Universität für Bodenkultur, Wien

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SURVEY AND IDENTIFICATION OF OLD LOCAL SWEET CHERRY (*Prunus avium*) CULTIVARS IN SCHARTEN, UPPER AUSTRIA

Masterarbeit

Zur Erlangung des Masters of Science an der Universität für Bodenkultur Wien

eingereicht von

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Abstract

This work was initiated and executed in collaboration with BOKU University Vienna and the community of Scharten. The aim was to find, map, identify and describe interesting old sweet cherry (*Prunus avium*) trees and varieties in Scharten and the Nature Park *Obst Hügel Land*. Selected trees were mapped manually and via GPS (n=75). The vegetative and generative parameters of selected trees were examined by qualitative and quantitative means (n=30). Special attention was turned on fruit and stone shape parameters, taste and chemical attributes. Plant nutrients like antioxidants and the content of cyanidin equivalents were measured for selected, promising samples (n=5). The measurement results were then processed with the statistics program PASW 18.0 and interpreted. The identification and description of the found cultivars, especially local varieties, formed the second main part. The identified varieties were compared to the existing literature. From the selected trees, seven varieties and two local varieties could be identified. Four possible cultivars could not be identified exactly.

Keywords: Sweet cherry; *Prunus avium*; local cultivars; Upper Austria

Diese Arbeit wurde initiiert und durchgeführt in Zusammenarbeit der Universität für Bodenkultur Wien und der Gemeinde Scharten. Das Ziel war, interessante alte Süßkirschenbäume (*Prunus avium*) in Scharten und dem Naturpark *Obst-Hügel-Land* zu finden, kartieren, identifizieren und zu beschreiben. Ausgewählte Bäume wurden dazu per Hand und mittels GPS kartiert (n=75). Die vegetativen und generativen Parameter ausgewählter Bäume wurden mithilfe qualitativer und quantitativer Methoden untersucht (n=30). Besonderes Augenmerk wurde dabei auf Frucht- und Steinformparameter, Geschmack und chemische Eigenschaften gelegt. Besondere pflanzliche Inhaltsstoffe wie Antioxdantien und der Gehalt an Cyanidinequivalenten wurde bei besonders interessanten Proben gemessen (n=5). Die Messergebnisse wurden dann mit dem Statistikprogramm PASW 18.0 ausgewertet und interpretiert. Die Identifizierung und Beschreibung der gefundenen Sorten, besonders der Lokalsorten, macht den zweiten Hauptteil der Arbeit aus. Die identifizierten Sorten wurden mit der bestehenden Literature verglichen. Aus den ausgewählten Bäumen wurden sieben Sorten und zwei Lokalsorten identifiziert. Vier weitere mögliche Sorten konnten nicht exakt identifiziert werden.

Schlüsselwörter: Süßkirsche; *Prunus avium*; Lokalsorten; Oberösterreich

1. Introduction and objectives

The sweet cherry (*Prunus avium)* was first cultivated on the south coast of the Black Sea, close to the city Kerasos. There, people achieved already from the 4th century BC to breed cherries from wild cherry types. On his drive against Mithridates in 74 BC, Lucullus – a Roman commander better known for his sumptuous feasts and exquisite taste, than for his victories – discovered the cherry plantation in Kerasos and decided to bring some trees home to Rome with him, together with all the other goods conquered in the campaign. It turned out, the cherries were his most durable loot, because they started to spread soon after through the whole Roman Empire and beyond (LAUDERT, 1999).

One of the first evidences of stone fruit culture in Upper Austria was found when in 1951 in Linz a bombed house was excavated and the caves of a Mithras sanctuary appeared. There, 130 coins and 4210 g of fruit seeds were found as religious sacrifices. The coins showed that the rooms were used between 222 and 425 AD. The fruit seeds could be related to wine grape (*Vitis vinifera L. ssp. sativa*), several forms of domesticated and half domesticated plums (*Prunus domestica*), sweet cherry (*Prunus avium*), cornel cherry (*Cornus mas*), apple and crab apple (*Malus communis and Malus silvestris*) and walnut (*Juglans regia*). With a total weight of 3920 g the cherry stones are by far the biggest share of the fruit seeds and stones found. The cherry stones have an almost globular shape and therefore seem to be primarily cultivars, with not much or no breeding influence. Even nowadays, there exist very old morphogenetic cultivars in Upper Austria, which are commonly called *Rainkirschen* (WERNECK, 1955).

Obst-Hügel-Land Nature Park is a 26 km² big nature preserve in Upper Austria, located between the cities Wels and Eferding. Between and along the hills of this park are not only many intensive fruit orchards located, but there also grows an abundance of old, extensively used fruit trees. Especially the cherry trees transform the region every spring into a sea of white petals and blossoms. To celebrate this wonderful spring occasion, the community Scharten invites every year visitors to wander on routes leading along the most beautiful sites of the landscape, trying to waken the guest's interest in fruit production and the conservation of old, yet vital fruit trees. Around the same time of the year, the annual Cherry Blossom Bicycle Race of Wels takes place, the oldest street bicycle race in Austria, celebrating the cherry blossom by leading directly through the nature park.

Since in Scharten the cherry tree is not only an economic factor but also its most important landmark, research was openly welcomed by the local authorities. The aim of this thesis was to find, map, identify and describe interesting old cherry trees growing in the nature park. To achieve these goals, evaluation of the cherry trees and their fruits took place in field and laboratory.

2. Literature review

2.1 Sweet cherry classification

Prunus avium, the sweet cherry belongs to the family of *Rosaceae*, specifically the genus *Prunus.* To this genus also belong other stone fruits like apricot (*Prunus armeniaca*), peach (*Prunus persica*) and almond (*Prunus dulcis*). Today, primarily the sup-species of *Prunus avium*, *Prunus avium ssp. duracina* and *Prunus avium ssp. juliana*, are used for fruit production. These sub-species were selected on fruit characteristics like size, sweetness and low astringency (SCHOLZ, 1995).

