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Quality Attribute-Price Relationship: Modernization of the Sweet Cherry Sector in Poland

Abstract. This study describes the development of sweet cherry production in Poland in the context of relationship between quality attributes and wholesale prices as well as modernization of orchards creating opportunities for increased exports. Global demand for sweet cherries increases because of their perceived unique health benefits, but the fruit must have the desired quality attributes. The link between quality attributes and prices is illustrated using the wholesale prices collected during the harvest season in years of limited and normal crop in Poland, respectively. Among the discussed varieties is 'Cordia' which dominates in the modern orchards. As the sweet cherry production declines in the region, with the introduction of modern production technology, the increasing yields and volume produced creates opportunities for increased exports also to countries outside the EU.

Keywords: sweet cherries, wholesale price, quality attribute, cultivar, price trend, exports

Introduction

The fresh fruit global market has been expanding due to increasing incomes and changing preferences. The increasing of fruit consumption in response to income has been illustrated in countries of varying economic development [Florkowski et al. 2014]. The observed consumer behavior is consistent with predictions based on Engle's curve, suggesting that the consumed volume of various foods increases in response to increasing incomes. In addition to increasing incomes, the changing preferences of consumers contribute to per capita growth of fruit consumption and alter the composition of the fruit basket. Among fresh fruits that have been experiencing a global growth in production and trade is sweet cherries. Largely unnoticed has been the expansion of fresh cherry production within the Pacific basin, namely between the United States and Canada acting as suppliers and Japan, South Korea, and even China as destination markets [Carew, Florkowski, Doroundian 2012]. The combination of health benefits, breeding, and postharvest handling changed the competitive position of sweet cherries in the market.

Sweet cherries are a common fruit in Europe, including several Central European countries such as Germany and Poland. They are generally well accepted and are one of the earliest fresh fruits of the season. Poland produces a substantial volume of sweet cherries and exports sweet cherries to a number of European countries.

The objective of this study is to describe some of the reasons behind the observed sweet cherry production expansions worldwide, examine the Polish sweet cherry sector

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including cherry exports, and to explore the link between observed market prices and selected sweet cherry attributes for major varieties. The investigation focuses on two years, 2007 and 2011, and applies data collected during the harvest season from the Poznan-Franowo, Poland, a major fruit wholesale market. The analyses of links between prices by variety and major quality attributes reveal that the market appears to send clear price signals to growers and traders in years when the supply of sweet cherries is limited, but not necessarily in years of average crops. Capricious price signals may discourage harvesting, but, more importantly, affect production decisions including planting of new orchards or replacement of old trees. The persistence of inconsistent price signals will result in production decrease, loss of export earnings, and less consumer access to healthy fresh fruit. Results of this study generate knowledge about the importance of specific quality attributes for sweet cherry prices, thus providing insights for choosing varieties for planting or re-planting, and allowing the anticipation of changes in Poland's domestic sweet cherry supply.

Health-promoting sweet cherry properties

Sweet cherries, like many other species from the *Prunus* genus, have a high nutritional value contributing to human health [Yahia 2010]. Besides water, their main components are carbohydrates, responsible for the sweetness, and organic acids, which determine sourness [Bernalte et al. 2003; Esti et al. 2002]. Over 80% of total sugars (110-150 g/kg FW) are glucose and fructose, and around 75% of total acids (29-54 g/kg FW) is malic acid [Hayaloglu and Demir 2015]. Sweet cherries contain both hydrosoluble (C, B) and liposoluble (A, E and K) vitamins and some carotenoids, in particular beta-carotene, and to a lesser extent, lutein and zeaxantine [Ferretti et al. 2010]. Sweet cherries are rich in phenolic compounds, notably anthocyanins [Gao and Mazza 1995; Yahia 2010]. The latter is the main contributor to the high antioxidant activity of sweet cherries, which was found to vary between 216 and 475 mM trolox/100 g FW [Liu et al. 2011].

The total phenolic content in sweet cherries depends on many factors, such as the growing location, cultivar, rootstock, cultivation, weather conditions etc. Several studies [Usenik et al. 2008; Ferretti et al. 2010; Faniadis et al. 2010; Hayaloglu and Demir 2015] have shown that the content of phenolic compounds can vary considerably depending on the growing location, from 44 to 265 mg of gallic acid equiv. 100 g−1 FW. Also, the accumulation of the phenolic compounds is higher in the same cultivars if they are grown on higher elevations or in colder climates [Faniadis et al. 2010]. Still others [Borochov-Neori et al. 2011; Fernandes de Oliveira et al. 2015] have found that the accumulation of anthocyanins in fruit is significantly higher in colder climates. High levels of anthocyanins result in darker cherry fruit which was found to have higher antioxidant activity [Gonzalez-Gomez et al. 2010; Hayaloglu and Demir 2015].

