cherries. In a study of melatonin content in Egyptian foods, melatonin levels in select grains ranged from 87 to 187 ng/100 grams food; concentrations in fruits such as pomegranates and strawberries were much lower ranging from 13-29 ng/100 gram (Badria, 2002). In a study of two tart cherry varieties, Montmorency cherries had an estimated melatonin content of 1.35 μg / 100 gram serving while Balaton cherries averaged 0.2 μg/100 gram serving, suggesting that variety is an important determinant of melatonin content (Burkhardt, 2001).

Melatonin supplementation appears to be efficacious in reducing jet lag (Herxheimer, 2002; Suhner, 2001), although not consistently (Spitzer, 1999). One explanation for inconsistent results in published studies may be that supplementation is most efficacious in people with demonstrated low excretion of melatonin during sleep as was demonstrated in a double-blind, placebo-controlled study (Leger, 2004). Dosing levels used in clinical intervention trials for sleep or jet lag generally range between 2 and 5 mg/day. Thus, while sweet cherries hold potential to enhance sleep and reduce jet lag related to the available melatonin, it is not likely that usual intake levels required to replicate doses used in clinical trials can be attained or sustained. Again, in combination with other behavioral approaches to promote sleep or reduce jet lag, sweet cherry intake in usual amounts could prove to be useful.

PRODUCTION AND CONSUMPTION

Although the U.S. has historically been the largest exporter in the world cherry market, currently the world production of cherries is the highest in Turkey, followed by the U.S. and Iran (FAO, 2006). Annually more than 50,000 tons of sweet cherries and 10,000 tons of tart cherries are exported from the U.S. The total production area for all cherries produced in the U.S. is reportedly 31,677 ha (producing 253,286 tons in 2005), in which the production area for sweet cherry increased almost linearly over 10 years, while that of tart cherry decreased (USDA Census, 2002). The State of Washington records the highest production of sweet cherries in the U.S. (150,000 ton; USDA NASS, 2006).

The majority of sweet cherry production is for fresh consumption with 40% processed as brined, canned, frozen, dried or juice. In contrast ninety-nine percent of tart cherries are processed primarily for use in cooking and baking. Limited data are available to estimate sweet cherry intake in the U.S., although it is clear that the majority of sweet cherry consumption is fresh and that there is significant seasonal differences in intake. Epidemiological studies to assess the relationship between cherry intake and health outcomes are limited by the lack of assessment of cherry intake.

Factors affecting Nutrient Content or Bioavailability of Bioactive Food Components

Ripening and Environment

Anthocyanin content of cherries, a major form of antioxidants in cherries, increases exponentially as the fruit ripens. In addition to the accumulation of anthocyanins, there is a decrease in chlorophyll, and changes in other chemical constituents that occurs during the cherry ripening process.

Serrano et al. (2005) reported changes in concentrations and activities of antioxidants of sweet cherry at 14 different stages of ripeness. They analyzed color, texture, sugars, organic acids, total antioxidant activities, total phenolic compounds, total anthocyanins, and ascorbic acid concentrations. Total anthocyanins increased exponentially from stage 8 and reached the maximum value at stage 14 (63.26 mg cyanidin equivalent activity per 100 g fresh sample). Total antioxidant activity (TAA) decreased from stage 1 to stage 8, and increased again from stage 8 to stage 12, and coincided with dynamics in total phenolic compound concentration and the accumulation of anthocyanins. TAA reached the maximum activity at stage 14 (50.03 mg of ascorbic acid equivalent activities per 100 g fresh sample). Harvesting sweet cherries at stage 12 of ripening, when fruit reaches maximum size would develop the highest organoleptic, nutritional and functional quality attributes.

Effects of harvest year and harvest time on anthocyanin concentrations have been reported (Poll et al., 2003). Large differences in the concentration of soluble solids, acid as well as anthocyanin were found between harvests of 'Stevnsbær' tart cherry harvested 7-10 times per year for 3 years . The highest levels of these quality attributes were found in the year characterized by higher temperature and greater solar radiation. The cyanidin-3-glucosid equivalent anthocyanin concentrations in the harvested cherry juice varied from as low as 500 mg/L to as high as 2300 mg/L.

Ultra violet light (UV-light) has reportedly increased anthocyanin concentrations of grapes (Kubota and Tsuchiya, 2001), apples (Arakawa et al., 1986) and sweet cherries (Arakawa, 1993). In cherries, a more significant increase of anthocyanin concentration was observed for postharvest cherries irradiated with UV-B (280-320 nm) than those with UV-A (320-400 nm) (Arakawa, 1993). Under a UV fluorescent lamp (1.3 W m^{-2} irradiance), 'Satonishiki' sweet cherries accumulated twice as much anthocyanin as those under a white fluorescent light (4.0 W m^{-2}) after 72 hours of irradiation. These data suggest that a small amount of UV light in the environment during cherry ripening has a significant effect on the resulting accumulation of anthocyanins. The use of shade materials and bird screen has the potential to reduce the UV light compared with that under unshaded or unscreened conditions. The cherries grown under shade or screen may have lower anthocyanin concentrations, although there is limited information available on the effects of pre-harvest conditions on the bioactive compositions and concentrations in harvested cherry fruit.

Processing

Bioactive compounds of fresh fruits and vegetables change according to pre-harvest conditions (including cultivation procedures, harvesting timings, and climate conditions), and post-harvest conditions (including storage conditions and shipping conditions). Sweet cherries contain approximately 1500 mg total phenols per kg fresh weight, with the phenols comprised mainly of hydroxycinnamates, anthocyanins, flavin-3-ols (catechins), and flavonols (Gao and Mazza, 1995; Goncalves, 2004). Considering cherries are often stored at 2-5˚C for several weeks during postharvest before reaching the consumers, information on changes in the phenolic bioactive compounds during select storage conditions is imperative.

Effects of storage temperature and duration on sweet cherry bioactive compounds (phenolics) were reported by Goncalves et al. (2004). The levels of phenolics and anthocyanins varied among cultivars and storage conditions. Storage at 15˚C increased the concentration of cynanidin-3-rutinoside (anthocyanin), while 2˚C caused changes specific to cultivars. Extracts of fresh harvested cherries exhibited significantly higher antioxidant activities than stored samples.

Comparisons in anthocyanins and polyphenolic compositions of fresh and processed cherries has been reported by Chavanalikit and Wrolstad (2004). More than 75% of anthocyanins in frozen Bing cherries were destroyed after 6 months of storage at -23˚C. Storage at -70˚C caused less degradation in anthocyanins and total phenolics. ORAC and FRAP assays indicated a decrease in antioxidant activity after 3 or 6 months of storage at -23˚C, but an increase after storage at -70˚C. In their studies of canned fruit, they found about half of the anthocyanins and polyphenolics were leached from the fruits into the syrup with little total loss per total can.

Changes of anthocyanin concentrations after processing fresh fruits to jams are reported for four cultivars of tart cherries by Kim and Padilla-Zakour (2004). All cultivars showed a significant decrease in anthocyanin concentrations (21-24% of the original level of the fresh fruits) due to the canning process of heating under high acid and sugar concentrations, although good retention was observed for the total phenolics and antioxidant capacity of the canned product.

CONSIDERATIONS FOR FUTURE RESEARCH

Dietary Measurement.

In addition, efforts to quantify cherry intake in the context of epidemiological research is warranted. While cherry intake has historically been seasonal in nature, with expanded access through importation from South America and Turkey, Americans can enjoy cherries almost year-round. More frequent intake and year-round access suggest that cherries should be considered for inclusion on food frequency questionnaire instruments commonly employed to assess diet-disease associations in large study populations.

***Biomarkers of Exposure*.**

In addition to more accurately assessing reported dietary intake of cherries, biomarkers of cherry exposure are needed to assess potential health related effects of cherry intake, especially given the variability in nutrient and bioactive food component composition in relation to cherry cultivar, ripening, processing, etc. Identifying the most reliable and valid biomarkers of intake in humans will contribute significantly to advancing the testing of hypotheses in this area. Scientifically acceptable biomarkers need to be valid, correlate significantly with dietary intake, be reliable and utilize biological samples which are easily collected from free-living people.

***Need for Human Feeding Studies*.**

While the current state of the evidence suggests that eating sweet cherries holds potential for improving overall health, more research is essential to clearly understanding the role of cherry consumption in reducing chronic disease risk, particularly in relation to human studies and establishing dose-specific guidelines. The mechanistic evidence exists to suggest that specific bioactive food components in sweet cherries can modulate oxidant stress and inflammation. This evidence warrants further scientific investigation regarding the role of sweet cherries in health. Although isolation of key bioactive food components to establish a specific dose-response would be one approach, in all likelihood it is the synergy among bioactive food components found in sweet cherries such as ascorbic acid, carotenoids and anthocyanins that results in the health-promoting effects realized from consuming the whole fruit.It is critical that the mechanistic research findings be further substantiated through the implementation of well designed human cherry feeding studies using fruits produced, harvested, stored, and distributed under standardized conditions as both pre-harvest and post-harvest conditions can significantly affect the concentrations of bioactive food components.

CONCLUSIONS

Sweet, fresh cherries and several cherry products are important sources of nutrient and bioactive food components in the human diet. Epidemiological studies assessing the role of nutrients and phytochemicals common to cherries (such as fiber, polyphenols or carotenoids) and specific health outcomes provide indirect evidence for the role of cherries in health promotion. The health-promoting effects of cherries have been demonstrated in select basic and animal studies; however, human intervention trials remain sparse. Such feeding studies should include some assessment of dose-response under standardized cherry production methods in order to more fully understand the optimal dose of cherry intake necessary to promote modulation of disease-specific biomarkers.

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CALIFORNIA
CHERRY ADVISORY BOARD

Research on the Health Benefits of Sweet Cherry Consumption

CDFA Block Grant #02-0769

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EXECUTIVE SUMMARY

The California Cherry Advisory Board (CCAB) applied for and received funding assistance from the California Department of Food and Agriculture (CDFA) in response to Notice of Funds Available #01-0575. CCAB had planned to use the $18,000 grant from CDFA to assess the antioxidant capacity of sweet cherries and their physiologic effects on human consumption. Due to the timing of the California cherry harvest, this research was conducted during the 2002 season. Instead, CCAB used the $18,000 CDFA grant to study the role of cherry consumption is reducing risk factors for human chronic inflammatory diseases (gout).

The University of California at Davis and Western Human Nutrition Research Center (WHNRC) conducted the study in May and June 2003 with analysis and subsequent reporting conducted through the first half of 2004. Initial findings suggest that eating fresh Bing cherries can help people who suffer from gout or other forms of arthritic inflammation. CCAB will be able to use the research results in its future domestic and international marketing campaigns.

INTRODUCTION

1. Describe the project benefits and results.

Traditionally, it was thought that eating cherries can help reduce the painful swelling associated with inflammatory diseases such as gout. In the last decade, the tart cherry industry has funded several in vitro studies which determined the anti-inflammatory properties in tart cherries, but no such information was available for sweet cherries and no studies were conduct on human subjects. Working with the University of California at Davis and Western Human Nutrition Research Center (WHNRC), the California Cherry Advisory Board (CCAB) determined that sweet Bing cherries do in fact have anti-inflammatory properties. The following provides additional details about the study.