The main difference between *Prunus avium ssp. duracina*, also called Bigarreau cherries or white-heart cherries and the subspecies *ssp. juliana*, called heart cherries, is the difference in fruit flesh firmness. While white-heart cherries show a characteristically firm and crisp fruit flesh, heart cherries tend to be softer and juicier in flesh. Both sub-species are found in light and in dark skin shades.

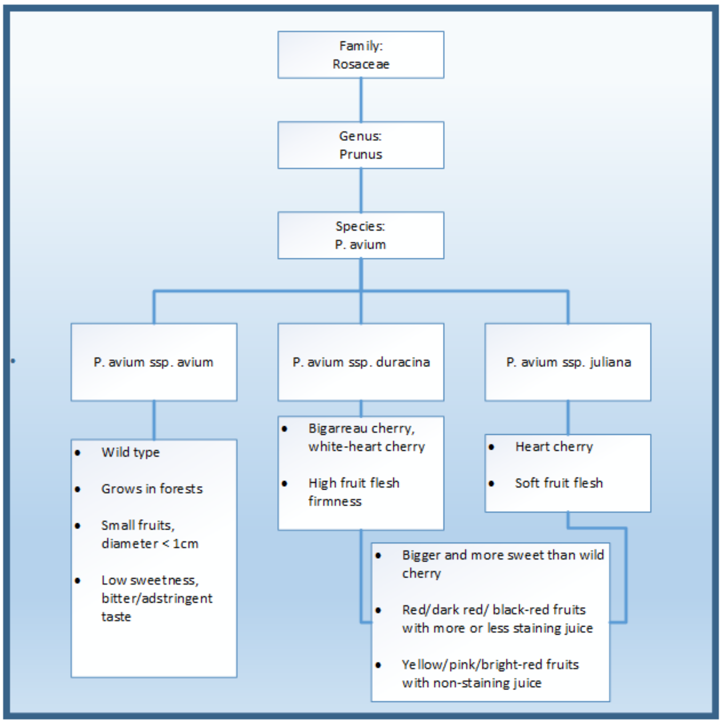


Figure 1: Classification of Prunus avium into its subspecies and their characteristics (after LAUDERT, 1999)

Today it is estimated that the wild cherry *Prunus avium ssp. avium* has been harvested and cultivated throughout Central Europe for eight to ten thousand years.

Early breeding attempts were made in Asia Minor and Western Asia, especially in the Black Sea region, where they were found by Roman general Lucullus in 70 BC who brought the cultivated sub-species to Europe (LAUDERT, 1999).

2.2 Biology of *Prunus avium*

2.2.1 Vegetative characteristics

The sweet cherry is a deciduous tree which can reach 20-25 m height and 5-10 m width (tree top). It has a life span of 80 to 100 years.

In profound soils, cherry trees grow a strong, heart-shaped root system, with a tap-root and a net of lateral roots. In shallow, heavy or waterlogged soils only a flat root system develops; these trees are prone to wind throw (PRYOR, 1988). The sweet cherry tree trunk shows a reddish-brown to grey-brown bark with big lenticels for gas exchange. Young cherry trees show strong apical dominance, which decreases with growing age. The tree top first shows an egg-shape, later a spherical shape. The cherry tree root system consists of a tap-root at a net of lateral roots. Cherry leaves sprout in a bronze color and grow fast into green leaf blades with doubly serrated margins. Directly between leaf blade and the reddish petiole sit extra-floral nectaries that have the purpose to attract ants which help the tree defend against pests (LUCAS, 1992; FRANKE, 2007).

2.2.2 Generative characteristics

Flowering occurs, depending on climate and location, from April to May. Two to six flower buds form into umbels. The hermaphrodite flowers are radial symmetric with five green to reddish-brown sepals and five white petals. The sepals arch downwards in full bloom. The stamen are yellow and of same length as the style. Sweet cherry is – except for few cultivars – not self-fertile and needs a pollinator tree of a different cultivar with matching S-alleles.

Figure 2: Sweet cherry flower bunch (www.lubera.com)

Cherry fruits are drupes and have a shape ranging from spherical to heart-shaped. They grow to sizes between 6-25 mm width. The membranous exocarp is glossy and its color ranges from yellow to black. The fleshy mesocarp can be more or less firm or juicy and shows colors from cream white to dark red. The endocarp evolves into a roundish or pointed stone with a smooth surface (LUCAS, 1992; FRANKE, 2007).

2.2.3 Nutritional compounds

Sweet cherries consist to 83-85% from water, 0.9% from crude protein and 0.5% of minerals. Carbohydrates are primarily the free sugars fructose and glucose with glucose in a slightly higher ratio than fructose. The average amount of macro and micro nutrients and vitamins can be found it the table below (HERRMANN, 2001).

Table 1: Nutritional composition of sweet cherry (modified after HERRMANN, 2001)

Nutrient composition of 100 g fresh sweet cherries			
Water, macro nutrients and energy content			
Carbohydrates [g]	13.3	**Water [g]**	83-85
Protein [g]	0.9	**Fiber [g]**	1.0-1.5
Fat [g]	0.3	**Energy [kcal]**	62
Mineral nutrients and vitamins			
Na [mg]	3.0	**Vitamin A [µg]**	50
K [mg]	220	**Vitamin B_1 [µg]**	40
Ca [mg]	17	**Vitamin B_2 [µg]**	40
Mg [mg]	11	**Vitamin C [mg]**	15
P [mg]	20	**Vitamin E [µg]**	100
Fe [mg]	0.4	**Niacin [µg]**	270

The fruits of the sweet cherry also contain a high amount of secondary plant metabolites like catechins, flavonoids and anthocyanins (HERRMANN, 2001).

Cherry aroma is mainly generated by alcohols, aldehydes, ketones and esters. Especially benzaldehyde (bitter almond aroma), linalool, hexanal and eugenol add to the characteristic cherry taste (SCHMID, 1986).

Anthocyanin in sweet cherries consists mainly of cyanidin-3-rutinoside and cyanidin-3-glucoside (HERMMANN, 2001; JAKOBEK, 2007).