The above findings suggest that sweet cherry cultivars grown in Poland can be expected to be darker and, consequently, have higher content of phenolic compounds than the same cultivars grown in southern locations. Therefore, in Poland, climatic conditions favor production of sweet cherries with high antioxidant content, that is, health promoting qualities. This intrinsic attribute offers opportunities to market sweet

cherries at a premium, even if the cultivars grown in Poland are the same as in southern Europe. It should be noted that the importance of the health benefits of eating fruit including sweet cherries was an explicit national policy objective under the centrally planned economy in much of Central and Eastern Europe [Kramer 1985] although the actual implementation fell short of that goal. Health benefits of eating sweet cherries are a major driving force behind the growing global demand and consequent exports from the United States and Canada to Asian markets.

Sweet cherry sector in Poland

Rather than simply sustaining the production [Ing 2008], Polish crop statistics show the tendency to increase. The growing specialization in sweet cherry production is demonstrated in the decreasing number of farms reporting sweet cherry production, while the area planted remains fairly stable. The agricultural census of 2010 reported 49,539 farms producing sweet cherries [GUS 2014]. The number of sweet cherry producing farms has decreased by 34% since 2002, the year of the previous agricultural census [Uprawy ogrodnicze 2012]. Total area planted with sweet cherries was 11,461 hectares in 2010 and was 40.5% larger than in 2002 [Uprawy ogrodnicze 2012]. More importantly, the share of farms growing sweet cherries on an area of 2 hectares or larger increased noticeably. The share of growers operating sweet cherry orchards with an area of no more than one hectare was 18% in 2010 and shrunk after 2002 indicating a shift away from small operations. Large orchards are likely to be high-density, irrigated operations that plant cherry trees grafted on new rootstock which, given Poland's climatic conditions, better tolerate freezes than old trees. Interestingly, the share of sweet cherry orchards in the total number of fruit tree operations has increased from 3.3% in 2005 to 4.4% in 2012, although the share decreased to 4.0% in 2013 [Uprawy ogrodnicze 2012].

Sweet cherry cultivation in Poland is risky due to climate [Sitarek, Grzyb, Kozinski 2008] causing variable yields. Yields per hectare can change by 1 or 2 tons from one growing season to another and determine profitability of production [Sitarek, Grzyb, Kozinski 2008]. The observed crop growth in recent years, in addition to the expansion of orchard area, has been a result of increasing yields, which have displayed a tendency to increase in recent years reaching 4.37 ton per hectare in 2013 [Agencja Rynku Rolnego 2014]. Growing yields reflect slow structural change in the sweet cherry sector that is induced by production specialization.

Climatic conditions are primarily responsible for regional concentration of sweet cherry production in Poland. Mazowieckie and Wielkopolskie Voivodships are the leading production areas with the share of the total area planted of 33.4% and 18.5%, respectively. In Wielkopolska, 4158 farms represent 8.4% of all sweet cherry producing farms, while 7747 farms or 15.4% of sweet cherry producing farms are located in Mazowieckie Voivodship. That is, 51.9% of the area planted with sweet cherries is operated by 23.8% of farms in the two leading regions. These figures suggest a growing tendency for sweet cherry production concentration and, consequently, the increasing role of wholesale markets in Warsaw and Poznan-Franowo as sweet cherry trading hubs shaping cherry wholesale prices in Poland. Buyers from Russia frequent the Warsaw

wholesale market and import, among others, sweet cherries. The recent embargo on food imports from Poland imposed by Russia on the European Union has curtailed the exports, but is unlikely to completely eliminate it because of the distance of alternative supply sources (for example, Argentina).

Sweet cherry cultivars grown in Poland differ from those in other areas of commercial cherry production (e.g., Bing, grown in the western United States and Canada) [Carew, Florkowski, Doroundian 2012]. Among cultivars planted in Poland, there is a clear domination of varieties developed in Germany, likely because of similar growing conditions and consumer preferences. Cultivar "Bütnera Czerwona" is known among producers under its Polish name "Bitnera." The cultivar originates from Germany and is known there under the name "Büttners Rote Knorpelkirsche" [Hartmann 2003, Braun-Lüllemann and Bannier 2010]. "Hedelfińska" [English name "Hedelfingen" in Westwood 1993] was also devloped in Germany, where it is known as "Hedelfinger Riesenkirsche" [Hartmann 2003, Braun-Lüllemann and Bannier 2010]. Both cultivars are well known and frequently recommended for commercial orchards in Poland [Rozpara 2005, COBORU 2015]. "Sznajder", the Polish common name for cultivar "Schneidera Późna" ("Schneiders Späte Knorpelkirsche" in German) [Rejman 1994, Hartmann 2003, Braun-Lüllemann and Bannier 2010, COBORU 2015], and cultivar "Regina" are among the most popular new varieties [Rozpara 2005]. The latter was developed in Germany in 1957 and introduced in commercial orchards in 1981 [Bundessortenamt 2000]. "Regina" is popular globally due to its late season maturity that allows the extension of crop season, higher yields, and large-sized fruit – all important economic attributes. Cultivar "Van" originated in Canada [Westwood 1993] and is a popular cultivar in Europe, from Italy to Norway [Rozpara 2005]. The wide popularity of cultivars "Hedelfinska", "Schneidera Późna", and "Van" has been reported [Kramer 1985]. In recent years, cultivars "Kordia" and "Regina" are the most popular in Poland [Agencja Rynku Rolnego 2014]. "Regina" has been very favorably accepted by consumers in other countries [Turner et al. 2008] and has been planted in the western United States and Canada.

