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Fruit Quality Evaluation of Raspberries and Blackberries at North Willamette Research and Extension Center

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FRUIT QUALITY EVALUATION OF RASPBERRIES AND BLACKBERRIES AT NORTH WILLAMETTE RESEARCH AND EXTENSION CENTER

by

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TABLE OF CONTENTS

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INTRODUCTION

The objective of the Oregon State University - US Department of Agriculture (OR-US) cooperative Rubus breeding program is to produce manageable, high yielding raspberry and blackberry cultivars that consistently bear superior quality fruit for use in the Pacific Northwest (Daubeny, 1989; Lawrence et al., 1987). Because nearly 98 percent of the blackberries and raspberries harvested in Oregon are processed (Schroeder, 1990), the focus of the OR-US breeding program has traditionally been on release of cultivars for processing. However, in response to a growing demand for pick-your-own and fruit for fresh shipping (Richardson, 1988), the OR-US program is stepping up its efforts to select for fresh market characteristics in addition to good processing quality. This report presents raspberry and blackberry fruit quality data collected by Oregon State University researchers at the North Willamette Research and Extension Center (NWREC) in support of the OR-US Rubus breeding program (Table 1 and Table 2).

Plantings of raspberry and blackberry plants from the OR-US program are maintained in at NWREC. In addition to OR-US plant materials, the NWREC plantings contain selections and cultivars from breeding programs in Washington, British Columbia, Arkansas, Minnesota, New York, Illinois, Great Britain, and New Zealand. The plant material from other programs is maintained for comparison to OR-US material, and to assess the possible benefit of raspberries and blackberries from other production regions for the Willamette Valley industry. Data collected from evaluations made at NWREC are used primarily by the OR-US breeder, but to encourage industry input into the selection process, yearly fruit quality results have been made available to processor representatives, growers, and other interested industry constituents.

Development of a new blackberry or raspberry cultivar in the OR-US program requires several screening steps, and the entire process can take up to ten years or more before a new cultivar is released for nursery propagation and sales (Sjulin, et. al, 1984). In the initial step, crosses are made by the breeder from select raspberry or blackberry parents. The seedlings resulting from each cross are established in a planting where the breeder qualitatively assesses and compares plant vigor and fruit characteristics of each individual to select the most promising among them. A majority of the seedlings are eliminated during this initial screening process, and only a small fraction of individuals are selected for further evaluation from plantings of hundreds of seedlings.

To complete the next screening phase, clones from selected seedlings are established in a planting, called a selection planting. In addition to seedling selections, OR-US selection plantings contain standard Pacific Northwest raspberry and blackberry cultivars that provide a basis for comparison and evaluation of new material. Each year new selections are added to the planting to continue the flow of material through the screening process.

Evaluations of all plants in the selection planting begin in the baby crop or first crop year. Harvest season records, cane size and vigor, inflorescence properties, fruit quality, and disease susceptibility are the parameters measured to screen material. Evaluations continue for several years before further selections are made. After sufficient evaluation, the breeder identifies the top performing selections, which are distinguished as advanced selections. Only advanced selections are continued subjected to final evaluation and screening.

The final screening process in the OR-US program involves evaluations from various sources in attempt to detect any weaknesses not discovered in previous screenings. Those advanced selections that consistently perform well

in the final evaluations are then considered candidates for release, but the breeder does not necessarily submit all advanced selection for release.

Once identified, advanced selections are established in long rows suitable for machine harvest. Yield data from the long rows are collected for a minimum of two years. To assess the adaptability of advanced selections under different growing conditions, the breeder distributes as many plants as possible to research facilities throughout the Pacific Northwest, where breeders and researchers from other programs evaluate the material. Input from growers is solicited by hosting field days at research sites, but more importantly plants are distributed to growers who agree to establish and compare advanced selection plantings to plantings of standard raspberry and blackberry cultivars. Grower trials allow the breeder to examine the adaptability of an advanced selection under conventional management, and from grower information, researchers can design experiments to develop optimum cultural recommendations should the advanced selection be released. Input from fruit processors and other industry constituents is also considered by the breeder in the final screening process.

FRUIT QUALITY

Raspberry and blackberry fruit should be firm, strong skinned with cohesive drupelets, have consistent and even ripening with full development of color, flavor, shape, and size. Raspberries and blackberries that are consistently misshapen, distinctly "odd" tasting with unappealing coloration, and/or difficult to harvest are usually eliminated, despite superior field characteristics. Additionally, high yielding plants are of little benefit to the industry if the fruit quality is sub-standard or unacceptable to the consumer (Sistrunk and Moore, 1983).

Procedures used to measure the fruit quality characteristic reported, discussions of the importance of the characteristics, and comparisons to illustrate desirable levels of the each characteristic are presented in the sections below. Because the criteria used by breeders in screening raspberries and blackberries for fruit quality are often subjective and vary according to breeding objectives and aesthetic judgement, discrete quality levels have not been defined.

BERRY SIZE

Fruit is harvested weekly during the season. Berry size determinations are made by weighing 50 fruit directly after picking, and the data reported are mean values from each harvest (Table 1 and Table 2).