Ten healthy women aged 22-40 were asked to eat a breakfast of 45 fresh, pitted, Bing cherries. Volunteers were instructed not to eat strawberries or other fruits and vegetables, or to drink tea or red wine, for the 2 days before the cherry breakfast. These foods are high in antioxidants and could have interfered with the ability to determine the specific effects of the Bing cherry antioxidants.

The main focus of the study was gout, a very painful form of arthritis where crystals of uric acid accumulate in the joints and cause pain. Urate in blood plasma is a precursor of these uric acid crystals. Therefore, the study closely measured volunteers' levels of plasma urate. The study also measured the amount of urate that was moved out of the body in urine. Blood plasma and urine samples were collected before the volunteers ate the cherry breakfast and at intervals of 1-1/2, 3, and 5 hours afterward.

Volunteers' plasma urate levels decreased significantly over the 5 hours after their meal of cherries. Levels of urate removed from the body in urine increased over those 5 hours. These urate results strongly suggest that cherries can play an important role in fighting gout. More importantly, this research invites additional examination in the antioxidant affects of cherries including reducing the risks of heart disease and cancer. CCAB will be able to use these results in future promotional campaigns.

2. Describe collaborative partnerships.

The California Cherry Advisory Board conducted this study in collaboration with the University of California at Davis and Western Human Nutrition Research Center (WHNRC) which is part of the USDA's Agricultural Research Service.

3. Describe industry interest and support.

CCAB's board of directors which represents the interests of 450 California cherry growers and packers (Bing, Rainier, Van and Lambert varieties) approved the research and the CDFA grant with a $17,000 cash contribution. This level of support demonstrates the importance of conducting the research to the California cherry industry and the interest in using the information in future promotional campaigns.

EVALUATION

1. Describe achieved goals and objectives.

CCAB accomplished the specific aims of this study which were to:

1. Determine the effects of chronic cherry consumption on serum concentration of CRP, nitric oxide, inflammatory cytokines and adhesion molecules.
2. Examine the relationship between the serum concentrations of inflammatory markers and antioxidants polyphenols in cherries and serum.
3. Determine the effect of cherry consumption on oxidative damage to body fat (lipid peroxidation).

2. Explain grant program benefits.

This study results provide the California cherry industry with scientific proof of the antioxidant benefits of eating sweet cherries. With scientific justification, the California cherry industry can now promote the anti-inflammatory benefits of eating fresh sweet cherries. Such information will help strengthen future promotional campaigns in the United States as well as the 11 international markets where CCAB currently conducts generic market development activities including Japan, Taiwan, Hong Kong, China, Korea, Singapore, Australia, New Zealand, Canada, Mexico, and the United Kingdom.

3. Discuss project timeframe.

The grant was awarded after the 2002 cherry season. Because the study requires the consumption of fruit samples, CCAB had to postpone the research until the 2003 Bing cherry season. There were some additional delays in harvest timing that pushed study initiation back by approximately two weeks and condensed the timeframe for recruitment of the study participants. The study initially called for subjects with serum CRP values between 3-25 mg/L. WHNRC had to drop the lower limit to 1 mg/L due to the lack of time to keep screening subjects. This change in methodology did not adversely affect the outcome of the research. CCAB met all other project completion time frames. Despite the slight change in methodology, none of these delays caused any cost overruns.

4. Discuss ability to overcome problems.

CCAB was able to overcome the timing of the grant award by postponing the project for one year as noted above. In addition, CCAB slightly adjust its study methodology to overcome a lack of time in screening subjects. Again, this process is noted above.

BUDGET

1. Total in-kind and matching contributions.

The total cost of the research was $35,000. CCAB offset the $18,000 CDFA grant award with $17,000 in cash contributions.

2. Discuss any changes to total contributions.

There were not changes to the total contributions.

3. Describe for any unspent funds.

CCAB spent all grant funds.

4. Discuss action plan to continue the project.

CCAB will utilize research results in future promotional campaigns both domestically and abroad.

ATTACHMENTS

1. Press clippings, letters of appreciation, or digital photos.

The following contains a sample of press clippings which reported the results from the research.

Prevention.com
Smart Ways to Live Well

Sweet Protection from Heart Disease

Snack on cherries to lower your risk of heart attack and stroke.

by Holly McCord, RD, with Gloria McVeigh

Though gout brings to mind Dickensian characters nursing swollen tootsies, its toxic source--high uric acid levels in the blood--portends future heart attacks and strokes. New preliminary research found that after 10 women ate 45 sweet cherries, their blood uric acid levels plummeted by 15%.

"It seems the anthocyanins that impart the lovely red color to cherries decrease blood urate, so they may help lower heart attack and stroke risk," says Robert A. Jacob, PhD, author of the USDA/University of California study. Jacob says canned or dried cherries, tart cherries, and cherry juice contain the same anthocyanins as fresh sweet cherries. One serving a day should have some benefit.

Holly McCord is Prevention's *former Nutrition Editor. Gloria McVeigh is the Nutrition News Editor.*

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Got arthritis? Fresh cherries may help

CAP PRESS 5/14/04

ARS News Service

Plump, juicy Bing cherries, eaten fresh, may help people who suffer from the pain of gout or other forms of arthritic inflammation. That's according to preliminary results from research at the Agricultural Research Service's Western Human Nutrition Research Center in Davis, Calif.

The 10 healthy women, aged 22 to 40, who volunteered for the first phase of this research ate a special breakfast of 45 fresh, pitted Bing cherries.

ARS chemists Robert A. Jacob (now retired) and Darshan S. Kelley collaborated with university scientists in that preliminary study and, recently, in a more extensive follow-up investigation.

The experiments are among the first to track anti-inflammatory effects of fresh Bing cherries in carefully controlled tests with healthy volunteers. That's in contrast to previous studies, conducted elsewhere, in which scientists analyzed extracts from sweet or tart cherries in the laboratory.

Jacob and Kelley found that levels of uric acid — a compound the body uses to form painful urate crystals during a gout attack — decreased significantly in volunteers' blood (plasma) over the five hours after they ate the Bing-cherry breakfast. And, levels of urate removed from their bodies in urine increased over those five hours.

On the Internet:

www.ars.usda.gov/is/AR/archive/may04/cherry0504.htm. The grower-sponsored California Cherry Advisory Board, Lodi, Calif., helped fund the research.

Agricultural Research Service
the in-house research arm of the U.S. Department of Agriculture

Fresh Cherries May Help Arthritis Sufferers


Fresh Bing cherries.
(K11182-1)

Arthritis hurts. But fresh cherries may help.

Results of a preliminary study by ARS scientists and their university colleagues suggest that some natural compounds in plump, juicy Bing cherries may reduce painful arthritic inflammation. Eating cherries may also help lessen the severity of other inflammatory conditions, such as cardiovascular disease or cancer.

Cherries already have a reputation for fighting inflammation. So what's new about the ARS study?

"Our test is among the first to track anti-inflammatory effects of fresh Bing cherries in a controlled experiment with healthy volunteers," says chemist Robert A. Jacob, who led the investigation. Jacob is now retired from the ARS Western Human Nutrition Research Center in Davis, California.

In previous studies at other laboratories, scientists analyzed extracts from sweet or tart cherries in vitro to learn more about the fruit's potential health-promoting properties. In contrast to these test-tube experiments, the California study is apparently the first to test key inflammatory disease indicators, or markers, in blood samples from healthy volunteers who were fed precise amounts of fresh Bing cherries. Reported in a 2003 issue of the *Journal of Nutrition*, the California investigation paved the way for a recent followup study at the Davis center.

Chemist Darshan Kelley (left) and Adel Kader, professor at the University of California, Davis, examine and weigh cherries.
(K11171-1)

Life—A Bowl of Cherries?

Imagine being asked to eat a bowlful of 45 fresh, pitted Bing cherries for breakfast. Ten healthy women, aged 22 to 40, agreed to do that for the California scientists' preliminary study. Volunteers were instructed not to eat strawberries or other fruits and vegetables, or to drink tea or red wine, for the 2 days before the cherry breakfast. These foods are high in antioxidants, thought to fight inflammation. "They could have interfered with our ability to determine the specific effects of the Bing cherry antioxidants," explains Jacob.

"Our main focus in this study was gout, a very painful form of arthritis," says co-investigator Darshan S. Kelley, a chemist at the nutrition center. "During gout attacks, crystals of a naturally occurring chemical, uric acid, accumulate in joints—commonly in the toes—and cause pain. Urate in blood plasma is a precursor of these uric acid crystals. So, we closely measured volunteers' levels of plasma urate.

Danise Gonzalez, a registered nurse with ARS's Western Human
Nutrition Research Center,

"We also indirectly measured the amount of urate that was moved out of the body in urine. We took blood plasma and urine samples before the volunteers ate the cherry breakfast and at intervals of 1-1/2, 3, and 5 hours afterward."

Volunteers' plasma urate levels decreased significantly over the 5 hours after their meal of cherries. Levels of urate removed from the body in urine increased over those 5 hours.

These urate results strongly suggest that cherries can play an important role in fighting gout. So do the results from the scientists' assays of some other indicators of inflammation. Significant changes in the levels of markers are an indication of a healthy immune system at work, attacking

completes a blood draw on a participant in a study of the potential benefit of cherries for inflammation and arthritis.
(K11174-1)

inflammation. Markers monitored included C-reactive protein, nitric oxide, and tumor necrosis factor alpha.

C-reactive protein, produced by the liver, increases rapidly during inflammation, such as during a gout attack. In a healthy body, blood (serum) levels of C-reactive protein are extremely low.

A study participant prepares to eat cherries for breakfast in a study designed to evaluate the fruit's potential benefit for inflammation and arthritis.
(K11184-1)

Another reliable sign of inflammation: the unwanted increase in nitric oxide. This biochemical is thought to play a role in damaging arthritic joints. The third marker, tumor necrosis factor alpha, is secreted in greater quantities when the body is fighting tumors that may induce inflammation. As is true for C-reactive protein, a healthy body that isn't fighting an inflammation has very little of this marker.

At the 3-hour monitoring interval, C-reactive protein and nitric oxide were somewhat lower than at the start of the study. "Even though these levels were not significantly lower, the trend was in the right direction and so is of interest," notes Kelley.

Unexpectedly, the scientists found no change in levels of tumor necrosis factor alpha. That's in contrast to a previous study, conducted elsewhere, in which natural compounds in fruits and vegetables were found to decrease levels of this marker. But the trends toward decreases in the other two markers do agree with results of other scientists' earlier, in vitro studies of cherry extracts.

Jacob and Kelley collaborated with chemists Giovanna M. Spinozzi and Vicky A. Simon of the nutrition center; chemist Ronald L. Prior, who is with ARS at Little Rock, Arkansas; and research associate Betty Hess-Pierce and professor Adel A. Kader, of the University of California, Davis.