Kordia is a relatively new, late-maturing variety, good for the fresh market, and developed in the Czech Republic. Fruits tend to be large weighing 8-10g [Rozpara 2005]. Kordia can grow large so the choice of rootstock is essential for a commercial orchard. This variety grafted on *Prunus avium* and *Prunus mahaleb* seedlings with interstocks of 'Northstar' and three types of *Prunus fruticosa* Pall reduced tree size and had positive influence on yield [Rozpara et al. 2011]. Grafting on rootstock that limtis growth did not reduce fruiting or compromises quality [Sitarek et al. 2011, Milatović et al.2013]. Because the variety is susceptible to winter and spring frost it requires a careful site selection [Rozpara 2005; Lech et al. 2012].

Fruit consumption has been increasing in Poland in recent decades [Florkowski et al. 2014] and sweet cherries compete with other fresh fruit. However, because sweet cherries are one of the earliest fruits of the season they are well liked. In addition, because fresh fruit prices are higher than prices for fruit destined for processing, Polish growers prefer to sell their cherry crop as fresh fruit. For example, the share of sweet cherries sold as fresh fruit was 86% in 2007, while the balance was processed. Detailed per capita consumption figures regarding sweet cherry consumption are not available for Poland, but it has been noted that fruit consumption has been increasing in Poland in recent decades [Florkowski et al. 2014]. The changing retail structure is a major factor

driving the changes in consumer fruit choices. Therefore, like many other fruits, sweet cherry consumption is increasingly dependent on sales through supermarket chains. Still, wholesale markets remain a major distribution channel because of fragmented sweet cherry production and less organized producer groups (as compared, for example, to apple growers).

Sweet cherry exports

Kramer [1985] reports that the former CMEA (the Council for Mutual Economic Assistance) member countries produced about 400,000 tons of sweet cherries and between 70% and 80% were destined for consumption as fresh fruit in the early 1980s. For Poland, despite not fulfilling the national goal of fresh fruit consumption, fresh fruit exports were important for the national economy in the 1980s [Kramer 1985]. The expansion of sweet cherry production was anticipated in Eastern Europe, especially areas whose climate is influenced by the Black Sea [Ing 2008]. Sweet cherry production in Russia, Ukraine, and Romania is utilized domestically, while some cherries have been exported from the countries in this region to Russia. Overall, the response of suppliers in the region was weak; for example, the production of sweet cherries in Bulgaria decreased [Borovinova et al. 2008].

In the most recent decade, sweet cherry production averaged around 40,000 tons in Poland. Since Poland has joined the EU, the lowest volume produced was 20,189 tons, was reported in 2007 [FAOSTAT 2015], while the highest crop of 47,600 tons was harvested in 2013 [GUS 2014]. A typical crop can be expected between 38,000 and 40,000 tons, but the crop size has shown a tendency to increase in recent years. Sweet cherry exports from Poland ranged from a low of 3,000 tons in 2009 to a high of 11,000 tons in 2010 in the period 2004-2013. Agencja Rynku Rolnego [2014] estimates that 20-30% of the sweet cherry crop is exported in years when cherry production is normal. However, it is reasonable to expect the steady expansion of production if technological progress can offset production risk arising from spring freezes and diseases [Sitarek, Grzyb, and Kozinski 2008].

Polish sweet cherry growers do not have strong competition within the region. Latvia, which continues to develop new sweet cherry varieties focusing on spring frost tolerance [Ruisa 2008], has a limited area of production and its crop is destined primarily for domestic consumption. In Bulgaria, the sweet cherry production expanded in the 1980s [Kramer 1985] and reached 11,004 hectares in 1990, but has since declined to 6800 hectares in 2002 [Borovinova et al. 2008]. Sweet cherry cultivars grown in Bulgaria include “Bing”, which has been outperformed in consumer tests [Turner et al. 2008], while “Hedelfinska” and “Van” had shares of 14% and 9%, respectively, in the total area planted. However, the sweet cherry sector is unlikely to expand soon in Bulgaria. Bulgaria’s advantage is the early ripening window and, as such, the country competes with Turkey as an international sweet cherry supplier.

Outside Europe, New Zealand has been expanding its small sweet cherry production area [Hewett, Hofma, and Weaver 2008]. The focus of producers is predominantly the export market, primarily Taiwan and the United States, but the list of countries importing sweet cherries from New Zealand exceeds 20. The primary

characteristic of the New Zealand sweet cherry crop is that it is harvested during the winter season in the Northern Hemisphere and the deliveries do not compete with the European crop. The primary challenge for growers at distant supply areas is the organization and optimization of a cold chain to maintain and protect cherry quality.