2.2.4 Cultivation

Prunus avium prefers to grow in full sun to half shade situations. For soils it favors fresh clay soils rich in humus and with an alkaline milieu. Although cherry trees grow best in sunny locations, they are sensitive to drought and high temperatures. Towards too low temperatures and mechanical damage Prunus avium reacts with an outflow of resin. Under salt stress cherry trees show a decrease of vitality (FRANKE, 2007).

3. Characteristics of Scharten and Obst-Hügel-Land (OHL) Nature Park

3.1 History of Scharten and the nature park

The name Scharten derives most probably from the Middle High German word "Scharte" for nick or cleft and points at the regions landscape, which was formed by glacier movements. Early evidence of settlement in Scharten can be traced back to the medieval age, when around 1400 AD the first church was build there. The almost 200 years old script "Franziäische Kataster" (1825) provides information about land-use in the region and shows, that many farms and settlements already existed in that time. The best locations were and are used for agriculture. Since in the mid-20th century the number of farms decreased, a lot of small size field parcels disappeared and with them many extensively used fruit orchards.

Fruit production occurs in different systems in the community. Several farms produce commercial fruit crops like apricot, pear and cherry in intensive production systems with spindle trees. The biggest impact on the picturesque landscape are the extensively used fruit trees and orchards. The trees are planted on field margins or grasslands and consist of high-trunked sweet cherry, apple and many other fruits. The trees are not necessarily planted in a regular order and are most of the time note taken care of intensively. Many of them were planted not only for fruit production, but also to stabilize the numerous slopes of the landscape. Many fruit trees can also be found in private gardens.

The destine of the in 2005 opened Nature Park "Obst-Hügel-Land" is to protect the cultivated landscape with its old, extensively used fruit trees like apple, pear, cherry and apricot.

Important products of the harvested fruits are apple and pear most, wine and sparkling wine, but also all kinds of spirits, juices and jams. Additionally, the interest in old varieties for fresh consumption or processing into specialties like cherry strudel is increasing nowadays (www.obsthuegelland.at).

3.2 Geographical situation

Scharten and the OHL nature park are situated in the district Eferding in Upper Austria, specifically in-between Wels, Eferding and Bad Schallerbach. The community Scharten consists of the townships Aigen, Breitenaich, Finklham, Herrnholz, Kronberg, Leppersdorf, Oberndorf, Rexham, Roitham, Roithen, Scharten, Vitta.

Figure 3: Geographical location of Scharten (www.obsthuegelland.at)

The community center of Scharten is located on 397 m above sea level. The highest positioned place is the hill "Roithner Kogl" with 448 m above sea level. The extent of the community is 5.3 km from north to south and 7 km from east to west. The expanse of the community is 17.5 km². 10.9% of this area are covered with forest, 75.3% are are used for agriculture (scharten.at).

The Nature Park Obst-Hügel-Land covers the two communities Scharten and St. Marienkirchen an der Polsenz to two thirds. The park has a total area of 26 km².

3.3 Geological characteristics

Scharten and the Nature Park OHL are located in the Eferding basin, which is a granite and gneiss highland. The characteristic subsoil in Scharten and the nature park is a marine siltstone, called "Schlier" in German. It consists of marl and fine sand, which were accumulated in marine basins or shelf through sedimentation. The young and tender bedrock shaped into a landscape of rolling hills. The silt, specifically *Robulus* silt, is a quite slippery subsoil and frequently causes shifting in the geological zone. This contributed to the inhabitants of the region planting fruit trees on the slopes. The spreading root system is supposed to support soil stability.

Figure 4: Apple tree growing on a slope (after BAUMGARTNER, 2008)

Brown earth and pseudogley are the dominant soil types in Scharten and St. Marienkirchen an der Polsenz (BAUMGARTNER, 2008; DORNINGER, 2011).

3.4 Climatic characteristics

The community Scharten and Obst-Hügel-Land nature park are located in the temperate zones and are influenced by a humid climate and the west wind zone. This climate zone is characterized by cool, humid summers and mild winters with intensive snowfall. With an annual average temperature between 8 and 9 °C it is one of the warmest regions in Upper Austria. The annual average precipitation of 700 mm (in the North, direction Eferding basin) to 900 mm (in the South, direction hill country) falls with 65% of the total precipitation mostly in the summer months June, July and August, peaking in July. A second peak of precipitation occurs in February. Intensive rainfall events in these months frequently lead to floods and landslides.

With a relative sunshine duration of 55% in the summer months and 25% in the winter months, Scharten is located in one of the regions of Upper Austria richest in sunshine (DORNINGER, 2011).

Table 2: Climatic benchmark data of Scharten and Obst-Hügel-Land nature park (modified after BAUMGARTNER, 2008)

Annual average air temperature	8 - 9°C	**Annual average precipitation**	700 - 900 mm
Average air temperature January	-1 - -2°C	**1st precipitation maximum**	July
Average air temperature July	18 - 19°C	**2nd precipitation maximum**	February

4. Methods

As a basis for this thesis, the projects of two pervious graduates (PILZ, 2012; SPÖRR, 2013) were used. Their methods, results and advices were a great help, to develop the procedure for this project.

4.1 Field

4.1.1 Mapping

The trees were selected with the help of the local farmers and private persons. Interesting trees were labeled with a stripe of plastic band, on which the tree code was remarked. Then the tree position was localized by using a GPS tracker. Also, the trees were tagged on aerial photographs of the region, to simplify finding the trees again.

Every sampled tree was given a code including the township in which it stands and a registration number in ascending order. The fifth tree found in Upper Scharten was therefore coded "S5", the seventh tree in Aigen was labeled "A7". Sometimes it was not possible to distinguish in which township a tree was located, and it had to be guessed. Hence, not all of the location coding might be correct.

Figure 5: Aerial photo with marked trees (picture private)

4.1.2 Tree evaluation

During the four field trips to Scharten, 75 trees were selected and mapped, of which then 30 were rated. For the evaluation, selected fruit descriptors developed by SZALATNAY (2006) were used. The evaluation scheme can be found in the appendix (Table 41 & 42).