A Month of Fresh Cherries

The follow-up study, conducted in 2003, involved more people, more cherries, and a greater array of inflammatory-response markers. Eighteen women and two men—aged 22 to 40—participated in the 64-day investigation.

Many of the new volunteers began the study with elevated C-reactive protein levels. "That made it easier to detect any decline in C-reactive protein levels as the study progressed," says Kelley. "We're particularly interested in this protein because a recent major study indicated that it's more reliable than cholesterol as a predictor of cardiovascular disease.

"This group ate the same daily amount of fresh Bing cherries as our earlier volunteers. But we asked them to eat the cherries throughout the day instead of just at breakfast." The volunteers did that for 28 consecutive days. The researchers are now analyzing blood samples.

The grower-sponsored California Cherry Advisory Board helped fund the research. Final results should be available later this year. Then we'll know more about the health benefits of this sweet treat.—By **Marcia Wood,** Agricultural Research Service Information Staff.

This research is part of Human Nutrition, an ARS National Program (#107) described on the World Wide Web at www.nps.ars.usda.gov.

Darshan S. Kelley is with the USDA-ARS Western Human Nutrition Research Center, One Shields Ave., Davis, CA 95616; phone (530) 752-5138.

"Fresh Cherries May Help Arthritis Sufferers" was published in the **May 2004** issue of *Agricultural Research* magazine.

Human Nutrition and Metabolism Research Communication

Consumption of Cherries Lowers Plasma Urate in Healthy Women[1,2]

(Manuscript received 3 January 2003. Initial review completed 30 January 2003. Revision accepted 28 February 2003.)

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ABSTRACT To assess the physiologic effects of cherry consumption, we measured plasma urate, antioxidant and inflammatory markers in 10 healthy women who consumed Bing sweet cherries. The women, age 22–40 y, consumed two servings (280 g) of cherries after an overnight fast. Blood and urine samples were taken before the cherry dose, and at 1.5, 3 and 5 h postdose. Plasma urate decreased 5 h postdose, mean ± SEM = 183 ± 15 μmol/L compared with predose baseline of 214 ± 13 μmol/L (*P* < 0.05). Urinary urate increased postdose, with peak excretion of 350 ± 33 μmol/mmol creatinine 3 h postdose compared with 202 ± 13 at baseline (*P* < 0.01). Plasma C-reactive protein (CRP) and nitric oxide (NO) concentrations had decreased marginally 3 h postdose (*P* < 0.1), whereas plasma albumin and tumor necrosis factor-α were unchanged. The vitamin C content of the cherries was solely as dehydroascorbic acid, but postdose increases in plasma ascorbic acid indicated that dehydroascorbic acid in fruits is bioavailable as vitamin C. The decrease in plasma urate after cherry consumption supports the reputed anti-gout efficacy of cherries. The trend toward decreased inflammatory indices (CRP and NO) adds to the in vitro evidence that compounds in cherries may inhibit inflammatory pathways. J. Nutr. 133: 1826–1829, 2003.

KEY WORDS: • cherries • gout • humans • anti-inflammatory • fruit

In addition to providing essential vitamins, minerals and dietary fiber, fruits contain phytochemicals that may lower the risk of cancer, heart disease and other chronic diseases. Both sweet and tart cherries are rich in antioxidants, including anthocyanins (responsible for red skin and flesh color), catechins, chlorogenic acid, flavonal glycosides and melatonin. Anthocyanins, cyanidin and hydroxycinnamates isolated from tart or sweet cherries inhibited oxidation of isolated human LDL and model liposomes to an extent comparable to vitamin E and BHT (1–3). Anthocyanins extracted from cherries have also shown anti-inflammatory properties, via inhibition of cyclooxygenase (COX)[4] activities (2,3) and scavenging of the reactive nitric oxide (NO) radical (4). In activated macrophages, anthocyanins and other phenolics inhibit NO production and modulate tumor necrosis factor (TNF)-α secretion (5,6).

Consumption of cherries and cherry products has been reported to be health promoting, particularly to alleviate arthritic pain and gout (7). Clinical case reports of three patients with gout showed that consumption of 227 g of cherry products daily for 3 d to 3 mo reduced plasma urate to normal levels and alleviated attacks of gouty arthritis (7). It is not known what compounds in cherries might be responsible for these alleged actions. Moreover, the putative anti-gout and anti-inflammatory properties of cherries have not been assessed in controlled experimental studies. The present study was conducted to determine the extent of these effects in healthy women consuming an acute dose of Bing sweet cherries.

SUBJECTS AND METHODS

Subjects and study design. The clinical portion of the study was conducted in May 2002, during California's fresh cherry season, at the USDA Western Human Nutrition Research Center (WHNRC), University of California Davis. Candidates recruited from the Davis, CA area were screened for good health by a medical history questionnaire, physical exam and standardized blood and urine tests including a complete blood cell count with leukocyte differential, clinical chemistry panel, urinalysis and tests for infectious disease. Candidates were excluded if they were in poor health, obese (body mass index >30 kg/m^2), regularly used nutritional supplements, medications, alcohol or recreational drugs. The ten women accepted into the study were nonsmokers, age 22–40 y (mean ± SD = 29.9 ± 6.1 y) and primarily Caucasian. The study was approved by the Human Subjects Review Committee of the University of California, Davis. All subjects signed informed consent before entering the study.

To partially standardize and limit intake of antioxidants before the experimental cherry dose, subjects were asked to refrain from consuming fruits and vegetables or their juices, tea or wine for 2 d before the cherry dose. Fresh sweet Bing cherries were obtained from O.G. Packing, Stockton, CA and were stored at 4°C until they were consumed. The subjects consumed 280 g of depitted cherries (about 45 cherries) after an overnight fast and were required to consume all

[1] Supported in part by the United States Department of Agriculture, Agricultural Research Service, and the California Cherry Advisory Board, Lodi, CA.

[2] Reference to a company or product name does not imply approval or recommendation of the product by the U.S. Department of Agriculture to the exclusion of others that may be suitable.

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[4] Abbreviations used: AA, ascorbic acid; COX, cyclooxygenase; CRP, C-reactive protein; DHA, dehydroascorbic acid; FRAP, ferric reducing ability of plasma; NO, nitric oxide; ORAC, oxygen radical absorbing capacity; TEAC, Trolox equivalent antioxidant capacity; WHNRC, Western Human Nutrition Research Center.

of the cherries within 10 min. Blood and urine samples were obtained before the dose, and at 1.5, 3 and 5 h postdose. Subjects emptied their bladder for the predose urine collection, and all urine was collected between each blood draw. Subjects were allowed to leave the clinical unit after the 1.5- and 3-h postdose blood draws but were required to return within 10 min of the next scheduled blood draw, and avoid consumption of any food or drink except from a 237-mL bottle of water given after the 1.5-h draw. The subjects were scheduled over 6 d and a 70-g portion of the cherries available was taken on each of the 6 d and frozen at −70°C until analysis for antioxidant and polyphenol content.

For comparison purposes, plasma urate values from a previous (unpublished) study on antioxidant capacity of fruits are included herein. The study design was similar to the present study, i.e., two servings each of red "crimson seedless" grapes (280 g), "Seascape" strawberries (300 g) and "Hayward" kiwifruit (300 g) were consumed 1 wk apart by seven healthy women, 18–40 y old, and blood samples were drawn over the next 5 h.

Sample collection and laboratory methods. Blood was drawn by venipuncture into evacuated tubes with EDTA and heparin anticoagulants. The blood was immediately processed to separate red cells in a refrigerated centrifuge and aliquots of the plasma were frozen at −70°C for later analysis. An aliquot of EDTA plasma was treated with an equal volume of meta-phosphoric acid (100 g/L) and the protein-free supernatant frozen at −70°C for later determination of ascorbic and uric acids by HPLC with electrochemical detection (8). A portion of the heparinized plasma was treated with an equal volume of 0.5 mol/L perchloric acid and the protein-free supernatant was frozen at −70°C for later determination of antioxidant capacity.

Urine was collected in tared containers and the total weight of the urine collection was recorded. After mixing of the urine, dipstick urinalysis was completed (Ames Diagnostics, Indianapolis IN), and aliquots of the urine were frozen at −20°C for later determination of creatinine and urate.

Urine urate was determined by a colorimetric peroxidase/uricase procedure utilizing a 3,5-dichloro-2-hydroxybenzenesulfonic acid/4-aminophenazone chromogenic system applied to a centrifugal analyzer (9). Plasma and urine creatinine were determined by the Jaffe picric acid spectrophotometric method adapted to the Hitachi 902 automated analyzer (Roche Diagnostic, Indianapolis, IN). Antioxidant capacities were determined in the cherries and blood plasma by the hydrophilic and lipophilic oxygen radical absorbing capacity (ORAC) methods (10,11), the spectrophotometric radical cation decolorization method utilizing 2,2′-azinobis(3-ethylbenzthiazoline-6-sulfonate), also known as the Trolox equivalent antioxidant capacity (TEAC) method (12) and the ferric reducing ability of plasma (FRAP) method (13).

Plasma C-reactive protein (CRP), TNF-α and NO were measured as inflammatory markers. CRP was measured by a high sensitivity enzyme immunoassay (Biocheck, Burlingame, CA). Plasma TNF-α was measured using the Quantikine high sensitivity TNF-α colorimetric immunoassay kit, and plasma NO was measured using the Total Nitric Oxide colorimetric assay kit (R&D Systems, Minneapolis MN).

Polyphenols were extracted from 5 g of frozen cherries with 10 mL of water/methanol (2:8) containing 2 mmol/L NaF. After filtration through a 0.45-μm filter, the supernatant was analyzed for polyphenols by HPLC with UV diode-array detection (14). Total phenolics were determined in the polyphenol extract using a modified spectrophotometric Folin-Ciocalteu method (15). Ascorbic and dehydroascorbic acids were extracted from cherries with a citric acid buffer and determined by HPLC with UV diode-array detection (16).

Statistical analysis. Data were analyzed using Instat 3.0 (GraphPad Software, San Diego CA). Descriptive statistics were computed for study measures at baseline (predose) and the three postdose time points. Urinary urate was normalized to creatinine concentrations. Repeated measures ANOVA with Student-Newman-Keuls adjustment for multiple comparisons was used to determine the effect of the cherry dose over the entire study period, from baseline to 5 h postdose. Paired t tests or Wilcoxon signed-ranks tests were used to compare specific postdose values with baseline, including Bonferroni adjustment of probability levels for multiple comparisons. Results are presented as mean ± SEM. Differences were considered significant for the two-tailed P-value < 0.05.

RESULTS

Hydroxycinnamates comprised the largest class of phenolics in the cherries ingested, representing ~42% of the total phenolics of 163 mg/100 g (**Table 1**). The next largest fraction of phenolics was anthocyanins at 23%. Only dehydroascorbic acid (DHA), the oxidized form of vitamin C, was detected in the cherries. No HPLC peaks were detected for the reduced form, ascorbic acid (AA).