Another Southern Hemisphere sweet cherry supplier is Argentina. However, this country (like Chile) does not compete with Northern Hemisphere suppliers. Tree fruit production has become an important sector in recent decades in Argentina. Fortunately, Polish sweet cherry growers are not affected by the expanding production. Indeed, the supply of fresh sweet cherries in winter months may sustain demand and increase sales once the harvest begins in Europe because accessibility may have developed a preference for sweet cherries among consumers.

The expansion of sweet cherry production in the western United States and Canada has been driven by the increasing demand in the wealthy East Asian markets of Japan, Taiwan, South Korea, and China. The development of new varieties combined with improved postharvest handling practices has generated returns, encouraging cherry orchard expansion. Polish fruit tree growers have become very competitive in recent decades and the expansion of sweet cherry orchard size proves that they are searching for alternative enterprises. With the competition from the Southern Hemisphere growers not being a factor and the production in surrounding countries declining, Polish growers are poised to fill the vacuum.

Figure 1 shows the volume of fresh sweet cherry exports from Poland in the period 2010-2014. Russia has become an increasingly important destination of Polish sweet cherries in recent years until the imposition of the trade embargo in the summer of 2013. Belarus replaced Russia as the primary export market in 2014. Overall, East European markets have been the primary recipients of sweet cherry shipments, both EU member (Lithuania, Estonia) and non-member countries (Ukraine). Among other EU countries, Germany has long been the largest destination of fresh sweet cherry exports. Available data does not provide information about specific varieties shipped to any destination.

Prices of fresh cherries fluctuated between 2010 and 2014 and the period is too short to draw firm conclusions. The highest prices were received by exporters to the three Baltic countries and Germany (on average 1,576 euros per ton in the period 2010-2014) – all EU members. Prices from exports to Russia averaged 1,262 euros per ton between 2010 and 2014. In contrast, the lowest export prices for fresh sweet cherries were obtained by shipping to Kazakhstan and Ukraine, 847 and 796 euros per ton in the period 2010-2014.

Exports of frozen sweet cherries have enjoyed a more diversified geographical destination than fresh sweet cherries. Overall, the direction of shipments is reversed and West European destinations (all EU members) prevail over East European countries. By far, the largest EU importer of Polish frozen sweet cherries between 2010 and 2014 has been Germany. Other countries that consistently imported frozen sweet cherries in the period 2010-2014, include the Netherlands, Great Britain, and Sweden. More recently, the group was joined by Belgium and Italy. Ukraine has decreased its imports, although until 2014 it was the largest overall importer of frozen sweet cherries. In Eastern Europe, Lithuania has been importing a small volume as well. Outside Europe, China intermittently imports frozen sweet cherries.

Prices for frozen sweet cherries were somewhat lower than for fresh product. The average price for frozen sweet cherries shipped to Germany was 1,262 euros per ton in

the period 201-2014. However, the highest average price was 1,368 euros per ton received for exports to Great Britain.

It appears that with a growing production, Polish sweet cherry exports will follow exports of other fruit after the Russian trade embargo. EU destinations and markets outside Europe will become relatively more important and the cherry sector could implement market and promotion programs developed by other Polish fresh fruit sectors.

Sweet cherry attributes and prices

Data

Data used in this study are daily sweet cherry prices recorded during the harvest seasons of 2007 and 2011. They include prices per kg per variety and include the score of color and a measure of size. Color is an essential attribute because it is an indicator of maturity and cherries tend to be sweeter if they are closer to peak maturity. However, sweet cherries also become more susceptible to bruising and cracking at advanced maturity stage posing a challenge to growers who have to balance the color intensity against postharvest handling practices to maximize sales revenues.

Sweet cherry color is commonly evaluated in Europe using a color chart developed in France. The chart distinguished among 7 different shades [Code Couleur Cerise 2015]. Sweet cherries traded at the Poznan-Franowo wholesale market had their color evaluated using this chart, but the actual color score range is narrower than from 1 to 7 because producers usually do not harvest sweet cherries until they reach maturity. Sweet cherries, a non-climacteric fruit, do not ripen once harvested; therefore, color is an important indicator of the stage of maturity. Too early harvest means the fruit is not sweet, while too late harvest considerably narrows that marketing window even when best postharvest handling practices are applied.