Tree age was either told by the farmers/private persons or had to be estimated. Since the focus of this work was on old varieties, trees older than 40 years were clearly favored.

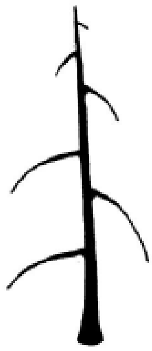
The **shape of the tree top** and the **growth form** of the tree were categorized after two tables of characteristic growth forms after BERNKOPF (1996). The nine possible tree top shapes of the table have each a number from 1 to 9.

1	flat pyramidal	2	pyramidal	3	high pyramidal
4	reverse pyramidal	5	flat spherical	6	spherical
7	high spherical	8	columnar	9	umbrella-like

Figure 6: Different tree top shapes (modified after BERNKOPF, 1996)

The **growth form** is divided into five categories:

Table 3: Five different growth forms of cherry trees (modified after SZALATNAY, 2006)

1 = upright	3 = semi-upright	5 = spreading	7 = semi-drooping	9 = drooping
				

Trunk height and **circumference** were measured with a measuring tape, which sometimes required a certain sports skill. The height was measured from the ground to the lowest leader branch of the tree top; the results are given in centimeters. The circumference was taken at the widest part of the trunk; results are described in meters. Following the examples of PILZ (2011) and SPÖRR (2013), the trunk height was categorized as below:

- < 1.50 m = low
- 1.51 – 1.70 m = medium
- 1.71 – 1.90 m = high
- > 1.91 m = very high

The **trunk circumference** was categorized similarly:

- < 100 cm = very small
- 101 – 150 cm = small
- 151 – 200 cm = medium
- 201 – 250 cm = big
- > 251 cm = very big

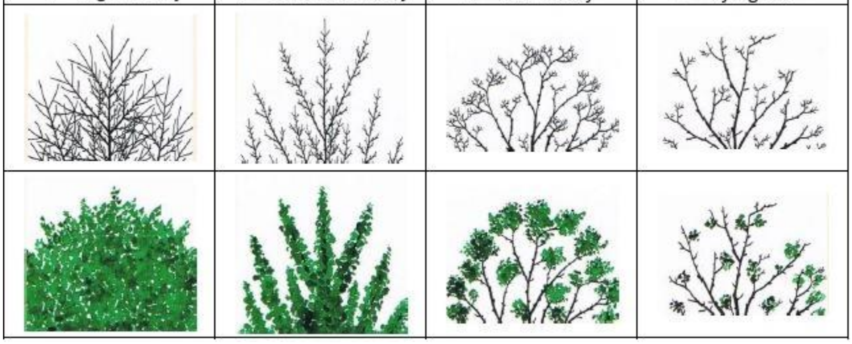
Fruit load was categorized as follows:

- 1 = very low fruit load
- 3 = low fruit load
- 5 = medium fruit load
- 7 = high fruit load
- 9 = very high fruit load

Vitality shows how vigorously the tree grows and can be best read from the foliage.

Table 4: Tree vitality categories (modified after ROLOFF, 2001)

1 = high vitality	3 = medium vitality	5 = low vitality	7 = dying off



Additionally to taking note of the tree position and its vegetative characteristics, also the **tree environment** was written down. Tree environment could range between meadow, field and street or none of the former.

- 1 = meadow
- 3 = field
- 5 = street
- 7 = others

Overall impression describes the impression of the tree with no specific focus on vitality, pruning or fruit load.

- 1 = very bad
- 3 = bad
- 5 = mediocre
- 7 = good
- 9 = very good

Pruning could in most cases only be estimated. Many times, even the farmers could not remember when the last pruning had been done. However, cutting wounds or misshaped tree tops made it possible to guess about the pruning work. The following categories were possible:

- 1 = existing
- 3 = lacking
- 5 = old
- 7 = new
- 9 = professional
- 11 = unprofessional

In many cases, not only one of the categories occurred at the same tree, e.g. an existing old pruning or a new and unprofessional pruning result.

Maintenance condition is a more general evaluation which can include parameters such as pruning, dead wood and damages. The categories for maintenance are:

- 1 = none
- 3 = low
- 5 = medium
- 7 = well
- 9 = very well

The existence and **position** of a **graft** gives a hint, if the tree is a cultivar or a seedling. However, not in every case it is possible to determine if a tree was grafted. The position of the graft was categorized as follows:

- 1 = trunk base
- 3 = trunk middle
- 5 = tree top base
- 7 = not visible/ no graft

Dead wood was estimated from 0-100%. Dead wood can be caused by disease, wind break or animal feeding. It also gives information about the maintenance condition of the tree. The dead wood percentage was categorized as follows (SPÖRR, 2013):

- Low to few dead wood = < 5%
- Single branches dead = 6 – 15%
- Quarter of the tree top dead = 16 – 25%
- Half of the tree top dead = 26 – 50%
- More than half of the tree top dead = > 50

Shot hole disease (*Clasterosporium carpophilum*) was estimated using the following categories:

- 0 = no disease visible
- 1 = few symptoms
- 2 = moderate symptoms
- 3 = severe symptoms

4.2 Laboratory

Figure 7: Cherry samples on a plastic tray during measurement (private picture)

For the fruit measurements and evaluation 50 fruits and several leaves per tree were collected. Ten of the fruits were used for the measurements, six for the photograph and several more for the tasting. During the harvest the cherries were stored in a cool box; in the following night, the cherries were kept in a fridge. For the evaluation, selected fruit descriptors developed by SZALATNAY (2006) were used. The fruits were placed with the stalk on a plastic tray. The fruits, and later the stones, were kept in the same order throughout the whole procedure.