Berry size affects acceptance and marketability of fresh raspberry and blackberry fruit, and is a factor in designation of U.S. Grades and Standards in whole berry products (Sistrunk and Moore, 1983). Large size is particularly desirable where fruit is hand picked and sold fresh or processed in whole packs. Size has less effect on machine harvestability. Generally, smaller fruit that has been machine harvested is processed as puree, juice or other products that don't retain whole fruit integrity.

Raspberry

'Meeker' and 'Willamette' are the predominant raspberry cultivars in the Pacific Northwest and are considered to be the standards for processing quality in Oregon and Washington. Although 'Meeker' and 'Willamette' are superior cultivars with good flavor, many of the other raspberries evaluated in the NWREC trials are found to produce larger and firmer fruit. Some of selections that show promise for large size in their baby crop year include OR-US 702-13, OR-US 905-1, OR-US 994-10, and particularly OR-US 1012-10. However, more data is required to determine whether the large-fruitedness is a consistent trait. Several years of data have been collected to verify that OR-US 576-47 and OR-US 2078 consistently produce large fruit with good flavor and firmness, and due to their overall superior performance, these two raspberries have been designated as advanced selections (Table 1).

'Centennial', a raspberry cultivar released jointly in 1991 by Washington State University, Oregon State University, and University of Idaho, is noted for its bright, glossy, medium-red fruit, and because of its outstanding size, 'Centennial' is well suited for the fresh market (Moore et al., 1990). NWREC results confirm the large size of 'Centennial' fruit. 'Comox' and 'Chilliwack', released in 1985 from British Columbia (Daubeny, 1987), are also found to produce superior fruit size in NWREC evaluations, and 'Chilliwack' is gaining popularity for fresh market production in Oregon and Washington due to its large size and good fruit quality. Two other cultivars that produce large fruit in the NWREC trials are 'Schoenemann' and 'Skeena'. 'Skeena', however, is susceptible to root rot and not grown widely in Oregon and Washington (Table 1).

Blackberry

'Marion' blackberry is considered to be the standard of quality for blackberry processing in the Willamette Valley. 'Marion' produces a full-flavored, machine harvestable fruit with good shape and acceptable color, but larger sized, firmer fruit are sought by processors for whole berry packs. Two advanced blackberry selections, OR-US 830-4 and OR-US 1826, are larger and firmer than 'Marion' with similar color, but no data has been collected regarding their processing quality. Although only one year of data has been collected, fruit size from OR-US 838-8, OR-US 1112-11, and OR-US 2008 is outstanding (Table 2).

Blackberry cultivars found to produce large fruit in NWREC evaluations include OR-US cultivars 'Waldo' and 'Kotata'. 'Waldo' is the larger of the two, but 'Kotata' is more similar in shape, flavor, and harvest season to 'Marion'. An erect type blackberry released from University of Arkansas, 'Shawnee' (Moore et al., 1985), produces outstandingly large fruit at NWREC, and 'Choctaw', a more recent release from University of Arkansas (Moore and Clark, 1989), shows promise in its baby crop year for large fruit production. Due to their large size, good firmness and erect growth habit, 'Shawnee', 'Choctaw', and other Arkansas releases are gaining interest from Pacific Northwest growers for fresh market sales (Table 2).

FIRMNESS

A fundamental objective in the OR-US breeding program is to select firm blackberry and raspberry fruit that will not crumble due to poor drupelet set or lack of drupelet cohesion. Raspberry and blackberry fruit firmness is important because it affects: 1) processing quality, 2) suitability for machine harvest, 3) shelf life, and 4) resistance to handling injury. Robbins and Sjulin (1989) found that soft raspberry fruit is related to high respiration rates and associated weight loss during fresh storage, and fruit lacking firmness is associated with a higher incidence of fruit rot. Soft fruit is subject to greater damage during machine harvesting, and only the firmest blackberries can be machine harvested for whole fruit processing. Also processors prefer firm blackberries, because they are less likely to lose whole fruit integrity. Consequently, selection for firmer blackberries is a priority in OR-US program.

Fresh firmness of raspberries is evaluated by measuring the force necessary to close the fruit cavity using a Hunter push-pull spring gauge (Barritt et al., 1990). Raspberry firmness values obtained with the spring gauge are an indication of drupelet cohesiveness and skin strength, which reflect how well the fruit will maintain its shape after harvest.

Blackberry fruit firmness must be measured differently from that of raspberry because the receptacle remains in the blackberry fruit cavity after harvest. Researchers at NWREC determine blackberry firmness by recording the force necessary to press the drupelets together around the exposed end of the blackberry receptacle. The force measurements reported for blackberries, therefore, are an assessment of the receptacle firmness, rather than cohesiveness of the drupelets. Firmness data presented for both raspberries and blackberries in this report are mean values of ten force measurements and all weekly harvests.

Raspberry

Although 'Meeker' and 'Willamette' are prized for their machine harvestability, yield and processing quality, they lack firmness. Much of the red raspberry breeding efforts in the OR-US program focus on development of a high yielding, full flavored raspberry that processes well and is firmer than 'Willamette' or 'Meeker'. 'Centennial', 'Chilliwack', 'Comox', 'Skeena', and 'Schoenemann' are firmer, but these cultivars are not widely grown in Oregon and Washington for the processing market. 'Amity', a primocane-fruiting cultivar, has outstanding firmness and good flavor, but its fruit does not detach easily when ripe limiting the possibilities for machine harvest and slowing hand harvest (DeGomez et al., 1986).