Another important attribute is size. Large cherries are preferred to smaller fruit. Although irrigation is becoming common in Polish fruit orchards, sweet cherry trees still depend on precipitation. A regular pattern of precipitation assures steady growth of fruit, while even a short drought followed by substantial rains may lead to rapid growth resulting in fruit cracking, a process that results in irreversible damage and unmarketable fruit. Susceptibility to cracking varies across cultivars and the early maturing cultivars tend to be more affected by cracking [Ruisa 2008]. Of particular importance to this study is the cherry variety because both color and size are, at least in part, influenced by the genetic makeup of the tree, and consumers pay attention to the fruit's appearance, including color and size [Ruisa 2008, Turner et al. 2008]. Generally, dark fruit is associated with maturity and sweetness, but some varieties never develop a deep red or dark color (we exclude varieties of yellow cherries from the discussion) and fully mature fruit remains light to medium red. Consumer visual assessment affects the purchase decision and, consequently, sweet cherry attributes associated with a specific variety must be considered by a grower when selecting a variety (or varieties) for planting [Ruisa 2008]. The examination of the link between fruit color, size, and price is, therefore, crucial in the process of investment decisions because fruit trees represent

a fixed asset with little salvage value. A cherry tree is expected to produce a commercially viable crop for about 20-25 years.

A total of 5 and 11 sweet cherry varieties were priced at the Poznan-Franowo wholesale market in 2007 and 2011, respectively. However, for the purpose of this study and to examine the relationship between selected attributes and prices, we focus on varieties that were traded in both years and for a relatively large number of days implying a substantial supply and, likely, demand.

The location of Poznan-Franowo between two major European agglomerations, Warsaw, the capital of Poland, and Berlin, the capital of Germany, offers opportunities for shipping fresh sweet cherries to large urban markets. Western and west-central regions of Poland have been sweet cherry production regions for decades [Kramer 1985] and correspond to Wielkopolskie and Mazowieckie Voivodships. It is worth mentioning that under the centrally planned economy in Poland (until the late 1980s) and the existence of the CMEA (Council for Mutual Economic Assistance (RWPG in Polish), the regional horticultural cooperative organization in Wielkopolska operated several retail outlets in East Berlin in the German Democratic Republic specializing in fresh and processed fruit and vegetable products. During the season, there were even daily shipments of fresh produce to those outlets. As a result, both Polish suppliers and German buyers had long established commercial relationships before the transition to the market economy in the late 1980s and Poland's accession to the European Union in May 2004.

The data for the 2007 and 2011 harvest seasons refer to the period June-July. Sweet cherry harvest can be expected to begin in the second half of June, somewhat later than in Germany, and lasts from 4 to 6 weeks [Kramer 1985] as various cultivars mature. Specific time periods vary for each variety in response to their genetic makeup and weather conditions throughout the growing season. The differences in response to climatic factors are best captured by the variation in periods of recording prices for the same variety in 2007 and 2011. For example, in the case of 'Schroedera Pozna', the period was June 20-July 5 in 2007, but June 14 - July 2 in 2011.

Results

The examination of the association between prices paid for fruit of various sweet cherry cultivars involved visual analysis of data plots and estimation of trends for each relationship in 2007 and 2011 supplemented by the calculation of descriptive statistics. The crop year of 2007 was unusually small due to a late spring frost. In turn, the crop in 2011 was only slightly lower than in the preceding and following year. Therefore, the examination of the above mentioned associations focuses on how wholesale prices in the major sweet cherry producing region behave in years of short and near-normal supply. We assume that prices reflect the supply of not only the sweet cherries, but also the supply of each of the two attributes that are measured in the sweet cherry trade, namely fruit color and size. Both attributes are important visual cues considered by the final consumer at the time of purchase decision or by importers of sweet cherries from Poland.

Prices of "Hedelfinska" showed slightly different patterns between the two considered years. In the short crop year, the association between price and size was flat, but in the year of near-normal supply the relationship was slightly negative. The estimated linear trend suggests that once the fruit reached score size 25-26 it was discounted. However, the association between price and color was strongly positive in both years (see Table 1 for the estimated trends).

In contrast to "Hedelfinska", "Butnera" showed a clear positive relationship between size and price in both years. Indeed the estimated price-size trend differs little between the two years. Most contrasting results between the year of short supply, 2007, and the near-normal crop year of 2011 are obtained for cultivar "Van". Although the size-price association in 2007 was largely flat, the relationship between price and color was positive, as darker colored fruit was priced higher on average. In 2011, both relationships were clearly negative suggesting that the larger and darker fruit of "Van" were discounted. This is an interesting result as this cultivar is widely planted in other countries and, therefore, familiar to consumers which may facilitate exports.

Similar results were obtained in the case of "Schneidera Pozna". Here, the estimated relationships between size and price as well as color and size are positive. Results for the 2011 season are much different; both estimated trends indicate a negative relationship of color and size with price.

Lastly, "Kordia" showed a strong relationship between color and price and size and price in 2007. But, in 2011, the estimated trends established a negative relationship between price and size, while the color scores did not show any variability (Figure 2 and 3).

Details of the estimation (Table 1) suggest that the market priced both attributes (especially color) higher, as the color score increased in the year of short supply. Such relationship is consistent with the scarcity of a product with a specific attribute. A closer scrutiny of relationships between price and attributes by variety in 2007 reveals that the market distinguishes among varieties and attributes.