4.2.1 Quantitative measurements

4.2.1.1 Outer characteristics

The knowledge about morphology and terminology of sweet cherries is necessary to be able to conduct correct measurements with reproducible and comparable results. The cherry fruit sits on a stalk that ends in the stalk groove on the stalk side. The opposite end of the cherry fruit is the pistil side, where the pistil is positioned. Between stalk side and pistil side runs the seam, a pigmented band, sometimes lying in furrow. The opposite side of the seam side is called the back side. Fruit measurement was conducted following the steps on table 43 (appendix).

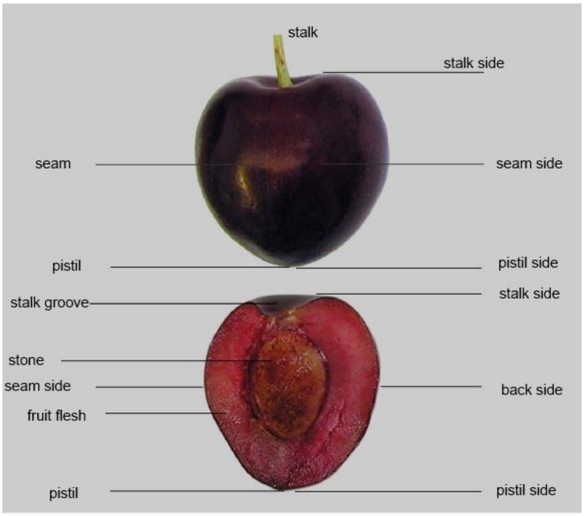


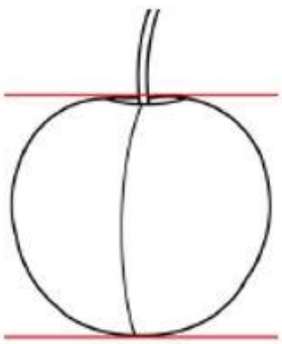
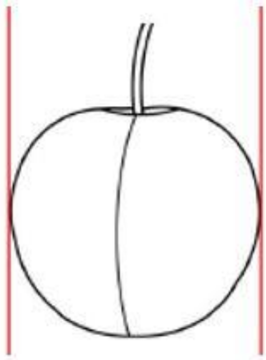
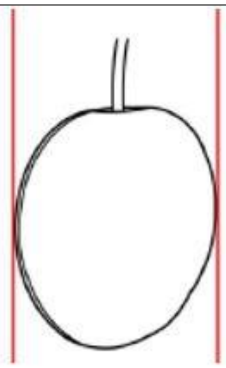
Figure 8: Important terminology for cherry measurement and evaluation (modified after SZALATNAY, 2007)

Stalk length was measured with a regular ruler in millimeters while the stalk was still on the fruit. The measured lengths were then categorized after SZALATNAY (2006):

- 1 = 3 cm or less = very short
- 3 = 3 – 4 cm = short
- 5 = 4 – 4.9 cm = medium
- 7 = 5 – 5.9 cm = long
- 9 = 6 cm or more = very long

Fruit length, width and gauge as well as **stone length, width and gauge** (Table 5) were measured using a digital sliding caliper (Sylvac, Switzerland). The measurement reading was recorded in millimeters. It is necessary to be able to differentiate width and gauge for fruit and stone. Cherry varieties can differ in their shape and therefore a certain amount of skill is required to distinguish width and gauge.

Table 5: Length, width and gauge of cherry fruits (above) and stones (below) (modified after SZALATNAY, 2006)

Length	Width	Gauge
		
		

The **fruit shape index** is a means to evaluate the shape of the fruit. It is calculated using the length, width and gauge of the fruit using the following equation:

$$FSI = \frac{\boldsymbol{length}^2}{(\boldsymbol{width} * \boldsymbol{gauge})}$$

Similarly, the **stone shape index** is calculated with the length, width and gauge of the stone.

$$\boldsymbol{SSI} = \frac{\boldsymbol{lenght}^2}{(\boldsymbol{width} * \boldsymbol{gauge})}$$

The results of both indexes can be interpreted in the same way. An index < 1 shows a shape with smaller length than width and gauge. For cherries this can be read as a flat fruit shape. An index of 1 exactly shows a spherical shape and an index > 1 can be interpreted as an elongated shape with the length bigger than width and gauge.

Fruit weight and **stone weight** were measured on a digital scale (Laboratory L 2200S, Sartorius AG, Germany) [g].

The **fruits** were then categorized after their **size**, which could be determined by width as well as by weight. For some fruits the categorization achieved through width was not the same as the one achieved through weight.

- 1 = very low = < 4g/ < 19mm
- 3 = low = 4-4.9g/ 19-20mm
- 5 = medium = 5-6.4g/ 21-22mm
- 7 = large = 6.5-7.9g/ 23-24mm
- 9 = very large = > 8g/ >24mm

The **stones** were categorized after LEIFER (2002) according to their **weight** as follows:

- 0.13 – 0.17 g = very lightweight
- 0.18 – 0.22 g = light
- 0.23 – 0.27 g = medium
- 0.28 – 0.32 g = heavy
- > 0.33 g = very heavy

The **stone share** describes, how much of the fruit weight is caused by the stone weight. From consumers as well as producers, a low stone ratio is a desirable quality trait. It can be determined by using the following equation:

$$\boldsymbol{Stone\ ratio} = \frac{\boldsymbol{stone\ weight} * \mathbf{100}}{\boldsymbol{fruit\ weight}}$$

The **stone share** categorization after DUHAN (1959, modified by SPÖRR, 2013) determines the following classes:

- < 4% = very small
- 4.1 – 5% = small
- 5.1 – 6% = medium
- 6.1 – 7% = high
- 7.1 – 8% = very high
- >8.1% = extremely high

Stalk release force is an important factor for harvest, either by hand or mechanical. The lower the release force, the easier is the harvest and the lower is the chance to damage the fruits. The force was measured using a digital penetrometer (AFG 500 N, Mecmesin, UK). Therefore the newton meter was fixated on a stand. The cherry was placed stalk down in the hook of the newton meter and the stalk was pulled until it detached from the fruit. The measurement was given in Nm. Afterwards, the force could be recalculated into the weight [g] which was necessary, to release the stipe with the following equation:

$$m\,[g] = \frac{force\,[N]}{9{,}81\ {}^{m}/_{s^2}} * 1000$$

Finally, the stipe release force could be categorized into the below categories (GRAF, 1996):