OR-US 1836 is an advanced raspberry selection with good overall fruit quality and fresh market appeal. Although, the values presented in this report do not show OR-US 1836 to be firmer than 'Willamette' or 'Meeker', Conway (1986) found OR-US 1836 to be significantly firmer at harvest during two consecutive years (1984 and 1985). Conway (1986) also found OR-US 1836 to be firmer with lower incidents of mold and fruit defects than 'Meeker', 'Willamette', 'Chilcotin', 'Nootka' and 'Amity' after 72 hr of fresh storage at 20C. These results suggest that OR-US 1836 has good fresh market potential, and may also be suitable for whole fruit processing (Table 1).

Selection OR-US 576-47 and OR-US 2078 are two other advanced selections that produce flavorful, large firm fruit with good processing quality. Some of the newer raspberry selections showing firm-fruitedness at NWREC include OR-US 994-10 and OR-US 1072-11, however, only data from the baby crop year has been collected for these two selections (Table 1).

Blackberry

'Marion' is valued for its flavor, shape, and processing quality, but it lacks firmness. Blackberry cultivars found to be firmer than 'Marion' in the NWREC evaluations included 'Hull Thornless', 'Chester Thornless', and 'Waldo'. Although, NWREC results did not show 'Kotata' to be outstandingly firm, it has been found to be considerably firmer than 'Marion' in other OR-US evaluations (Lawrence, 1987). 'Kotata' processes well, and because its flavor is similar to 'Marion', 'Kotata' may have promise as a substitute for 'Marion' in individually quick frozen (IQF) and other whole berry packs. 'Silvan' blackberry is found to be firmer than 'Marion' in NWREC measurements, but Silvan does not retain whole fruit integrity well and tends to juice easily after harvest. The erect cultivars from Arkansas, 'Choctaw' and 'Shawnee' are much firmer than 'Marion' at NWREC, but 'Navaho', the first erect cultivar released from Arkansas (Moore and Clark, 1989), lacked firmness in its baby crop year at NWREC (Table 2).

Among the selections with repeated evaluations, OR-US 1826 and OR-US 830-4 excel in firmness as well as size. Both of these selections have been designated for advanced status and will be evaluated for yield in advanced screening trials. Of the one-year evaluations, blackberry OR-US 2007, OR-US 2008, and particularly OR-US 1112-11 have outstanding firmness (Table 2).

SOLUBLE SOLIDS

Soluble solids (SS), titratable acids (TA), pH, color and seed characteristics are determined from defrosted, blender pureed frozen fruit samples. Fruit from early, middle, and late harvests are included in equal portions in all purees to minimize any variability in fruit quality and ripeness due to date-of-harvest differences.

Percent soluble solids (degrees brix) are determined from filtered puree samples at room temperature with an Atago hand-held refractometer. The resulting refractometer readings are interpreted here as a measure of the total percent sugar contained in the fruit at harvest.

High soluble solids are particularly important when fruit is processed without sugar, and greater amounts of natural sugars reduce the amount of added sugar necessary in production of jellies, jams and other sugared packs, thus reducing cost. Sweeter fruit increases the acceptability of IQF and other unsugared packs, and high fresh fruit brix decreases the amount of reduction required to reach a desirable brix level for juice concentrates.

Raspberry

The raspberry cultivars highest in soluble solids at NWREC are 'Amity', 'Munger', and 'Chilliwack'. The standards 'Meeker' and 'Willamette' have intermediate soluble solid content, and 'Ruby' contains the smallest amount of sugar of the all the raspberry cultivars and selections evaluated at NWREC. Of the selections, the yellow types tend to produce sweeter fruit, but the red selection OR-US 759-10 had the highest soluble solids readings of all the selections tested (Table 1). OR-US 958-10 and OR-US 576-47 are also notable for their high soluble solids percentages (Table 1).

Blackberry

Soluble solids of blackberry selections varied quite a bit, OR-US 913-12 and OR-US 1054-11 having the highest levels. Both these selections require further evaluation, but because they lack good firmness and size, OR-US 913-12 and OR-US 1054-11 are better evaluated as parents rather than potential cultivars. The selection with the best overall quality that also contains a high percentage of soluble solids is OR-US 2007. 'Navaho' has the highest soluble solids of the cultivars tested, but this may be due in part to the unexpectedly small fruit size (Table 2).

SOLUBLE SOLIDS : TITRATABLE ACIDITY (SS:TA)

Percent titratable acidity (% TA), expressed as citric acid, is determined by titrating 5 g of fruit puree in 10 ml water with 0.1 N NaOH to an endpoint of 8.2. Based on a calculation reported by Ruck (1963), a citric acid factor of 0.065 is used to calculate the % TA values presented in this report.

The perceived tartness or sweetness of a fruit is defined by the balance of soluble solids and acids. High sugar content is generally desirable for both fresh and processed fruit, but without a proper balance of acids, a fruit may be perceived as bland, lacking fullness of flavor in fresh or whole processed forms. The sugar:acid balance of the selections and cultivars evaluated is reported as the ratio of soluble solids to titratable acidity (SS:TA).