Even the small differences in wholesale prices are important to growers. In the short term, such price differences influence harvesting and storage because the shortage of sweet cherries creates price bargaining opportunities. In the long term, the observed differences in price-attribute association are taken into account when growers consider tree replacement or orchard expansion decisions. Although not the sole factor, market evaluation of attributes is important.

Price risk needs to be considered as well. The estimated price trends for data in the short crop year of 2007 showed an increasing trend for all five cultivars. The calculated values of R squared are: 0.8055 for "Butnera", 0.7798 in the case of "Kordia" (Figure 4), 0.5977 for "Hedelfinska", 0.4173 for "Van," and 0.1424 for "Schneidera Pozna". The trends in 2011 were different and for "Van" the trend was negative, implying a decrease in prices as the harvesting season progressed. The explanatory power of the trend equation was weaker in 2011 as reflected in lower values of R squared as compared to 2007. The values were 0.5567, 0.3281, and 0.5416 for "Butnera", "Kordia", and "Hedelfinska", respectively. The price trend in the case of "Schneidera Pozna" was largely flat and the corresponding R squared value was 0.0083. Buyers paid about the same price for that cultivar throughout the harvesting season.

The average prices in each year vary across sweet cherry varieties, but a variance is a measure of price volatility. The larger the variance, the higher the price risk, which

growers and traders need to consider. Prices are likely to fluctuate during the sweet cherry harvesting season, and if there is a shortage of short-term storage, growers face the risk of sudden price dips if they arrive at the Poznan-Franowo wholesale market with a sweet cherry lot on a day other growers also bring their crop. The comparison of price variances across varieties in both years (Table 2) shows larger variance in the year of short crop, i.e., 2007. The larger variance suggests higher price risk, a phenomenon that reflects the varied daily supply of each variety and, possibly, variable quality.

Overall, the average prices and variances were higher in the year of short supply (2007) than in the year of a near-normal crop (2011). Results also show a clear tendency to discount four out of five considered varieties, with the exception of "Kordia". Such tendency is also captured by the larger number of cultivars traded in 2011 than in 2007, but one could argue that it was the result of the short 2007 crop. Therefore, the illustration provided in the next section sheds additional light on what can be expected in the sweet cherry market in the coming years in Poland, namely a major shift away from old standards to new cultivars. The new developments are captured in the production of certified trees for various cultivars between 2005 and 2014.

Future trends

The number of certified trees in nurseries is a good indicator of the future supply of sweet cherries in Poland and the export potential. In the first full year of Poland's EU membership (2005), the number of certified trees was 689,000 and the leading cultivar was "Kordia", with about 154,000 trees. "Burlat" and "Regina" were the other cultivars produced in the largest quantities. In 2008, the total number of trees was already 810,000 and cultivar "Summit" became the second most numerous cultivar among the certified trees. "Kordia" was still the most popular cultivar. By 2012, the total number of certified trees declined to 332,000 and "Regina" was the most popular cultivar (85,000) followed by "Summit" and "Burlat". The total number of trees increased slightly in 2013, but declined in 2014 to a total of 277,000. "Kordia" (84,000), "Summit" (45,000) and "Regina" (41,000) were the most popular cultivars.

It is reasonable to assume that the certified trees reflect the preferences of growers replacing trees or expanding sweet cherry orchards. Surprisingly, the lack of consistently clear relationship between size or color and price, "Kordia" was the most popular cultivar. "Regina" – a late maturing cultivar – was also popular. Its late maturity allows extension of the marketing window, while fruit quality is good. American experts noted that any large, firm, sweet fruit among cherry cultivars is well accepted by consumers. The comment discounted the importance of a specific cultivar, especially "Bing", which dominated the United States domestic and export supplies.

The certified tree numbers suggest that the main expansion in sweet cherry commercial orchards in Poland took place about 5-7 years ago. This expansion seems to have been reflected in the increasing crop size and yield already reported in 2013. Since then, barring any spring frost, the crop size has likely increased improving export opportunities.

Conclusions

The future of sweet cherry production is fairly positive in Poland. Given the health benefits of sweet cherries and increasing fruit consumption, the demand for sweet cherries is potentially high. The aging population of Europe and other well-developed economies of the Northern Hemisphere (notably the United States, Canada, Japan, South Korea, and Taiwan) will continue to spend on fresh, quality fruit.

The structure of sweet cherry production changes rapidly in Poland. Fewer farms operate increasingly large sweet cherry commercial orchards. Similarly to other commercial fruit production, sweet cherry orchards increase in size, use irrigation, and apply higher density plantings than in the past. As a result, yields per hectare increase steadily. There is also a shift towards new cultivars. Among popular cultivars are "Kordia" and "Summit", but especially "Regina", a late-maturing cultivar (therefore more tolerant of frost) that yields large, dark fruit.

The estimated trends of relationships between size or color and price showed that the market prices larger and darker fruit higher, but the relationship is better explained in years of short supply than in near-normal crop years. More importantly, there are differences across cultivars showing that "Schneidera Pozna" and "Van" are more likely to be discounted by the market. Not surprisingly, these cultivars are in small numbers among the produced certified trees in Poland. New cultivars must have superior quality fruit as measured by size, color, and soluble solids influencing the taste to meet consumer expectations (Turner et al., 2008). Good appearance, but lack of flavor is unlikely to sustain sweet cherry sales because of the intense competition in the domestic and international fresh fruit market.