- < 400 g = easy release
- 401 – 500 g = medium release
- 501 – 600 g = bad release
- > 601 g = very bad release

Skin color and **juice color** were measured with a portable spectral photometer. The results were first saved on the chip of the device, then copied into an excel sheet. The measurement is taken as a three dimensional graph, with the axes named *L*, *a* and *b*. *L* represents the luminescence, *a* the red-green proportion and *b* the blue-yellow proportion of the color spectrum. For the measurement on the fruit skin, the spectral photometer sensor was pressed firmly against one cheek of the cherry. The juice measured was a mixture of the juices of all ten measured fruits. One drop of the juice was put on a white cellulose tissue on a table, then the sensor was put upon the tissue firmly. It is important to cover the sensor of the spectral photometer completely to avoid sunlight to fall into the sensor during the measurement.

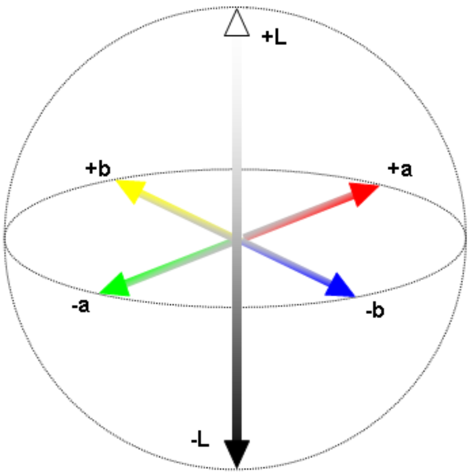


*Figure 9: Illustration of an L*a*b spectrum for spectrophotometry (www.codeproject.com)*

Fruit flesh firmness can indicate how well a cherry variety can be transported. Soft fleshed fruits are damaged easily during transportation and thereby lose their value for fresh consumption. During the fruit ripening, the firmness of the fruit flesh changes: cell division stops and cell elongation proceeds, leading to a softer fruit flesh (WHITING, 2007). Therefore it is important to harvest and measure all fruits at the same degree of ripeness. All fruits but S20 were harvested ripe; S20 was harvested at 3 different ripening stages. The fruit flesh firmness was measured using the same penetrometer which was used for the stalk release force. The hook was replaced by a forcer tool. The newton meter was fixated on the stand, but could be moved up and down electrically. The fruit was placed between the staff and a wooden board. While moving down, the staff of the newton meter penetrates the fruit skin and flesh. Caution is advised to not move the newton meter down too fast, to avoid the staff to come upon the cherry stone.

The measured values [N] are then transformed into the mass [g] that is necessary to penetrate skin and fruit flesh. The equation is the same as for stalk release force:

$$\boldsymbol{m\,[g] = \frac{force\,[N]}{9{,}81\ {}^{m}/_{s^2}} * 1000}$$

The resulting values are categorized as follows:

- < 500 g = soft
- 501 – 1000 g = medium
- > 1001 g = firm

4.2.1.2 Inner characteristics

Soluble solids (SS) in cherries consist to 85-87% of carbohydrates. By far the biggest share do have glucose and fructose, with saccharose only having an inferior role. Additionally, sorbit – a sugar alcohol - increases the sweetness of cherries (HERRMANN, 2001). The soluble solids were measured with a refractometer (PR-101, Atago, Japan). The already open fruits (split after the fruit flesh firmness measurement) were squeezed manually until enough juice leaked to cover the lens of the refractometer. The SS results are given in °Brix.

The values were then categorized after DUHAN (1959):

- < 15.0 = moderate sweetness
- 15.1 – 15.8 = medium sweetness

- 15.9 – 16.9 = rich sweetness
- 17.0 – 17.9 = especially rich sweetness
- 18.0 – 19.2 = intensive rich sweetness
- > 19.3 = extraordinarily rich sweetness

The **pH** of the fruits was measured using a pH meter. Measurements on single fruits had been conducted before (SPÖRR, 2013), but the handling turned out difficult. The pH of the fruit flesh around the stone is lower compared to the flesh closer to the skin. For this work, another method was used. The open fruits without stone were placed into a regular kitchen potato ricer and squeezed, until no juice would emerge anymore. Since one fruit would only give a very small amount of juice, all ten fruits' juices were mixed and an average value was achieved.

The values were again categorized after DUHAN (1959) (modified):

- 3.38 – 3.45 = especially sour
- 3.46 – 3.59 = dominantly sour
- 3.60 – 3.99 = strongly sour
- 4.00 – 4.19 = pleasantly sour
- 4,20 – 4.29 = sourly
- 4.30 – 4.69 = slightly sour
- >4.70 = faintly sour

The **amount of acid** was measured via titration. Five milliliters of the sample juice were placed into an automatically titration machine. The machine measures the amount of acid in the juice by using soda lye to neutralize the acid, then calculates how much lye was necessary. Since malic acid is the main acid in sweet cherry (ESTI, 2002; BERNALTE, 2003; FERETTI, 2010), an adapted equation was used to calculate the amount of malic acid in the fruit juice. The resulting values are given as g/l.

$$\mathbf{C_S * V_S * Z_S = C_L * V_L * Z_L}$$

$$\mathbf{Malic\ acid\ content\ [g/l] = V_L * 670.45}$$

C_S = concentration acid	V_S = volume acid	Z_S = proton charge acid
C_L = concentration lye	V_L = volume lye	Z_L = proton charge lye

Antioxidative capacity was measured in five cherry juices. The measurement was only conducted a small sample of juices because the used method was rather time consuming. This approach was chosen to substitute a vitamin C measurement. Usually, vitamin C is by simple methods, like test strips. This approach turned out to show disaffected results for sweet cherries. The test strips are supposed to show a color change depending on the amount of the detected ascorbic acid in the tested liquid. Unfortunately, when used in cherry juice, the color pigments of the juice falsify the color change.