Raspberry

'Willamette' red raspberry is considered to have a strong raspberry essence with a tart flavor; the SS:TA ratio measured at NWREC is 5.1:1. In comparison, the SS:TA ratio of 'Chilcotin' is lower (4.8:1), explaining its acidic taste. 'Meeker' is sweeter than 'Willamette' with a SS:TA ratio of 7.5:1. OR-US 576-47, OR-US 2078, and OR-US 1836 are considered flavorful and sweet with ratios of 6.8:1, 7.2:1, and 7.7:1. Informal taste tests have shown a preference for OR-US 2078 and OR-US 1836 over OR-US 576-47, probably explained by their higher SS:TA ratio. Although not an advanced selection, the taste of OR-US 759-10 compares favorably to 'Meeker' having a SS:TA ratio of 7.6:1. The yellow-fruited cultivars have ratios ranging from 5.0:1 to 6.8:1, similar to 'Willamette' and 'Meeker', however, the flavor of yellow raspberries is usually considered bland in comparison to most red types (Table 1).

Blackberry

'Marion' blackberry contains a high level of acids and soluble solids and is rated as sweet and highly flavorful. The SS:TA ratio of 'Kotata' is found to be the same as 'Marion' (8.5:1) in NWREC tests, and they have similar flavor. Blackberry OR-US 1826, has a lower sugar:acid ratio (6.7:1) than 'Marion', and its taste is noticeably more tart than 'Marion'. In comparison, OR-US 830-4 is sweeter than OR-US 1826 due to its higher SS:TA ratio. 'Waldo' tends to be sweeter than 'Marion' reflected in the higher SS:TA ratio measured at NWREC (Table 2).

Although the SS:TA ratios of the 'Boysen' clones at NWREC are somewhat higher than 'Marion', 'Boysen' fruit are generally more tart with a strong flavor distinctly different from 'Marion'. Other hybrid cultivars, such as 'Logan' and 'Tayberry' are also perceived as tart with a distinct flavor. 'Thornless Evergreen' blackberry contains less acid and a higher SS:TA ratio

(17.4) than most of the earlier ripening cultivars possessing a milder, less tart flavor. The three erect type cultivars have higher SS:TA ratios than 'Marion' having correspondingly blander flavors (Table 2).

FRUIT PH

Fruit pH is determined from undiluted puree samples at room temperatures with a glass electrode. The level of pH in strawberry fruit has been linked to pigment stability in frozen storage, with a pH value higher than 3.5 resulting in color degradation (Wrolstad et al., 1970). Although, no threshold has been established for color stability in either raspberries or blackberries, their anthocyanin properties are known to be influenced by pH (Wrolstad, 1976). The level of pH also affects other chemical aspects of processing. In an Oregon State University in-house processor survey conducted by Barrett (1991), pH is reported to be an important factor in puree production and a consideration in IQF, clarified juice concentrate, and straight pack processing.

COLOR

Pigment from 10 g of whole fruit puree is extracted twice with an acid ethanol solvent, 85:15 (95 percent ethanol:1.5 N HCl) using procedures detailed by Conway (1986). The same procedure is used for raspberries and blackberries. Color of the resulting extract is analyzed by measuring absorbance at 535 nanometers with a Varian DMS 80 Spectrophotometer. The raw absorbance values presented in the tables are for comparison within this study only, those selections with higher absorbances being more deeply colored.

The "redness" of red raspberry fruit is easily discerned. Bright red raspberries and novelty colors (yellow, apricot or golden) are preferred for fresh marketing, whereas darker red berries are usually better for processing. Alternatively, most blackberries appear uniformly dark, and variation in pigmentation is of little importance in fresh market acceptability. According to an OSU processor survey, color has been rated the most important criterion for sliced and straight pack processing of both raspberries and blackberries (Barrett, 1991). The participants of the survey rated raspberry color as a more important consideration in raspberry than blackberry production. However, the survey shows that color is more important for juice production from 'Marion' blackberries than from raspberries, and color also factored highly in blackberry IQF processing (Barrett, 1991).

Raspberry

'Willamette' red raspberry has a high color absorbance and appears dark with purplish overtones. This dark coloration is not desirable for fresh market. A lower level of anthocyanin, gives 'Meeker' a brighter red appearance, but due to superior processing traits, most 'Meeker' raspberries are not sold fresh. 'Chilliwack', noted for its bright red color and glossy sheen, is well suited for the fresh market and is rarely processed. 'Centennial', 'Comox', 'Skeena' and 'Chilcotin' are other brightly colored red raspberries with good fresh market appeal. The primocane-fruiting cultivars vary in fruit color. 'Heritage', 'Summit' and 'Ruby' are among the darkest of the cultivars evaluated at NWREC, and 'August Red' and 'Redwing' are among the lighter. OR-US 576-47, OR-US 2078, OR-US 520-48, OR-US 1836, and OR-US 759-10 are comparable to 'Meeker' in color and brightness, which is reflected in their low anthocyanin content. Selections with higher anthocyanin levels appear darker and sometimes dull or overripe, and are best evaluated for their processing potential (Table 1).