The competition from sweet cherry growers within the EU is not much different than in other fresh fruit production. The competitive advantage reflects production costs, variety selection, and postharvest handling, and is modified by climatic conditions. Polish growers are competitive in labor expenses, while the domestic variety adoption programs focus on testing cultivars released from breeding programs in other countries (such as Canada, the United States, Hungary, the Czech Republic, and Germany) to Poland's growing conditions [Rozpara 2008]. This approach, in combination with rootstock selection, aims at improving sweet cherry tree tolerance of spring frost, which is the primary weather-related source of risk.

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Table 1. Descriptive statistics and estimated price trend with regard to size by cultivar in 2007 and 2011

Year	Cultivar	Sales period	Average price	Price variance	Average size score	Estimated linear trend
2007	Buttnera	June 20-July 11	6.79	4.19	25.17	$Y = 0.0485x + 24.683$; R^2=0.0863
	Hedelfinska	June 20-July 11	7.38	4.31	24.84	$Y = 0.0131x + 7.0512$; R^2=5E-05
	Kordia	June 21-July 8	9.04	6.73	26.94	$Y = 1.1487x - 21.9020$; R^2=0.3728
	Schneidera	June 20-July 5	6.74	1.77	26.56	$Y = 0.7568x - 13.3600$; R^2=0.2123
	Van	June 20-July 10	6.75	1.58	25.76	$Y = -0.0409x + 7.8036$; R^2=0.0012
2011	Buttnera	June 16-July 7	7.57	1.82	25.92	$Y = 0.6473x - 9.2054$; R^2=0.0230
	Hedelfinska	June 21-July 11	7.35	1.65	24.54	$Y = -0.4319x + 17.945$; R^2=0.0306
	Kordia	June 17-July 11	10.01	1.44	26.78	$Y = -0.9621x + 35.777$; R^2=0.1055
	Schneidera	June 14-July 2	9.17	0.47	26.47	$Y = -0.0524x + 10.562$; R^2 = 0.0010
	Van	June 13-26	9.16	0.58	26.25	$Y = -0.7314x + 28.356$; R^2 = 0.3161

Source: own elaborations.

Table 2. Descriptive statistics and estimated price trend with regard to color by cultivar in 2007 and 2011

Year	Cultivar	Sales period	Average price	Price variance	Average color score	Estimated linear trend
2007	Buttner	June 20-July 11	6.79	4.19	1.75	$Y = 3.7415x + 0.2415$; R^2=0.6309
	Hedelfilska	June 20-July 11	7.38	4.31	5.77	$Y = 1.5639x - 1.6474$; R^2=0.2818
	Kordia	June 21-July 8	9.04	6.73	5.77	$Y = 2.3149x – 4.3166$; R^2=0.6353
	Schneidera	June 20-July 5	6.74	1.77	5.30	$Y = 0.9370x + 1.7760$; R^2=0.1610
	Van	June 20-July 10	6.75	1.58	4.73	$Y = 0.3876x + 4.9172$; R^2=0.1113
2011	Buttnera	Not available	NA	NA	NA	NA
	Hedelfinska	June 21-July 11	7.35	1.65	5.61	$Y = 1.0564x + 1.4233$; R^2=0.0307
	Kordia	June 17-July 11	10.01	1.44	5.94	$Y = 0.0250x + 9.8625$; R^2=1E-05
	Schneidera	June 14-July 2	9.17	0.47	4.88	$Y = -0.1563x + 9.9365$; R^2 = 0.0043
	Van	June 13-26	9.16	0.58	3.53	$Y = -0.4561x + 10.768$; R^2 = 0.5226

Source: own elaborations.