For this work, measurement using a DPPH (2,2-Diphenyl-1-pikrylhydrazyl radical) solution was conducted following a tested protocol (JAKOBEK, 2007; SHARMA, 2009; PYRZYNSKA, 2013). Measurement was executed in a DU 800 UV/Visible Spectrophotometer (Beckman Coulter, USA). The spectrophotometer measures a color change in the solution to be tested at a specific wavelength. DPPH produces a purple solution in methanol; its color can be traced back to a free electron at the DPPH's nitrogen molecule. Mixed with a radical scavenger like ascorbic acid, the free electron binds on a hydrogen atom of the antioxidant, emerging as H_2 and the color of the solution gradually changes from purple to yellow. The spectrophotometer detects and measures this color change. The higher the content of antioxidants in the solution the faster is the color change. After the measurement, the content of antioxidants in the solution can be calculated using a calibration line for the DPPH and ascorbic acid.

In this case, measurement was conducted at 517 nm, with one measurement each minute in a total of 30 minutes. A 0,1mM DPPH solution was prepared by mixing a ratio of 9.85 mg DPPH crystals with 250 ml of methanol in an Erlenmeyer flask. The flask was closed with parafilm™ and wrapped in aluminum foil to prevent DPPH decay by oxygen and UV light. The flask was then placed on a magnetic mixer until the DPPH crystals were dissolved. This solution was stored at 8 °C in the fridge until its use.

The juice in testing was thawed at room temperature and centrifuged for ten minutes with 10000 tpm. Of each juice 0, 1, 5, 10, 15 and 20 µl we pipetted into 2 ml cuvettes and filled up to a volume of 20 µl with methanol. Some juices however showed a very strong decay of DPPH so quickly, that the juice concentration was cut in half in another set of cuvettes (0/ 1/ 2.5 /5.0 /7.h5 /10 µl). A blank was measured using 2 ml of methanol. The cuvettes with the diluted juice were placed into the measurement slide and each filled with 2 ml of the DPPH solution. The slide was placed immediately into the spectrophotometer and the measurement program was started. The resulting values were then inserted into a pre-programmed excel sheet with a calibration curve for ascorbic acid and an equation for the content of ascorbic acid given in µmol Trolox equivalents per ml juice.

It has to be kept in mind, that the juice that was measured was produced in a very simple way. By extracting only the liquids of the cherry, most probably a high amount of antioxidants stay in the fruit flesh.

Anthocyanins are the main pigments in many red, purple, blue or black fruits like berries and cherry (HERRMANN, 2001; JAKOBEK, 2007) JAKOBEK et al. (2007) found out, that cyanidin-3-rutinoside and cyanidin-3-glucoside were the two main anthocyanins found in sweet cherry with a share of 91.4% of the total anthocyanins. The remaining 8.6% are composed of peonidin. The content of anthocyanin equivalents was measured using a DU 800 spectrophotometer at 520 nm wavelength. The blank (methanol) and the samples were pipetted into 1.5 milliliter cuvettes. First, the blank was measured with 1 ml of pure methanol. The cherry juices were diluted with methanol and prepared into three different concentrations: 1:10, 1:100, and 1:1000. A calibration line was established with pure cyandin diluted with methanol in concentrations of 1:1000, 5:1000, 1:100, 2:100 and 3:100.

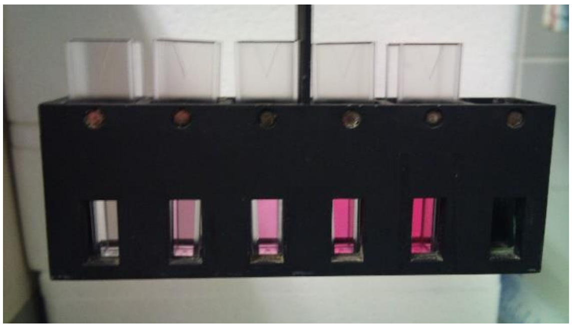


Figure 10: Cyanidin solution in dilutions of 1:1000, 5:1000, 1:100, 2:100 and 3:100 (from left to right) in the measurement slide of a spectrophotometer (picture private)

The values of the calibration line were transferred to Excel to establish an equation. This equation then was used to calculate the anthocyanin concentration of the measured fruit juices.

4.2.2 Qualitative ratings

Additionally to the fruit measurement, fruit evaluation and rating were conducted one day after fruit harvest. The evaluation is compared to the measurements always biased by the conductor of the rating and therefore a subjective means. The fruit evaluation sheet can be found in the appendix (Table 44).

4.2.2.1 Outer fruit characteristics

Fruit shape was determined after five shape categories, ranging from globular to heart-shaped.

Table 6: Cherry fruit shapes (modified after SZALATNAY, 2006; picturs private)

1 = kidney-shaped	2 = flat spherical	3 = spherical	4 = oval	5 = heart-shaped
				

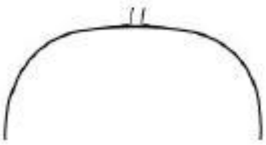
Skin color was categorized from bright colors (yellow) to the darkest shades (black).