Blackberry

Because of the deep coloration of blackberries, variations in anthocyanin content are usually not detectable by the eye, but color levels and color retention in blackberries are important in processing (Barrett, 1991). In frozen storage, some blackberries have a tendency to lose color and turn red. Sapers found that loss of coloration during frozen storage is less likely in fruit that is fully ripe and highly pigmented when fresh (Sapers et

al., 1985). Saper's findings suggest that blackberry cultivars with darker fruit may retain color better in cold storage. An OR-US breeding objective for blackberry fruit color is to select those with deep and uniform coloration, but tests for blackberry color retention during frozen storage have not been developed for use in the selection process.

'Marion' is preferred for frozen packs because of its superior flavor and pleasing shape. Although NWREC measurements did not show Kotata to have greater anthocyanin content than 'Marion', 'Kotata' is generally found to have darker fruit than 'Marion' with less of a tendency to turn red during frozen storage. Because of its darker and firmer fruit, some processors consider 'Kotata' to be an acceptable substitute for 'Marion' in IQF packs. Advanced blackberry selection OR-US 1826, is deeply colored with other superior fruit characteristics, possibly another good candidate for freeze processing (Table 2).

SEED WEIGHT AND SEED AS PERCENT BERRY FRESH WEIGHT

Seeds collected from 5 g of defrosted puree samples are dried at room temperature overnight, counted, and then weighed to determine seed as percent of berry fresh weight. Individual seed weight is determined from the same procedure.

Fruit seed percentage, or "seediness", is a measure of the seed to pulp ratio, an important component in the acceptability of both fresh and processed whole fruit. Because raspberry seeds are smaller and more numerous than blackberry seeds, the number of seeds contributes more to "seediness" in raspberries, whereas seed size contributes more to "seediness" in blackberries. Too many seeds or excessively large seeds make fresh or whole packed fruit seem gritty and hard to chew (Ourecky, 1975). Additionally, excessively large seeds can cause a problem in the production of seeded purees, because the screen size needed to allow large seeds to pass with the puree may not screen out some of the larger contaminants. Although excessive seediness is undesirable, characteristics of the seed contribute to some quality components of both raspberries and blackberries (Jennings et al., 1990). The existence of seeds, especially in raspberries, is important in jam making.

Raspberry

'Willamette' and 'Meeker' have medium-size seeds and are not considered to be excessively "seedy". Some of the more outstanding fruits with lower seed percentages than 'Willamette' and 'Meeker' include advanced selections OR-US 1836 and OR-US 576-47, 'Chilliwack', 'Centennial' and 'Skeena', all of which have good fresh market potential due to their smooth texture minimally "seedy" texture (Table 1). Raspberries found to have the greatest seed percentages at NWREC include 'Munger' black raspberry, 'Tulameen', 'Amity', and the yellow-fruited selection OR-US 959R-1. Although not particularly "seedy", the primocane-fruiting cultivar 'Perron Red' produces exceptionally large seeds that make the fruit hard to eat. Other notable examples of large-seeded selections found in the NWREC trials include OR-US 702-13, the yellow-fruited selections OR-US 969R-10 and 1020-2. Outstanding among the cultivars are 'Schoenemann' and 'Chilcotin' (Table 1).

Blackberry

Large seed size is often correlated with large fruit size in blackberries. This is best illustrated in 'Hull Thornless', and to some extent among the Boysen clones. However a goal in blackberry breeding at University of Arkansas has been to select for large fruit with smaller seeds. 'Shawnee', an erect cultivar from University of Arkansas, is found to produce large fruit in the NWREC planting with seeds not much larger than those of 'Thornless Evergreen' fruit. 'Choctaw', another Arkansas erect type, produces larger fruit than 'Marion', yet seed size measured at NWREC is found to be smaller than those of 'Marion'. For the most part, excessive seed size is not much of a problem in northwest trailing type blackberries, but since seed size does vary, attempts are made to eliminate the larger-seeded selections.

'Marion' seeds are medium-sized, and because the seeds are also soft,

'Marion' fruit is noted for its smooth grit-free texture. In contrast, 'Thornless Evergreen' blackberry, another industry standard, produces considerably larger seeds, resulting in a much "seedier" texture than 'Marion'. 'Waldo' has large fruit with seeds comparable in size to 'Marion'. The large-fruited Boysen clones produce large rough seeds which make the berry seem gritty. Nevertheless Boysen fruit produce excellent packs and are prized for their unique flavor when eaten fresh. Blackberry OR-US 830-4 is comparable in fruit size to the largest 'Boysen' (clone 34), yet it's seed size and number is substantially lower. OR-US 1826 also has a relatively large fruit size without excessively large seeds. The most notable selection for low seed percentage is OR-US 828-27, and OR-US 1717 also produces minimally "seedy" fruit (Table 2).

HARVEST DATE

The dates presented are the earliest and latest dates in which 50 ripe fruit could be harvested across all the years specified. The purpose of this method of reporting is to present the extremes in harvest date rather than average intervals.

Concentrated harvest periods are sought for mechanical harvesting, whereas longer periods are preferred by pick-your-own operations. Primocane-fruiting raspberries and late season blackberries (mostly erect types) are predominately used by fresh market growers to fill late season demands. The lack of acceptance by the processing industry is more the result of late season fruiting than lack of quality.