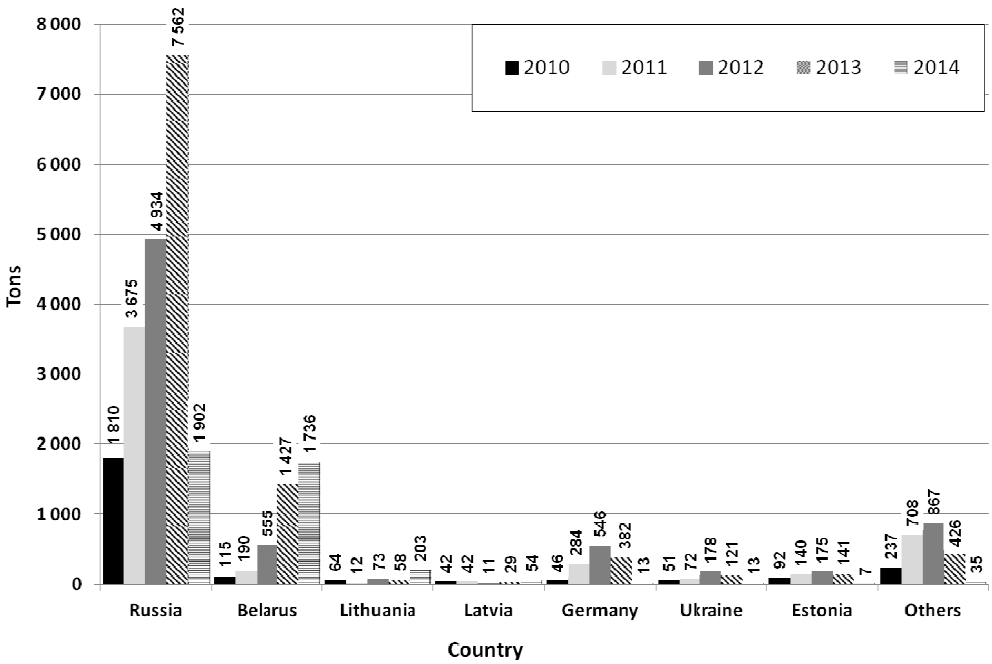

Fig. 1. Major destinations of Polish sweet cherry exports in the period 2010-2014, in tons

Source: Zakład Ekonomiki Ogrodnictwa IERiGŻ-PIB.

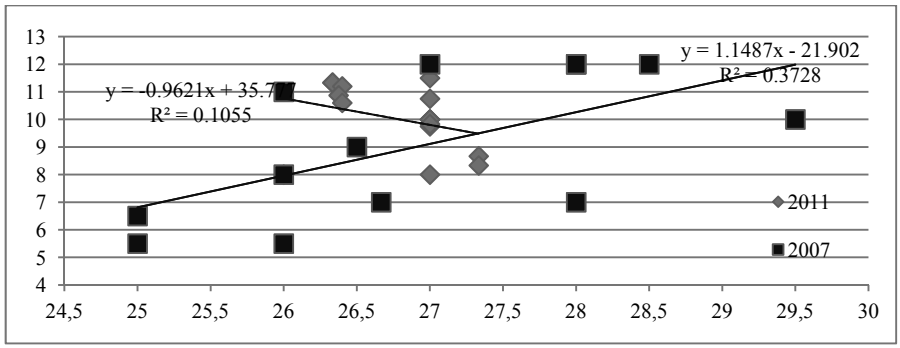

Fig. 2. Plots of actual prices (Y axis) and size scores (X axis) of variety 'Kordia' with calculated trends during the harvest season at Poznan-Franowo wholesale market in 2007 and 2011

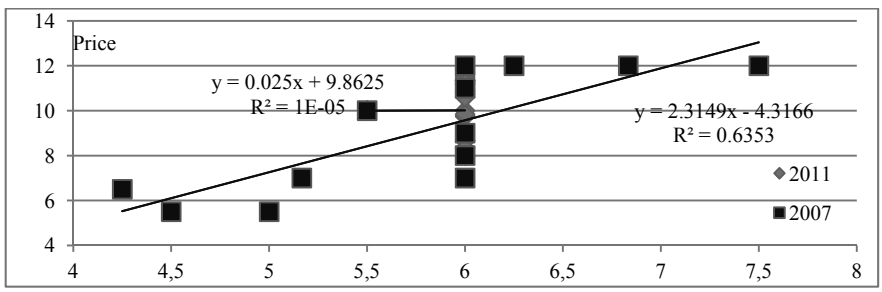

Fig. 3. Plots of actual prices (Y axis) and color scores (X axis) of variety 'Kordia' with calculated trends during the harvest season at Poznan-Franowo wholesale market in 2007 and 2011

Note: The trend was indistinguishable in 2011.

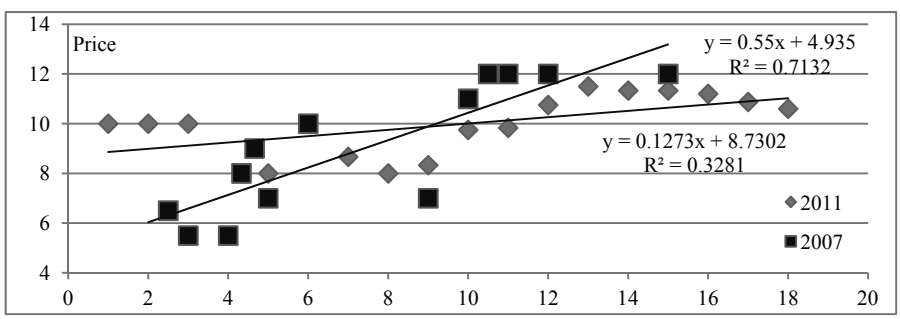

Fig. 4. Plots of actual prices (Y axis) over time (X axis shows consecutive days) of variety 'Kordia' with calculated trends during the harvest season at Poznan-Franowo wholesale market in 2007 and 2011

Note: X axis shows consecutive days of trading.