Plasma urate decreased significantly over the 5-h period after cherry consumption (ANOVA), and the concentration at 5 h postdose was significantly lower than at baseline (**Table 2**). Urinary urate, expressed per mmol creatinine, increased over the 5 h postdose and at each postdose sampling time compared with baseline. After similar doses of grapes, strawberries or kiwifruit, plasma urate concentrations did not change over time, nor were any postdose concentrations significantly lower than those at baseline.

Among inflammatory biomarkers, plasma TNF-α did not change after cherry consumption. Plasma CRP and NO did not decrease over the entire 5-h period (ANOVA), but both were marginally decreased ($P < 0.1$) at 3 h postdose compared with baseline, by Wilcoxon's signed-ranks test (CRP) and paired t test (NO) (Table 2). The plasma CRP data were not normally distributed because values for one subject were well above the normal range of 0.1–8.2 mg/L (17). The subject's baseline value of 22.9 mg/L was 2.7 SD above the mean and declined 44% to 12.9 mg/L at 3 h postdose.

Among antioxidant capacity measures, the hydrophilic ORAC and TEAC measures did not differ after cherry consumption, lipophilic ORAC increased and FRAP decreased at all postdose sampling times. Plasma ascorbic acid increased significantly at 1.5 and 3 h postdose. Plasma creatinine decreased significantly at 1.5 and 5 h postdose, and marginally ($P = 0.07$) at 3 h postdose. Plasma albumin was unchanged throughout.

DISCUSSION

Fruits contain a wide variety of phytochemicals that are known or suspected to provide health benefits, yet most phytochemicals in fruits have not been studied for their effect on

TABLE 1

Concentrations of antioxidant substances in Bing sweet cherries[1,2]

Substance measured	Concentration
	mg/100 g fresh weight
Hydroxycinnamates	67.9 ± 4.0
Procyanidins	21.7 ± 2.5
Flavanols	34.8 ± 3.9
Anthocyanins	38.0 ± 3.6
Total phenolics	163 ± 9
Vitamin C[3]	18.4 ± 2.3
Antioxidant capacity (TEAC), *µmol TE/100 g*	211 ± 8
Antioxidant capacity (FRAP), *µmol/100 g*	170 ± 2

[1] Values are mean ± SEM, $n = 5$ batches of cherries.

[2] TEAC, Trolox equivalent antioxidant capacity; FRAP, ferric reducing ability of plasma.

[3] As dehydroascorbic acid.

TABLE 2

Plasma and urine biomarkers in healthy women before and after cherry consumption[1,2,3]

Biomarker	Baseline	1.5 h	3 h	5 h
Plasma urate, *μmol/L*				
Cherries†	214 ± 13	221 ± 22	203 ± 13	183 ± 15*
Grapes	278 ± 25	263 ± 26	257 ± 23	260 ± 21
Strawberries	286 ± 25	280 ± 20	277 ± 25	262 ± 29
Kiwifruit	285 ± 28	256 ± 21	257 ± 23	281 ± 19
Urinary urate, *μmol/mmol creatinine*	202 ± 13	278 ± 29*	350 ± 33*	260 ± 17*
Plasma				
C-reactive protein, *mg/L*	4.29 ± 2.18	ND	3.07 ± 1.26	3.59 ± 1.59
Nitric oxide, *μmol/L*	37.4 ± 5.2	ND	31.1 ± 2.9	31.6 ± 2.1
ORAC (lipophilic),[4] *μmol TE/L*	531 ± 37	628 ± 37*	681 ± 24*	711 ± 27*
FRAP, *μmol/L*	454 ± 23	432 ± 21*	403 ± 14*	414 ± 21*
Ascorbic acid, *μmol/L*	65.4 ± 5.6	74.5 ± 5.6*	71.8 ± 6.0*	68.2 ± 5.2

1 Values are means ± SEM, $n = 10$. * Different from baseline, $P < 0.05$. † Significant decrease over time, $P < 0.05$.
2 Plasma urate concentrations of grapes, strawberries, and kiwifruit are for seven women in a separate but similar study (unpublished data) with the last time point at 4.5 h.
3 Abbreviations: ND, no data; ORAC, oxygen radical absorbing capacity; FRAP, ferric reducing ability of plasma.
4 Units are μmol Trolox equivalents/L.

human health. Polyphenolic flavonoids have been shown to provide antioxidant, anti-inflammatory, antithrombotic, and anticarcinogenic actions, which may reduce the risk of chronic diseases (18). Deeply colored cherries and berries contain a large amount of phenolic compounds, ~9 times the amount of vitamin C for the Bing sweet cherries ingested in the present study (Table 1). Cherries have a unique reputation for providing anti-gout and anti-inflammatory benefits; this is largely anecdotal and has not been confirmed in controlled nutrition studies. The present results support an anti-gout effect of cherries because the cherries provoked a significant decrease in plasma urate over 5 h postdose, whereas the other fruits produced no change (Table 2). Although the observed mean decrease (214 to 183 μmol/L or 14.5%) is within the lower range of normal (155–357 μmol/L) (17), it supports the claim that consumption of cherry products may benefit individuals who suffer from high levels of plasma urate and arthritic gout. By comparison, acute ingestion of milk proteins also lowered serum urate (19), whereas purine-rich foods (beef liver, haddock, soybeans) increased serum urate at 2–4 h postdose (20).

Data from the present study cannot definitively establish the mechanism whereby cherry consumption lowers plasma urate. Plasma urate is largely reabsorbed in the renal tubules after glomerular filtration, whereas plasma creatinine is cleared without reabsorption. The observed postdose increase in urinary urate per unit creatinine excretion and the decrease in plasma creatinine suggest that cherries may exert their urate-lowering effect by increasing the rate of renal glomerular filtration and/or reducing tubular reabsorption.

Biomarkers of the inflammatory response, plasma CRP, NO and TNF-α, were measured in the present study because of reports that consumption of cherries relieved the arthritic joint pain of gout (7), that anthocyanins and other phenolics inhibit NO and alter TNF-α production in activated macrophages (5,6), and that anthocyanins isolated from cherries inhibit the activity of the proinflammatory enzyme COX II in vitro (2,3). The trend toward decreased plasma CRP and NO 3 h after cherry consumption is consistent with previous in vitro evidence (2–5) and suggests that compounds in cherries may inhibit inflammatory pathways in vivo. Decreased in vivo NO production may reduce the progression of inflammatory arthritis because increased 3-nitrotyrosine concentrations found in rheumatoid arthritis patients have been cited as evidence that the NO radical plays a role in arthritic joint damage (21).

The constancy of plasma albumin values throughout indicates that postdose changes in urate and inflammatory markers were not due to changes in hemodilution or hydration status. That measures of plasma water-soluble antioxidant capacity were unchanged (hydrophilic ORAC and TEAC) or decreased (FRAP) after cherry consumption is not surprising because urate is the largest single contributor to plasma hydrophilic antioxidant capacity (22), and its concentration decreased after cherry consumption. The finding that lipophilic ORAC increased substantially is unexpected because most antioxidant compounds in cherries, e.g., phenolic glycosides and vitamin C are water-soluble compounds. However, reports that cherry and berry phenolics show strong antioxidant activity in phospholipid liposomes (1,2,23) indicate that these compounds are active in lipophilic as well as hydrophilic systems. Support for this includes findings that the less polar anthocyanin aglycone, cyanidin, has stronger antioxidant activity than its glycosides (2), and that flavonoids alter membrane fluidity by partitioning into the lipophilic core of model membranes (24). Melatonin may have contributed to the increase in lipophilic ORAC because it is more active than vitamin E as a lipophilic antioxidant (25) and occurs in "Balaton" and "Montmorency" cherries in amounts of 0.2 and 1.3 mg/100 g, respectively (26).

The finding that the cherries ingested contained only the oxidized form of vitamin C, dehydroascorbic acid (DHA), and not the reduced form, ascorbic acid (AA), is unusual among fruits. The average DHA content of 12 fresh fruits as a percentage of total vitamin C (AA + DHA) was 15.2%, with a range of 6–48% (27). Because care was taken to keep the cherries frozen until analysis, and acidic extraction buffers were used to preserve any AA, it is not likely that the DHA finding is due to artifactual oxidation of the vitamin C. Indeed, a small amount of AA standard added to a cherry homogenate was converted to DHA. This is likely due to oxidation of the AA in the cherries by phenoxyl semiquinone radicals and/or *o*-quinone metabolites formed from the reaction of polyphenols with polyphenol oxidases (28). That plasma AA increased significantly after consumption of cherries that contain only DHA (Table 2) argues against recent claims that DHA in fruits is poorly available as vitamin C (29,30) and is consistent with evidence that DHA is absorbed in the small intestine and recycled into AA in vivo (31).

In conclusion, the decrease in plasma urate after cherry consumption supports the anti-gout reputation of cherries. The trend toward decreased plasma concentrations of the inflammatory markers CRP and NO adds to the in vitro evidence that compounds in cherries may inhibit inflammatory pathways. Further research is required to determine the potential of cherry and polyphenol consumption for inhibiting the inflammatory cascade and for improving the condition of individuals who are at risk or suffer from gout and arthritis.

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Cherry Consumer Survey Results

Prepared for:

Northwest Cherries

October, 2006

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Objectives

The primary objective of this research is to deliver actionable information about consumer attitudes and purchase behavior regarding cherries.

Specifically we wanted to identify and understand:

- **the level of planned cherry purchases vs impulse purchases;**
- **key consumer decision-making criteria and drivers, i.e. price, display, appearance, quality, ads;**
- **consumer perceptions of cherries compared to other fruits;**
- **the importance of cherry size; and**
- **packaging preferences.**

Approach

In order to deliver against the objectives, the Perishables Group (PG):

- **Worked with Northwest Cherry to develop a targeted consumer interview questionnaire.**
- **Surveyed a total of 1,000 cherry consumers at four chains, one in each region:**
  - ***Northeast***
  - ***Midwest***
  - ***South***
  - ***West***
- **Processed and analyzed the information to document the results of the consumer research and create a set of learnings that can be applied to the overall cherry category.**

Note: Consumers targeted for surveys had cherries in their shopping basket when asked for feedback. As a result, responses reflect the input from actual purchasers vs. the general population. Care must be taken in analyzing and projecting data

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Summary of Key Findings

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Summary of Key Findings

- **More than half (54%) of cherry buyers say they purchase cherries regularly during the season, with 29% saying that they believe they purchase cherries nearly every week while in season.**
  - ***At the other end of the spectrum, close to half of consumers are making two or fewer purchases during the cherry season.***
- **Just over half (53%) of the respondents made the decision to buy cherries while in the store. Consumers over age 35 are much more likely to plan their cherry purchase vs. younger shoppers. Households with two or more children in the home are much more likely to plan cherry purchases.**
- **Product appearance is the most important factor in triggering impulse purchases (46%).**
- **When looking at purchase patterns by ethnicity, Asians are much more likely to make impulse purchases based on product appearance while Hispanics are much more likely to be influenced by a sale price.**