Raspberry

Among the june-bearing cultivars, 'Chilliwack', 'Chilcotin', 'Skeena', and 'Schoenemann' are often earlier than 'Willamette' and 'Meeker', however the results at NWREC show that they first ripen at the same time or later than 'Meeker' and 'Willamette'. Three of the most promising raspberry selections OR-US 1836, OR-US 2078, and OR-US 576-47 ripen at about the same time as 'Willamette' and 'Meeker', but OR-US 1836 generally has a longer harvest season. The latest ripening raspberries include OR-US 1012-10, OR-US 1013-11, and the three yellow selections. Although these later ripening types are too late for processing, they may have some benefit in extending the fresh market season.

'August Red' is the earliest primocane-fruiting cultivar evaluated at NWREC, and results show this cultivar to consistently ripen first. Generally, early primocane-fruiting raspberries are preferred, because late types are more vulnerable to early frost and subsequent crop loss. Two of the primocane-fruiting selections that show promise for early ripening are OR-US 662-11 and OR-US 932-2 (Table 1).

Blackberry

'Thornless Evergreen' serves a unique role in the blackberry processing industry. It extends the processing season and thereby spreads the cost of machinery for both the processor and the grower. A good quality mid-season blackberry would span the gap between 'Marion' and 'Thornless Evergreen' harvest to keep blackberries available during the entire season.

Breeding efforts to produce a mid-season thornless blackberry with good fruit quality, that is more winter hardiness and firmer than 'Marion' are ongoing. Although, it is soft-fruited and lacks overall fruit quality, OR-US 913-12 is useful as a breeding parent for its mid-season ripening traits. With more evaluation, OR-US 838-8 may prove to be a valuable parent for its later harvest season. The most promising blackberry tested at NWREC for its mid-season ripening habit is advanced selection OR-US 1826, because it produces a vigorous healthy plant with good fruit quality that can be machine harvested (Table 2).

The fruit quality comparisons presented here are to inform the fruit processing industries, growers and breeders of the great diversity of quality components available in raspberry and blackberry germplasm. Fruit breeding programs endeavor to anticipate the future needs of the fruit industry, and

there is always potential opportunities for marketing non-traditional fruit and fruit products. Cooperation between OSU and USDA-ARS in implementing the OR-US Rubus breeding program facilitates input from growers and other industry representatives in defining plant and fruit characteristics to best meet future and present needs. A continuing cooperative program enables more opportunities to exploit the diversity of plant material available and develop raspberry and blackberry cultivars that fit new niches and maintain existing markets.

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Table 1. Fruit quality characteristic data means from raspberries grown at the OSU North Willamette Research and Extension Center, Aurora, OR, 1984, 1985, 1987-1990.

	Berry Size (g)	Firmness (g)	pH	SS (%)	TA (%)	SS:TA	Color (Absorb. @ 535 nm)	Individual Seed wt. (mg)	Seed as % of berry fresh wt.	Harvest Date Earliest First	Harvest Date Latest Last
June-bearing											
Meeker (5)[z]	3.0	183	3.26	11.8	1.57	7.5	0.244	1.54	4.7	6/15	8 / 2
Willamette (5)	3.0	189	3.06	10.8	2.12	5.1	0.425	1.62	4.7	6/15	7/19
Canby (1)	3.0	154	3.31	11.2	1.40	8.0	0.166	1.42	4.4	6/26	7/17
Centennial (2)	3.7	190	3.10	11.0	1.69	6.5	0.235	1.50	3.5	6/19	7/19
Chilliwack (2)	3.5	230	3.12	12.7	2.10	6.1	0.391	1.50	3.5	6/15	8/2
Comox (2)	3.5	217	3.10	10.1	2.30	4.4	0.343	1.56	3.8	6/15	7/24
Chilcotin (2)	3.2	159	3.18	9.9	2.07	4.8	0.197	1.70	5.1	6/19	7/17
Tulameen (1)	2.9	141	3.05	11.0	2.29	4.8	0.374	1.63	5.6	6/19	7/10
Nootka (1)	2.5	93	3.17	12.0	1.70	7.1	0.318	1.67	3.8	----	----
Schoenemann	3.5	216	3.26	9.2	1.67	5.5	0.340	2.03	5.3	6/26	7/10
Skeena (1)	3.4	214	3.21	11.0	1.82	6.0	0.224	1.40	3.2	6/19	7/24
Titan (1)	2.9	191	3.07	9.0	2.08	4.3	0.308	1.29	4.3	6/15	6/29
Munger(1)(B. Rasp)	1.8	170	3.45	12.2	1.20	10.2	1.225	1.52	9.4	6/19	7/10
OR-US Selections											
1836 (6)	2.9	185	3.32	11.6	1.50	7.7	0.259	1.84	4.0	6/17	8/3
2078 (2)	3.4	196	3.29	11.5	1.59	7.2	0.236	1.67	4.6	6/17	7/27
520-48 (3)	3.0	172	3.22	10.4	1.69	6.2	0.253	1.87	5.2	6/28	7/19
576-47 (4)	3.7	237	3.10	12.5	1.85	6.8	0.295	1.55	3.2	6/19	7/20
674-17 (3)	3.2	189	3.05	11.5	1.80	6.4	0.235	1.80	3.2	6/22	7/26
702-13 (1)	4.3	157	3.08	10.0	1.85	5.4	-----	1.98	3.5	6/15	7/13
712-12 (1)	3.5	198	2.91	11.8	2.39	4.9	-----	1.74	3.3	6/15	7/27
759-10 (4)	3.0	157	3.19	12.7	1.68	7.6	0.223	1.53	3.8	6/16	8/3
769R-10(2)(yellow)	3.6	244	2.93	12.6	2.50	5.0	0.019	2.16	3.6	6/29	8/3
780-10 (1)	4.0	257	2.97	11.8	2.68	4.4	0.409	1.64	4.1	6/19	7/17
870R-12 (1)	3.5	195	3.00	11.8	2.22	5.3	0.437	1.56	4.4	6/19	7/10
900-10 (1)	4.0	228	3.16	10.2	2.43	4.2	-----	1.90	3.8	6/15	7/27
905-1 (1)	5.1	193	3.27	8.8	1.43	6.2	-----	1.86	4.8	6/19	7/17
958-10 (1)	3.6	326	3.09	12.6	2.13	5.9	-----	1.58	4.1	7/10	8/7
959R-1(1)(yellow)	3.5	220	3.09	12.2	1.92	6.4	-----	1.81	5.4	7/3	7/31
962-13 (1)	3.9	225	3.13	8.6	1.77	4.9	-----	1.37	3.7	6/26	7/24
994-10 (1)	4.6	264	2.94	10.0	2.22	4.5	-----	1.87	2.7	7/3	7/24
1011-3 (1)	4.2	204	3.19	11.8	1.37	8.6	-----	1.62	2.6	6/19	7/24

[z] years of data collected

Table 1. Fruit quality characteristics of raspberries continued.

	Berry Size (g)	Firmness (g)	pH	SS (%)	TA (%)	SS:TA	Color (Absorb. @ 535 nm)	Individual Seed wt. (mg)	Seed as % of berry fresh wt.	Harvest Date Earliest First	Harvest Date Latest Last
OR-US Selections											
1012-10 (1)[z]	6.0	247	3.05	11.2	1.89	5.9	-----	1.64	2.0	6/26	7/3
1013-11 (1)	4.2	217	3.18	10.6	1.52	7.0	-----	1.75	4.1	6/26	7/24
1020-2 (1)(yellow)	4.5	221	3.10	12.6	1.85	6.8	-----	2.02	3.1	7/10	7/24
1020-5 (1)	4.9	238	3.28	11.2	1.42	7.9	-----	1.75	3.1	7/3	7/31
1072-11 (1)	3.6	262	3.07	11.8	2.02	5.8	-----	1.72	5.1	6/19	7/2
Primocane-fruiting											
Amity (5)	2.6	279	3.25	13.6	1.68	8.1	0.411	1.58	5.4	8/7	8/31
Autumn Bliss (1)	3.4	218	3.23	10.0	1.56	6.4	0.259	1.35	3.7	7/24	8/21
August Red (1)	2.8	127	3.11	9.8	2.05	4.8	0.152	1.38	4.3	7/17	9/14
Heritage (2)	2.6	194	3.00	11.5	2.25	5.1	0.455	1.16	3.7	8/7	9/18
Perron Red (2)	4.7	223	3.10	10.9	2.13	5.1	0.394	1.92	4.8	8/7	9/20
Redwing (2)	2.4	148	3.07	10.3	2.23	4.6	0.232	1.46	5.1	8/7	9/20
Ruby (1)	4.2	213	3.05	8.2	2.03	4.0	0.434	1.29	2.8	8/21	9/18
Summit (3)	2.4	229	3.08	12.9	2.12	6.1	0.433	1.51	5.2	7/31	9/7
OR-US Selections											
662-11 (1)	2.7	156	3.00	12.6	2.37	5.3	-----	2.00	3.8	8/3	9/7
752-1 (1)	3.3	167	2.85	10.8	3.09	3.5	-----	1.57	3.4	7/27	8/24
753-2 (1)	2.5	169	3.08	11.4	2.05	5.6	-----	1.56	4.1	8/10	9/14
932-2 (1)	2.8	169	3.28	11.0	1.72	6.4	-----	1.78	3.4	8/3	9/7
938-10 (1)	2.8	143	3.07	10.0	1.94	5.2	0.181	1.67	4.5	7/27	9/30
979-2 (1)(yellow)	2.8	199	2.87	10.2	2.20	4.6	-----	1.14	2.5	7/31	9/5

[z] years of data collected

Table 2. Fruit quality characteristic data means from blackberries grown at the OSU North Willamette Research and Extension Center, Aurora, OR, 1984, 1985, 1987-1990.