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Summary of Key Findings

- **Nearly two thirds of cherry shoppers (64%) were also planning to purchase other fruits in addition to cherries.**
  - ***Only 6% of buyers said their cherry purchase was a substitute for another fruit. Of the small number of consumers who said they substitute cherries for other fruits, grapes were most likely to be dropped in favor of cherries (41%) followed by strawberries (16%) and plums (14%).***
- **Cherry pricing is very important to consumers; 71 percent of buyers said either "a lower every day price" or a "sale price" would be the main factor to cause them to purchase more cherries.**
- **A majority of shoppers (60%) said cherry size is not important and they will buy what is available. However, 29% of consumers "prefer or will only buy larger cherries."**
- **Among ethnic groups, Asians and Hispanics have the highest preference for large cherries while African Americans are significantly more likely to say they will "buy what's available."**

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Summary of Key Findings

- **Consumers in the Northeast placed the highest preference on size with 40% (vs. 29% nationally) saying they prefer or will only buy larger cherries. Consumers in the South reported with lowest preference levels (20%) for larger cherries.**
- **While only 14% of consumers say they can recall not purchasing cherries due to concerns about fruit size, 81% of those individuals said the fruit was "too small."**
- **Shoppers generally prefer to buy cherries in a ziplock bag (39%), vs bulk (25%). Clamshells had the lowest preference level at 7%. Shoppers over age 45 were more likely to identify zip lock bags as the preferred package.**
- **The top reasons consumers prefer certain packages:**
  - ***Bulk/Loose -- "Can see/inspect fruit" (81%)***
  - ***Clamshells --"Fruit doesn't get crushed" (51%)***
  - ***Ziplock bags-- "Can reseal bag" (51%)***
  - ***Plastic bags– "Can see/inspect fruit" (46%)***

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Study Implications

Study Implications

- **The survey design called for interviews with consumers purchasing cherries. As a result, the findings provide good insights into the behavior and attitudes of actual cherry purchasers. On the other hand, attitudes of non-users are not represented. As a result, this study cannot address issues related to the reasons why non-users avoid the category.**
- **Among cherry buyers there appears to be a broad, loyal base of buyers. With more than half of buyers indicating that they buy weekly throughout the season, cherries seem to have a very strong consumer franchise. Conversely, there remains a very strong opportunity to boost sales by increasing the purchase frequency. Nearly one-half of consumers said that cherries are purchased only two or fewer times during the four month season which indicates significant opportunities to increase transactions among light users.**

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Study Implications

- **About half (53%) of cherry purchases were made on impulse at the store, with cherry appearance, quality and pricing being the most important purchase drivers. This suggests that to optimize sales, retailers must place cherries in a visible, high traffic location as at least half of consumers will not purchase unless they see the display and are then motivated to buy based on perceived quality and value.**
- **Among current buyers, cherries are categorized as an incremental fruit transaction. This is an important message to retailers as nearly two-thirds of cherry buyers were planning additional fruit purchases on the shopping trip when the interview occurred.**
- **Of the small percentage of consumers (6%) indicating cherry purchases were a substitute for other fruits, grapes (41%) were the dominant fruit given. This suggests that a significant portion of potential product substitutions can be minimized at the retail level by ensuring that grape/cherry displays are not located side-by-side to limit price comparisons.**

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Study Implications

- Appearance was the key purchase consideration given by 46% of buyers. However, cherry buyers answered several questions in the survey that indicate there is price resistance. Seventy-three percent of buyers indicated that lower pricing (either every day or on promotion) is the best ways to induce additional cherry purchases. Moreover, the importance of price increased as household size and the number of children increased. In these larger households, the planned purchase rate was higher than average indicating that these consumers are assessing value and finalizing purchase decisions prior to arriving at the store.
- Cherry size was not given as a strong purchase driver as a majority of buyers say size is not an important purchase consideration. However, it is possible that consumers were simply satisfied with the size of cherries generally available for sale, (during audits 90% were 10.5 row and lgr.) thereby lowering the need to emphasize fruit size as a purchase factor.

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Cherries Consumer Panel Research

Prepared for:

Northwest Cherries

September 2005

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Consumer Panel Data
Shopping Behavior

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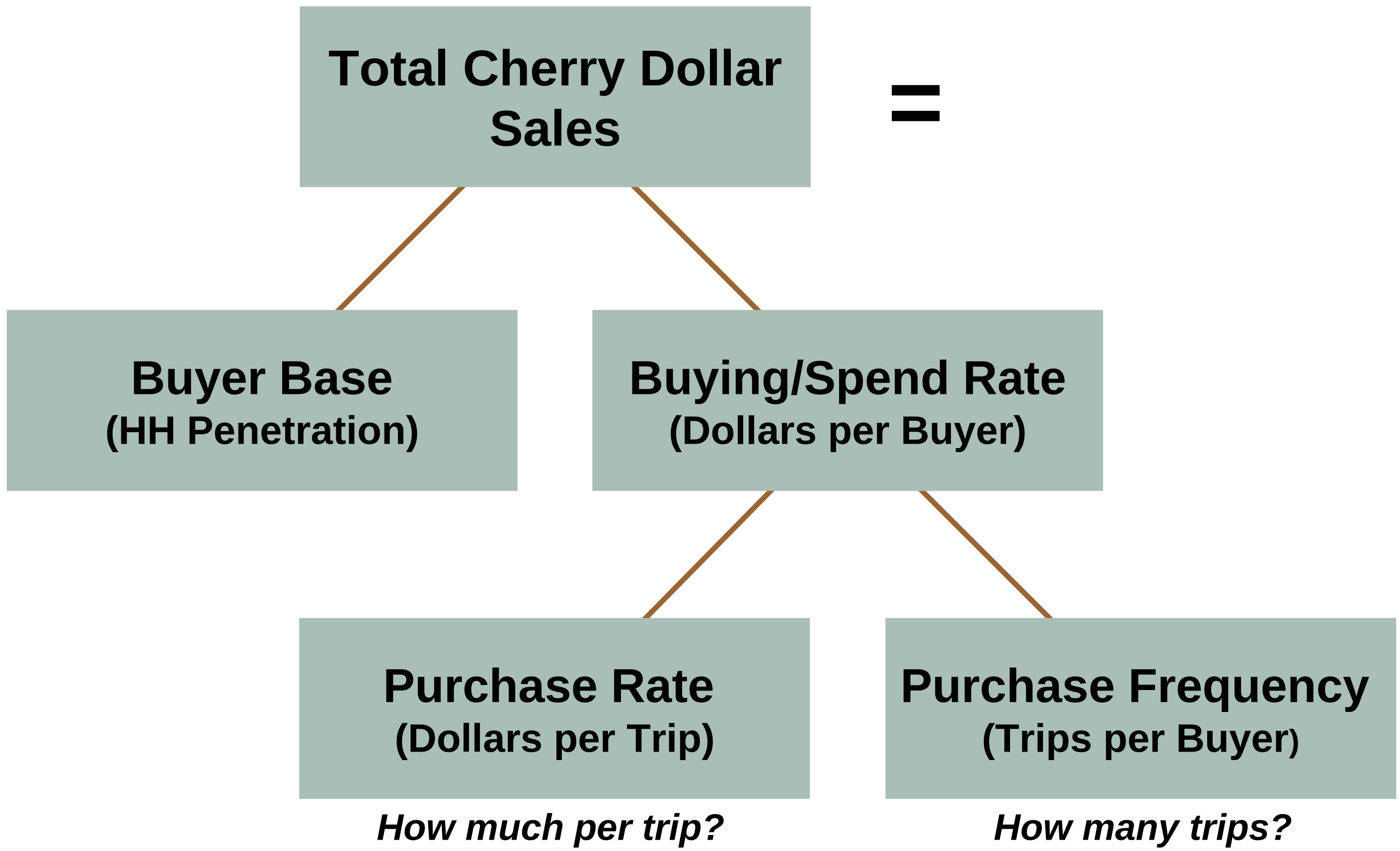
Consumer Shopping Behavior

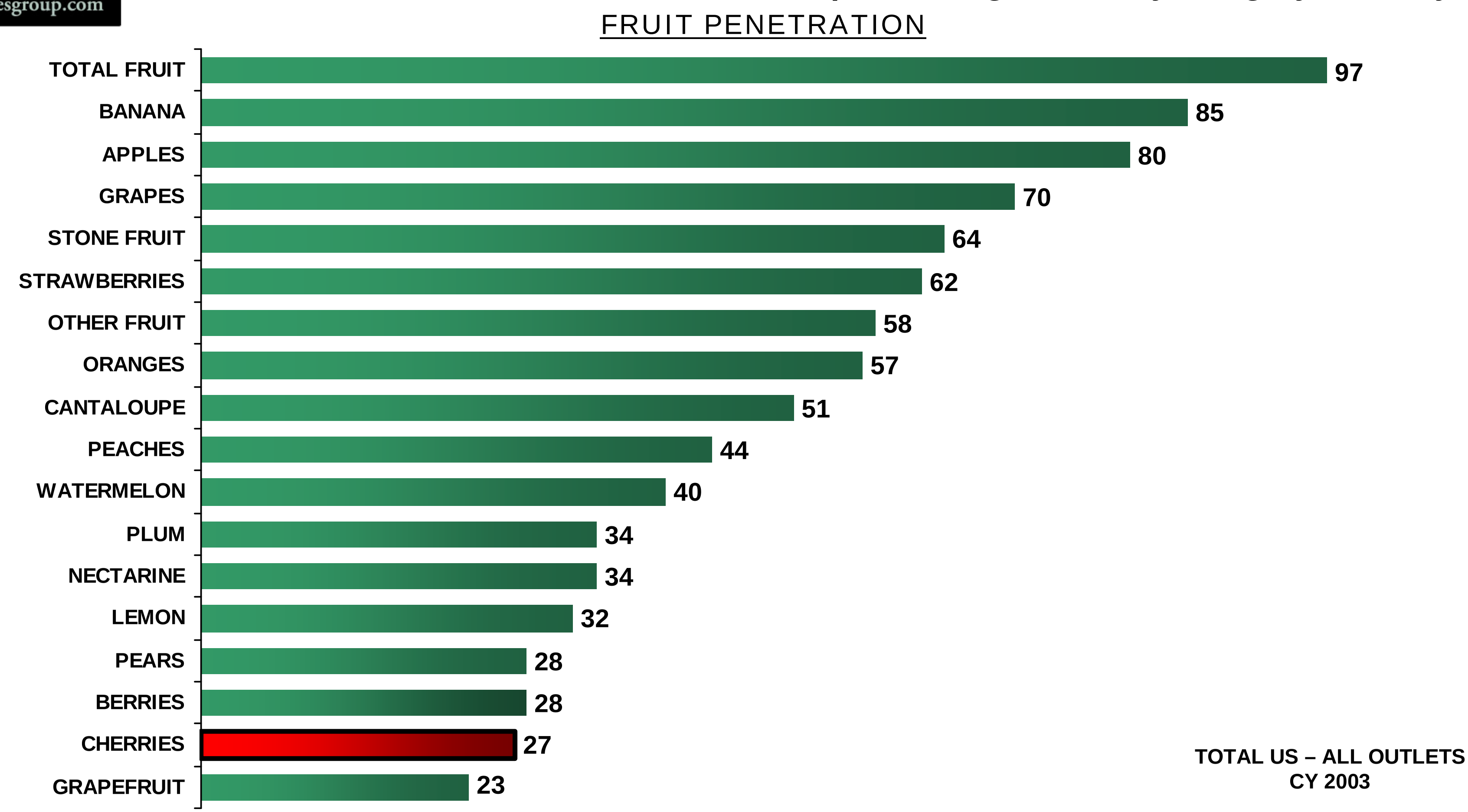
Shopper Components



Source: ACNielsen Homescan Panel Data, 2004

Consumer Shopping Behavior

- **Benchmarking penetration across fruit categories**
  - ***Penetration of cherries is relatively low compared to other fruits, at 27%. Less than 1 out 3 households are purchasing the cherry category annually.***



Penetration = % of HHs that purchases the product atleast once.