	Berry Size (g)	Firmness (g)	pH	SS (%)	TA (%)	SS:TA	Color (Absorb. @ 535 nm)	Individual Seed wt. (mg)	Seed as % of berry fresh wt.	Harvest Date Earliest First	Harvest Date Latest Last
Cultivars											
(Trailing types)											
Marion (5)[z]	4.8	727	3.18	13.8	1.62	8.5	0.923	2.23	3.0	6/27	8/3
Thornless											
Evergreen (6)	3.5	782	3.73	14.4	0.83	17.4	0.788	3.58	5.0	7/25	9/24
Ollalie (6)	5.3	1005	3.34	11.9	1.36	8.8	0.886	2.65	2.9	6/20	7/27
Kotata (6)	5.1	1135	3.30	12.1	1.42	8.5	0.905	2.50	3.2	6/26	8/3
Waldo (6)	5.9	978	3.42	13.4	1.43	9.4	0.851	2.16	3.8	7/3	8/17
Tayberry (6)	5.7	517	3.55	10.1	1.17	8.6	0.579	2.02	3.4	6/6	7/20
Silvan (4)	6.2	842	3.39	11.8	1.36	8.7	0.745	2.70	2.3	6/20	8/3
Hull											
Thornless (4)	6.5	936	3.31	10.8	1.09	9.9	0.662	4.46	2.9	7/3	9/14
Black Satin(4)	4.8	827	3.28	11.9	1.22	9.8	0.775	3.70	4.8	7/26	9/21
Chester											
Thornless (4)	5.5	1000	3.18	10.8	1.27	8.5	0.861	3.26	2.5	7/25	10/12
Perron											
Black (2)	4.4	802	3.34	11.3	1.35	8.4	0.676	3.42	3.9	8/8	9/13
Logan (6)	5.0	656	3.33	10.2	1.66	6.1	0.557	2.24	3.7	6/6	8/1
Boysen 5 (6)	7.9	861	3.34	11.4	1.36	8.4	0.941	3.62	2.8	6/26	7/27
Boysen 34 (4)	9.0	871	3.39	11.6	1.25	9.3	0.838	4.02	2.3	7/3	8/3
Boysen 43 (4)	8.6	830	3.40	11.0	1.26	8.7	0.819	3.74	2.1	6/26	8/3
NZ Boysen (4)	8.2	727	3.41	11.1	1.25	8.9	0.904	3.95	2.6	7/5	8/3
(Erect types)											
Choctaw (1)	5.8	868	----	12.8	0.92	13.9	0.583	2.29	2.4	6/28	6/12
Shawnee (2)	8.1	978	3.45	12.2	1.14	10.7	0.726	3.86	3.0	7/11	8/22
Navaho (1)	2.7	863	3.49	16.6	1.48	11.2	0.674	3.59	5.7	7/12	7/26
OR-US Selections											
728-3 (1)	7.3	1021	3.58	8.2	1.10	7.5	0.798	2.40	3.5	7/7	7/27
826-2 (3)	6.0	963	3.36	11.7	1.41	8.3	1.159	2.30	2.2	6/27	8/10
828-27 (2)	5.2	791	3.31	11.8	1.76	6.7	0.906	1.50	1.3	7/5	8/2
828-42 (3)	5.1	825	3.53	10.3	1.16	8.9	0.822	1.68	2.0	6/27	8/3
830-4 (3)	9.2	1352	3.23	11.3	1.57	7.2	0.870	2.84	3.2	6/20	8/17

[z] years of data collected

Table 2. Fruit quality characteristics of blackberries continued.

	Berry Size (g)	Firmness (g)	pH	SS (%)	TA (%)	SS:TA	Color (Absorb. @ 535 nm)	Individual Seed wt. (mg)	Seed as % of berry fresh wt.	Harvest Date Earliest First	Harvest Date Latest Last
OR-US Selections											
838-8 (1)[z]	8.2	973	3.45	12.2	1.51	8.1	1.392	2.09	3.3	7/11	7/18
838-19 (3)	5.6	469	3.01	9.8	2.16	4.5	0.648	2.28	2.6	6/28	7/19
840-8 (1)	4.5	710	3.70	9.6	0.82	11.7	0.570	2.01	3.2	7/5	7/19
913-5 (3)	5.1	822	3.16	12.2	2.02	6.0	0.921	2.59	4.2	7/5	8/22
913-10 (4)	5.8	676	3.19	11.6	1.94	6.0	0.844	2.98	2.5	6/26	8/10
913-12 (2)	6.2	965	3.45	14.8	1.67	8.9	1.224	2.43	2.7	7/7	8/22
916-1 (3)	6.6	1101	2.31	11.3	2.36	4.8	0.819	2.09	2.3	7/11	8/22
969-3 (2)	4.9	1067	3.32	13.2	1.79	7.4	0.687	2.10	2.1	7/5	8/1
1054-11 (1)	5.8	992	3.70	14.8	1.05	14.10	-----	3.56	2.7	7/5	7/26
1112-11 (1)	7.9	1400	3.32	11.2	1.60	7.0	-----	3.64	3.6	7/5	7/19
1466 (3)	4.6	855	3.63	12.0	1.04	11.5	1.038	2.01	3.4	6/22	8/10
1681 (1)	3.8	594	3.88	8.0	1.35	5.9	1.067	2.31	2.6	7/7	7/14
2007 (1)	6.5	1114	3.33	13.2	1.76	7.5	0.917	3.45	1.5	7/5	7/19
2008 (1)	7.6	1150	3.43	11.2	1.50	7.5	1.044	2.21	2.5	6/20	7/25
2009 (1)	4.4	899	3.43	13.4	1.25	10.7	0.760	2.59	3.7	7/6	8/10
1717 (5)	4.6	841	3.65	12.2	1.04	11.7	0.869	1.69	1.9	6/26	8/17
1826 (4)	8.5	1204	3.13	11.7	1.75	6.7	0.994	3.14	2.7	7/3	8/17

[z] years of data collected