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Source: ACNielsen Homescan Panel Data, 2004

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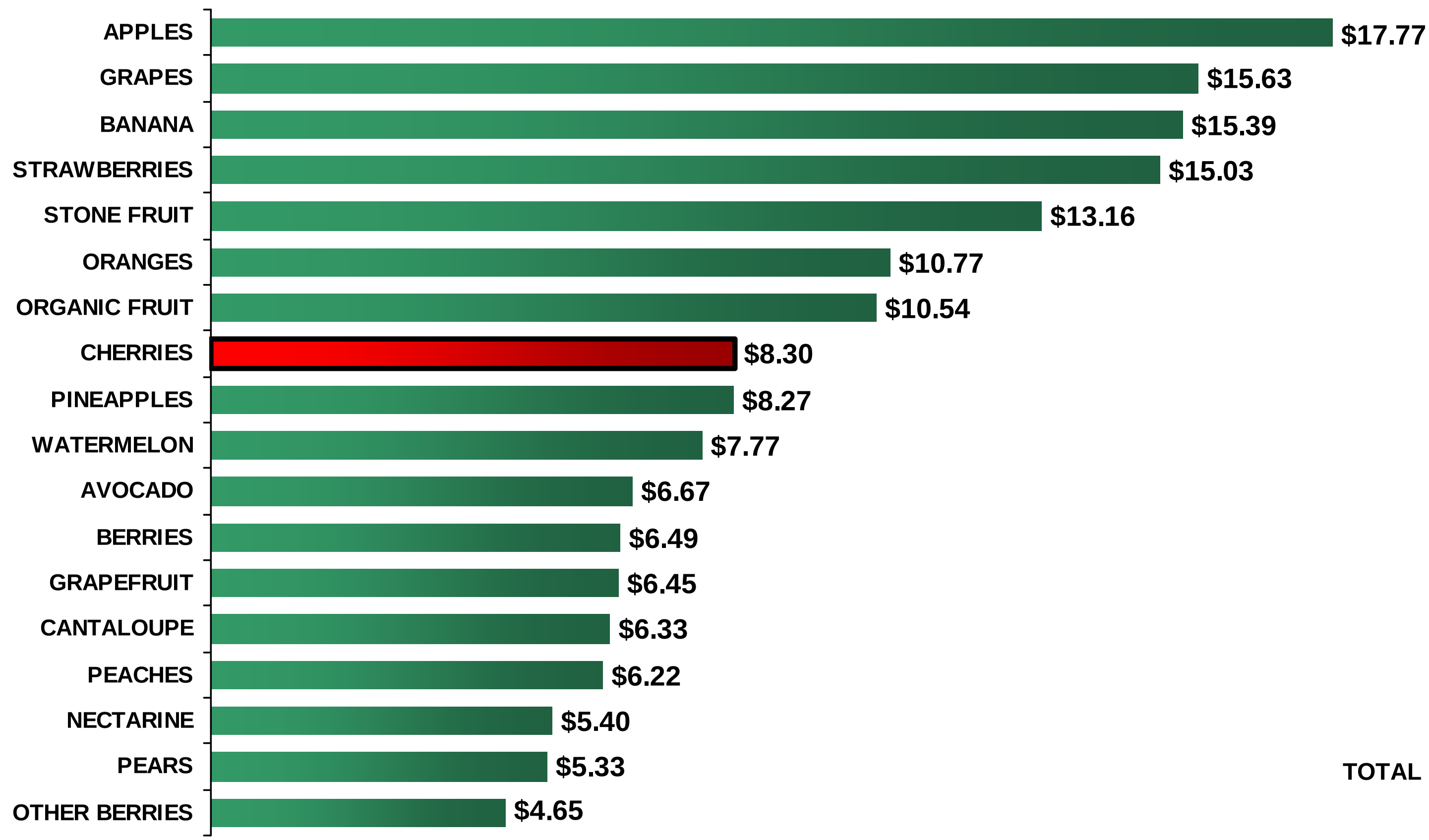
Consumer Shopping Behavior

- **Benchmarking buy rate across fruit categories**
  - ***Annual spend rate of cherries is $8.30, on the moderate level likely due to the seasonal nature of the category***

FRUIT BUYING RATE (SPEND RATE)



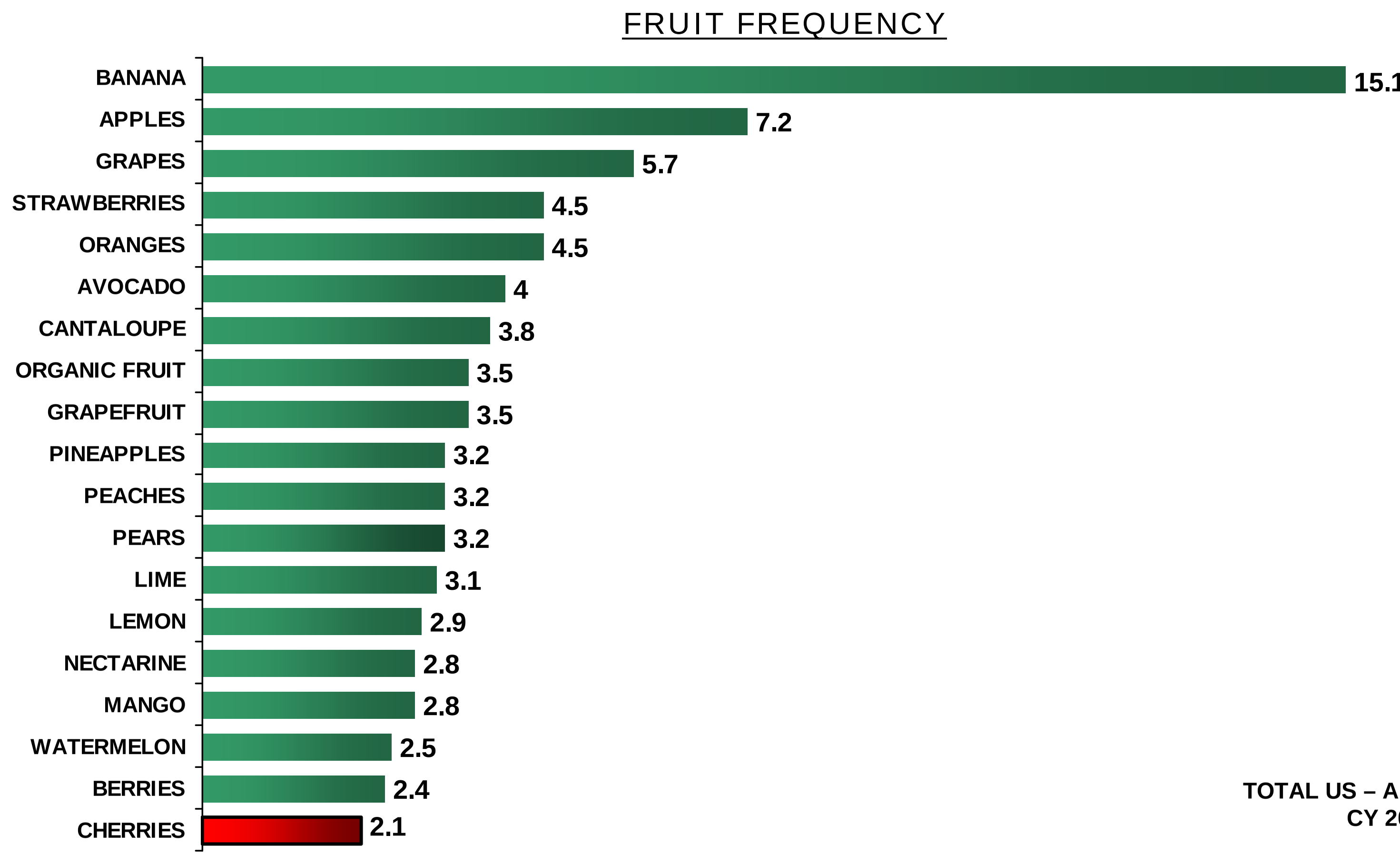
TOTAL US – ALL OUTLETS
CY 2003

Buy Rate = The average dollars spent per buyer.

www.perishablesgroup.com *Source: ACNielsen Homescan Panel Data, 2004*

Consumer Shopping Behavior

- **Benchmarking frequency across fruit categories**
  - ***Cherry buyers are making roughly 2 trips per year***



TOTAL US – ALL OUTLETS
CY 2003

Frequency = The average annual number of product purchase occasions.

Source: ACNielsen Homescan Panel Data, 2004

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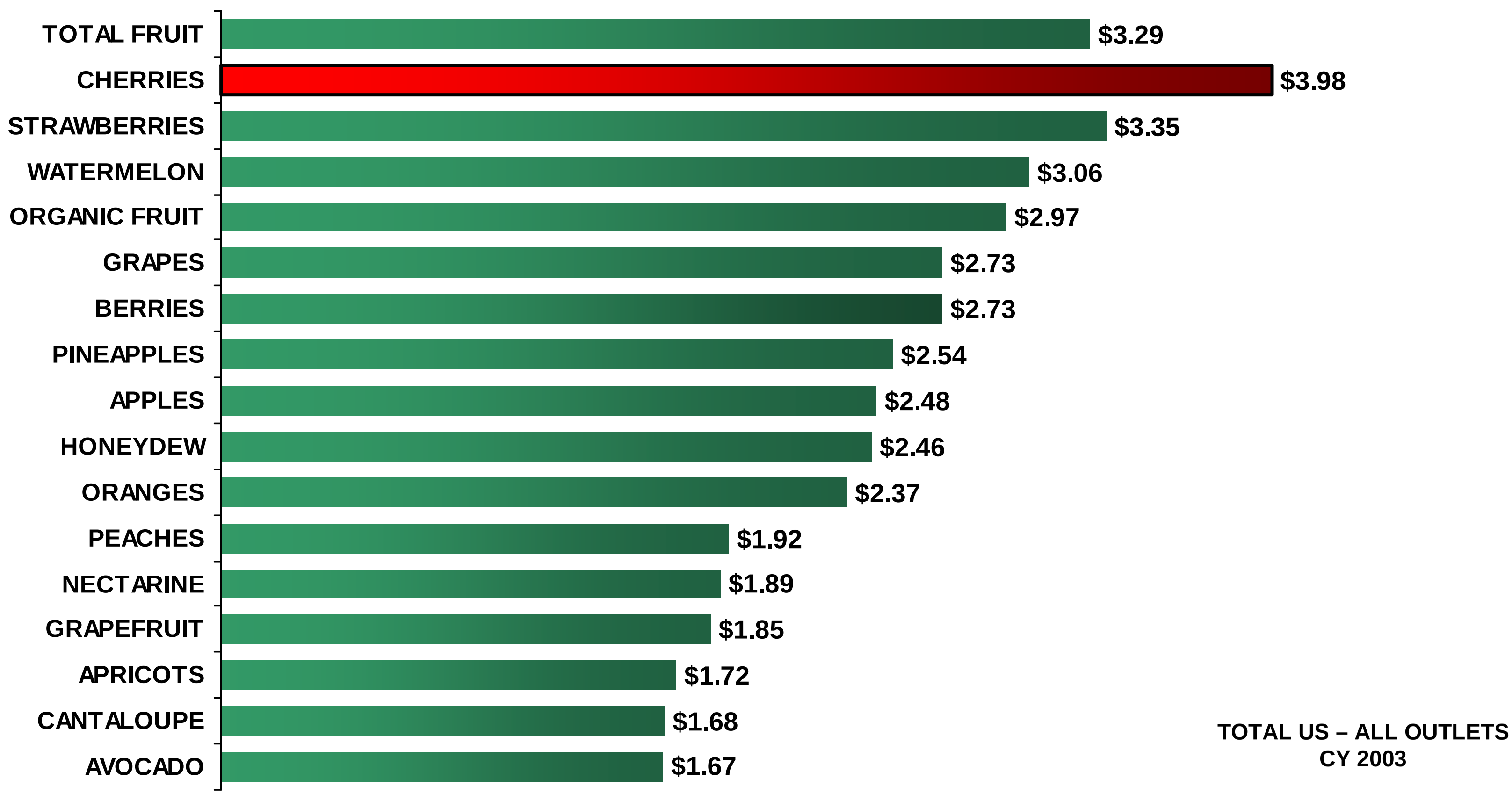
Consumer Shopping Behavior

- **Benchmarking transaction size across fruit categories**
  - ***The average cherry consumer spends $3.98 per trip, the highest of all fruits***

FRUIT TRANSACTION SIZE



TOTAL US – ALL OUTLETS
CY 2003

Dollars per Trip = The average dollars spent per product purchase occasion.

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Source: ACNielsen Homescan Panel Data, 2004

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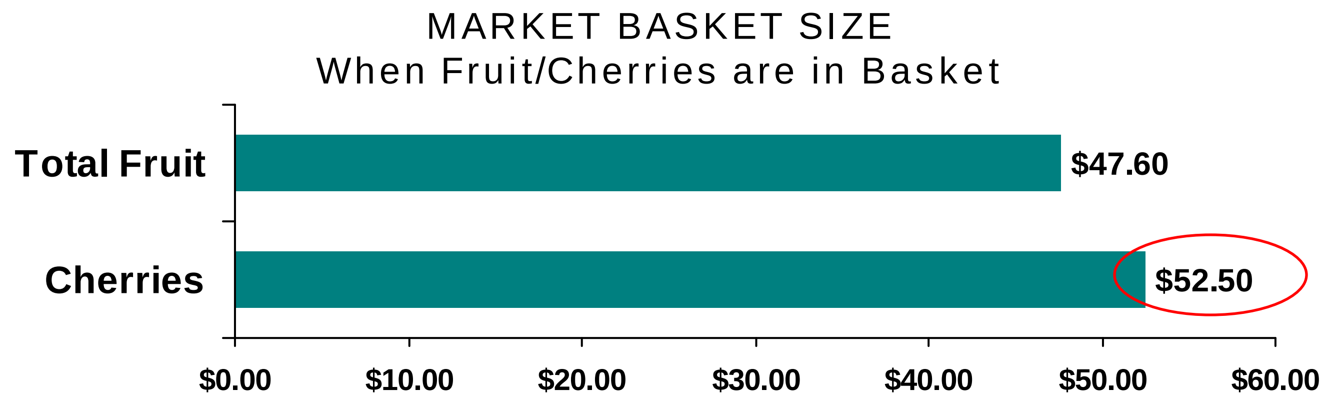
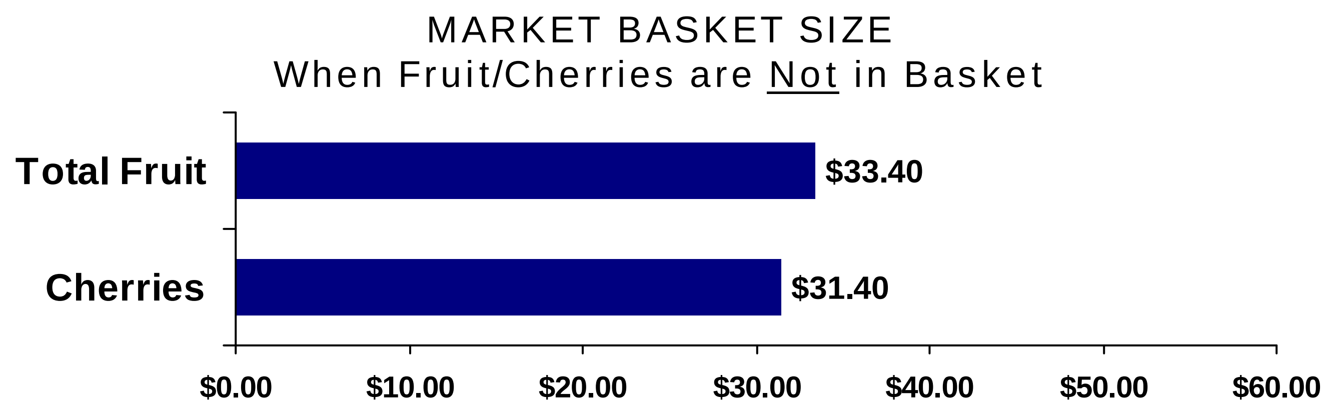
Consumer Shopping Behavior

- **Market Basket Size**
  - ***The average dollar value of the shopping basket is $52 when cherries were included. This is double the basket when cherries were absent. Cherries add significant additional shopping basket spending dollars to the retailer, even more than the average fruit.***





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Source: ACNielsen Homescan Panel Data, 2004

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Summary of Key Findings

Retailer Performance

- **There were great differences in category performance among the chains. Retailer D led sales with $3,550 per week per store and Retailer B generated the lowest sales with $728 per week per store.**
- **As expected, Bing/Dark Cherries dominate volume and dollar sales at all retailers. However, chains selling a higher percentage of Bing/ Dark Cherries generated higher contribution to department dollars.**
- **Retailer D, the highest performing chain by a wide margin, was the only retailer that stocked a 4 lb. clamshell. Retailer C (2nd highest performance) and Retailer D limited yellow cherry options to a single item while the other chains offered two or more SKU's.**
- **Often, as average retail price climbed, the category contribution decreased. Retailer B with the highest average retail price had the lowest weekly volume/dollars and the 2nd lowest category contribution.**
- **For all retailers, high retail prices had a stronger correlation to reduced category performance later in the season than the same price point early in the season.**
- **Category space/location did not seem to have a significant impact on category contribution.**
- **Retailer B (lowest performance) had the highest percentage of cherries on un-refrigerated tables as well as highest percentage of "split" displays.**
- **With product adjacencies, the two lower performing chains were twice as likely to display cherries next to grapes and/or berries. The two highest performing chains were nearly twice as likely to display cherries adjacent to apples and/or citrus.**

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Findings

- **In terms of the total produce department, Cherries rank 1st in total department productivity ($/sq ft) for both years but have nearly the smallest category space allocation in total produce department**
- **During the season, Cherries generated nearly double the dollars per square foot of display space as the other fruit categories**
- **In terms of dollars generated per square foot during the season, Cherries were ranked #1 in 6 out of 7 months covered during this study**
- **Cherry display allocation showed a broad range through the season, but never commanded shelf space similar to other top performing seasonal fruit items. During the season, cherry space ranged from 12 square feet to very small displays of approximately one carton (1 sq. foot)**
- **Several key categories utilize large amounts of produce department space yet generate relatively low productivity per square foot**
  - ***Citrus, melons, tomatoes are examples of categories with high space allocation and low relative productivity***

Northwest Cherries

Findings

- **Within the season, June 2003 saw the highest average productivity at $239.75/sq ft with August, 2003 showing the lowest at $75.25/sq ft. Even at this level, cherries still ranked #2 overall for shelf space productivity**
- **June 2003 had the largest space allocated to Cherries (12 sq ft) and August 2002 saw the lowest**
- **Average space doubled for the 2003 (7 sq ft.) season versus 2002 3 sq. ft.) yet the category still had the highest productivity by a wide margin**
- **Individual store analysis indicated that a season-long space allocation, of at least 8 feet will generate up to 94% more dollars per store per month than sets four feet and under**
- **Appropriate display space in June and July is critical to achieving strong category performance. May and August space is important, but have a smaller impact on overall seasonal performance**

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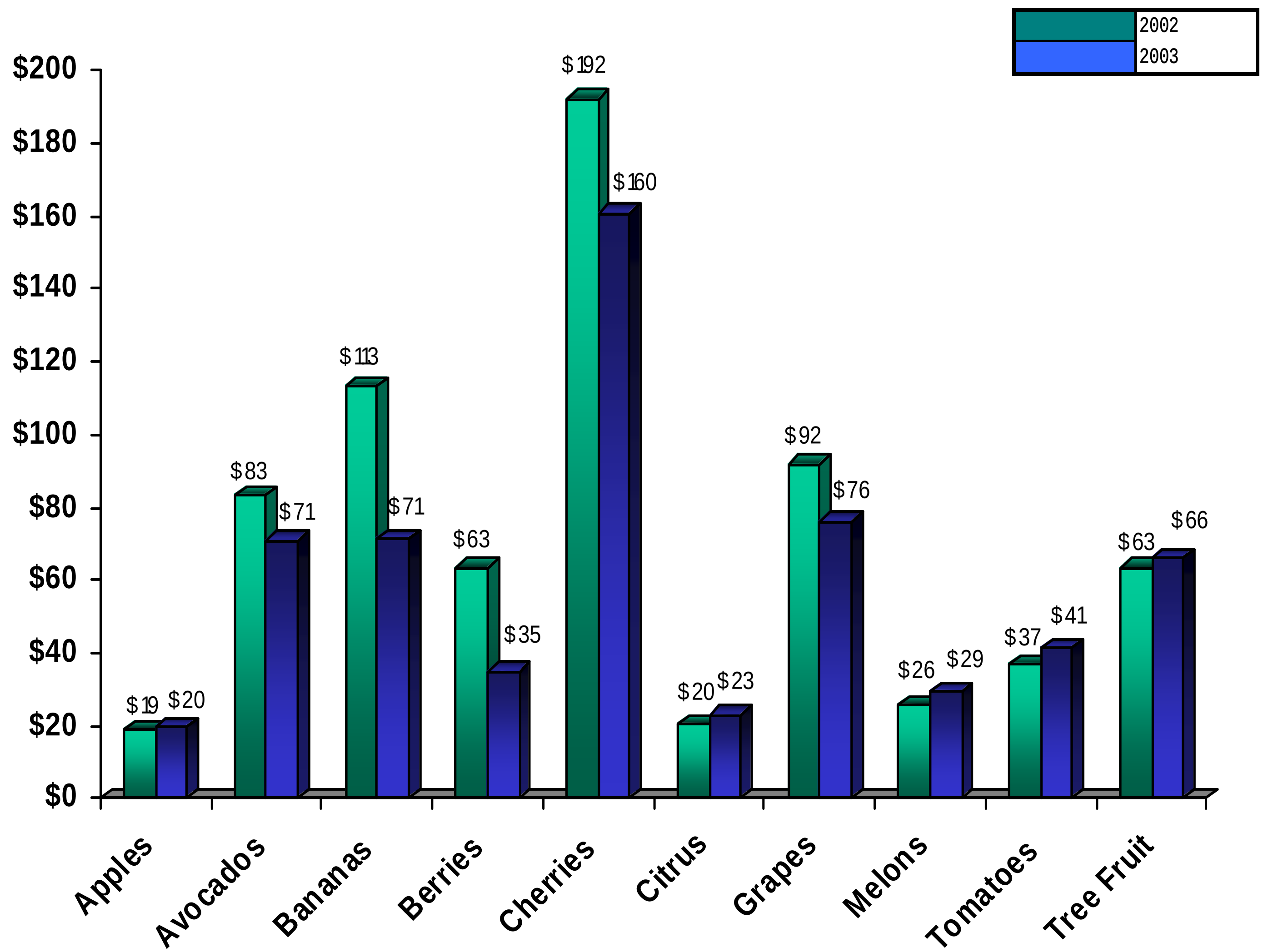
Dollars per Square Foot: 2002 vs. 2003

2002 (May-August) vs. 2003 (June - August)



Northwest Cherries

Category Contribution – Cherry Category – June 2004

BRYANT CHRISTIE INC.
INTERNATIONAL AFFAIRS MANAGEMENT
REPORT

THE RUSSIAN SWEET CHERRY MARKET: TRENDS AND ANALYSIS FOR NORTHWEST SWEET CHERRIES

Prepared by Bryant Christie Inc.
for the Washington State Fruit Commission

September 30, 2007

Seattle Telephone: 206 292 6340
Sacramento Telephone: 916 492 7062

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I. EXECUTIVE SUMMARY

The Russian sweet cherry market has developed considerably in recent years. Growing disposable incomes have led to increased consumer demand for fresh fruit. During the Soviet era, the market for sweet cherries was limited due to the lack of local fresh fruit production and undeveloped retail distribution channels. Recent economic growth has improved distribution and a greater number of Russian consumers can now afford sweet cherries including imports. Between 2000 and 2005, Russian cherry consumption rose 38% (0.65 to 0.9 kg per capita). Imports have increased nearly 60% over the last three years.[1]

Despite a recent increase in Russian cherry production, domestic cherries only satisfy a small fraction of the total market demand. The Russian industry is disadvantaged by a short harvest season (May-June) and limited growing areas. As a result, the majority of the Russian cherry supply is imported. Product from former Soviet republics (Commonwealth of Independent States - CIS) account for the largest share of imported cherries.[2] However, due to their low quality CIS cherries are not considered a threat to premium imports from the Northwest.

Premium imported sweet cherries are mostly purchased by the Hotel, Restaurant, and Institutional (HRI) sector in Moscow and St. Petersburg. Indeed, 90% of U.S. cherries imported in 2006 were distributed through the HRI sector, particularly up-scale hotels and restaurants in those two cities. Consumers there have the greatest purchasing power among Russian consumers and these cities attract substantial numbers of tourists and business visitors each year. More efficient distribution chains there also facilitate transportation and storage for premium imported cherries.

Despite the demand for premium sweet cherries, the U.S. is a minor player in the market. U.S. imports are limited due to price, and misconceptions regarding U.S. quality standards and delivery times to access the market. U.S. sweet cherries also confront significant competition from Turkey and Western Europe whose cherry exporters have had a longer presence in Russia.

There are, despite these constraints, opportunities for Northwest cherries. First, growth in Russia's HRI sector (the main destination for premium imports) should provide new outlets for U.S. product. The sector has grown 23-26% annually in recent years. Second, high-end retail chains in Moscow and St. Petersburg are handling growing volumes of premium imported fruit.

BCI recommends the WSFC strengthen relationships with trade companies that service the HRI and upscale retail sectors, and address misperceptions regarding quality standards. A concerted effort to develop HRI relationships and resolve confusion over quality standards should enable the Northwest cherry industry to develop Russia as a profitable niche market.

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[1] Export Market Development Report: Cherries in Russia Euromonitor International. May 2007.

[2] Anatoly Kutsenko, Chief of Plant Breeding Department of the Ministry of Agriculture of the Stavropol region.

II. INTRODUCTION

In June 2007, Bryant Christie Inc. (BCI) was retained by the Washington State Fruit Commission (WSFC) to study the market for Northwest sweet cherries in Russia. The project consisted of desk research and in-country interviews with over 30 contacts in the Russian trade. Based on this research, BCI has concluded that there is market potential for Northwest cherries in Russia, within high-end HRI establishments and specialty retail outlets in Moscow and St. Petersburg.

It should be noted that the WSFC received grant funds from the Washington State Department of Agriculture for this project. Those funds were allocated to support a project on behalf of Washington State's sweet cherry industry. However, the report that follows refers to Northwest cherries, not only product from Washington. Though Washington represents 85% of Northwest sweet cherry production and trade, individual state names are not used for international branding and market development work. The "Northwest USA" or simply "Northwest cherries" is how product from this region is known among international trade, consumers, and media. All interviews conducted for this study referred to Northwest cherries to ensure consistency with the trade's nomenclature. The report reflects this.

III. METHODOLOGY

BCI conducted extensive desk research while preparing this report. Sources included USDA Foreign Agricultural Service (FAS) attaché reports, Euromonitor, CIA World Factbook, U.S. and Russian government websites, the Global Trade Atlas, and news articles. BCI also worked with a Russian consulting firm to conduct 34 interviews with retailers, wholesalers, and other experts familiar with the Russian cherry market. Major Russian cherry distributors including Nord City LLC, Taganskoye State Unitary Enterprise, and Fruktovy Ray LLC were among the companies interviewed.

BCI also reached out to Russian trading companies that handle other Northwest fruit commodities. While companies such as Globus Fruit Trade, Nevskaya Co. and Euro Fruit SPB are important traders for premium imported produce, these particular companies have reportedly not handled Northwest cherries. A list of all interviewees has been provided in the appendix to this report.

It is important to note that Russian contacts do not always distinguish between sweet and tart cherry varieties. This was particularly evident when BCI analyzed and compared trade data from different sources. In areas where there is potential inconsistency because of this issue, the differing source data is discussed.

VIII. CONCLUSIONS AND RECOMMENDATION

BCI believes marketing resources should be spent to further develop markets in Moscow and St. Petersburg. The HRI sector in particular represents an immediate target as there are a number of hotels and restaurants (including chains) already handling imported premium sweet cherries.

There are several constraints to market development that the Northwest cherry industry needs to address simultaneous to market development. Specifically, price, importer misconceptions regarding delivery times and shelf life, and consumer perceptions of U.S. products as "unnatural" need to be addressed on marketing, policy and transportation supply chain levels.

These constraints can be overcome and this is an area where the WSFC can help. To address these issues and assist in the development of Russia as a larger niche market for the Northwest cherry industry, BCI suggests the WSFC:

- *Educate Russian importers about the availability of Northwest cherries*—The perception among many importers is that U.S. cherries are incapable of accessing the market within a timeframe that maximizes remaining shelf life. However, Northwest cherries already have limited distribution in Russia and are sold in upscale, quality-conscious HRI establishments. The WSFC could send a delegation of industry members to Russia to meet with key trading companies, to discuss the availability of Northwest cherries and the industry's commitment to providing premium quality fruit.

- *Educate the trade and consumers about the quality and safety of Northwest cherries* – Another misperception discussed previously is that U.S. food products are unsafe or unnatural because of excess pesticide usage and the incorporation of genetically modified organisms. These issues should be confronted directly through outreach to the trade and through media education. But it is also because of this very issue that Northwest shippers should be mindful of Russian tolerances for certain pesticides used on cherries. Dicofol was one compound cited earlier for which the Russian tolerance is more restrictive than the U.S. tolerance. The USDA-sponsored MRL database (www.mrldatabase.com) is now being expanded to include Russian tolerances. Northwest cherry shippers should consult this resource for information on potential issues with compounds used.

- *Consider participating in a Russian Trade show*—Trade shows such as World Food in Moscow, Prodexpo in Moscow, and Interfood in St. Petersburg should be considered as appropriate venues to promote sweet cherries and identify importers. Trade shows can be particularly beneficial if WSFC staff or industry members are not familiar with the Russian market and need assistance identifying appropriate trade partners.

- *Invite trade and media to visit the Pacific Northwest*—Trade missions that bring key HRI and retail buyers, importers, and press to the Northwest would be invaluable for education purposes and to begin the process of establishing needed relationships.

- *Apply for Quality Samples Program and Emerging Market Program funds*-The USDA's Quality Samples Program (QSP) is designed to cover the cost of purchasing and shipping samples to emerging markets where buyers would otherwise have difficulty purchasing those samples. QSP funds are typically for educational, not promotional, purposes. The same is true for Emerging Markets Program funds. But because there are misconceptions about the availability and safety of Northwest cherries, an educational effort funded through EMP and QSP would be appropriate.

- *Apply for WSDA or FSMIP funds for retail promotions*-The Washington State Department of Agriculture program that funded this study could be used to fund the next stage of promotional activity in Russia. For example, market promotion funds could be secured to organize a retail promotion with the 7th Continent. Such a promotion would go a long way towards demonstrating the viability of Northwest cherries in this market to dubious traders. Similarly, the Federal State Marketing Improvement Program (FSMIP) provides funds for developing new sales and marketing channels in domestic or foreign markets. Funds through both programs are limited but could augment WSFC's resources available for Russia.

Bryant Christie Inc. appreciated the opportunity to work with the Washington State Fruit Commission on this important research project. If you have any questions about information contained within this report please contact Eric Rosenberg at (206) 292-6340 or by email at ericr@bryantchristie.com.