Table 7: Cherry skin colors from yellow to black (modified after SZALATNAY, 2006)

1 = yellow	3 = yellow on red base	4 = bright red	5 = red	7 = dark red	9 = black
					

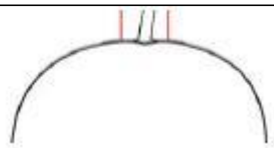
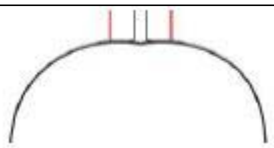
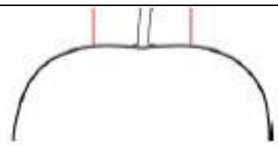
The **shape of the stalk side** is expressed by the degree of shouldering and can reach from flat/even to strongly shouldered:

Table 8: Stalk side shapes from flat or even to shouldered or strongly shouldered (modified after SZALATNAY, 2006)

1 = flat	2 = even	3 = shouldered	4 = strongly shouldered
			

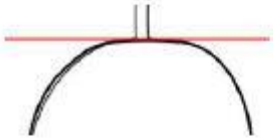
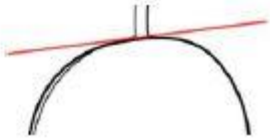
The **width of the stalk side** shows how wide the cavity between the shoulders is and it is classified as:

Table 9: Stalk side width from slim over medium to large (modified after SZALATNAY, 2006)

3 = Slim	5 = Medium	7 = Large
		

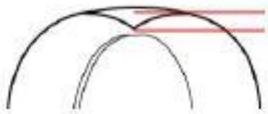
The **inclination of the stalk side** can be seen easily by noticing to which direction the stalk inclines:

Table 10: Stalk side inclination can be horizontal, to the seam or to the back side of the cherry (modified after SZALATNAY, 2006)

1 = horizontal	2 = to the seam	3 = to the back
		

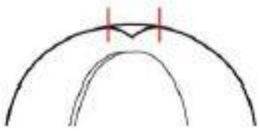
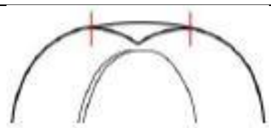
Depth of the stalk groove is classified into:

Table 11: Stalk groove depth can be classified as shallow, meduim or deep (modified after SZALATNAY, 2006)

1 = shallow	3 = medium	5 = deep
		

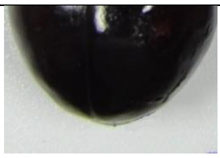
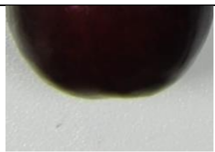
The width of the stalk groove is, similarly to stalk side width, divided into narrow, medium and broad.

Table 12: Stalk groove width can be categorized as narrow, medium or broad (modified after SZALATNAY, 2006)

1 = narrow	3 = medium	5 = broad
		

The **shape of the pistil side** could be categorized as

Table 13: The shape of the pistil side can range from pointed over even and indented to rounded (after SZALATNAY, 2006; pictures private)

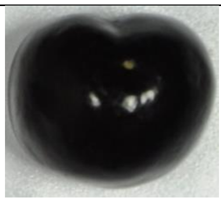
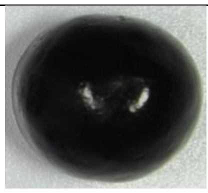
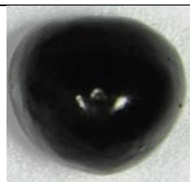
Pointed = 1	Even = 2	Indented = 3	Rounded = 4
			

The **position of the pistil** is evaluated in relation to the pistil side and can be

- 1 = Indented
- 2 = Even
- 3 = Elevated
- 4 = On a tip

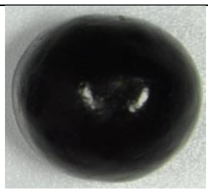
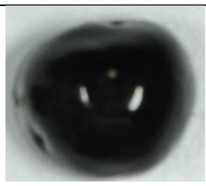
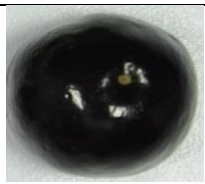
The **location of the pistil** is determined by regarding the cherry from the pistil side. The pistil can be

Table 14: The pistil can be located shifted to the seam side, central or shifted to the back side (after SZALATNAY, 2006; pictures private)

Shifted to the seam = 1	Central = 2	Shifted to the back = 3
		

The **size of the pistil** can range from small (3) and medium (5) to big (7).

Table 15: The size of the pistil can range from small to big (after SZALATNAY, 2006; pictures private)

Small = 3	Medium = 5	Big = 7
		

The **seam** can be more or less furrowed and is categorized as

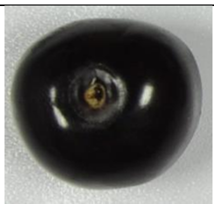
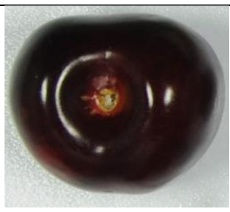
- 1 = Even, invisible
- 3 = Hardly visible
- 5 = Easily Visible
- 7 = Explicit

The **seam side** of the cherry can run to the pistil either flattened (1) or bulged (3).

Seen from above, the following fruit shape categories can occur:

- 1 = Belly flat, back flat
- 3 = Belly bulged, back bulged
- 5 = Belly flat, back bulged
- 7 = Belly bulged, back flat

Table 16: Cherry fruits seen from above with or without bulge on seam and back side (after SZALATNAY, 2006; pictures private)

1	3	5	7
			

4.2.2.2 Inner fruit characteristics

The tasting was conducted by myself and Elisabeth Schüller.

Ripeness of the fruits could be categorized as

- 1 = Unripe
- 2 = Marginally ripe
- 3 = Ripe
- 4 = Overripe

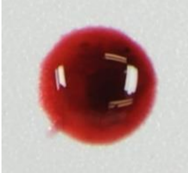
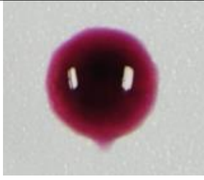
The **color of the fruit flesh** was determined by cutting open several fruits and using the following color scheme:

Table 17: Fruit flesh colors from cream white to dark red (modified after SZALATNAY, 2006; pictures private)

Cream white = 1	Yellow = 2	Pink = 3	Red = 4	Dark red = 5
				

Juice color was determined by a similar scheme.

Table 18: Cherry juice colors from colorless to black-red (modified after SZALATNAY, 2006; pictures private)

Colorless = 1	Pink = 3	Red = 5	Purple = 7	Brown-red = 8	Black-red = 9
					

White veining can also be characteristic for cherry cultivars and varies from invisible to strongly visible.

Stone ease describes how easily the stone can be separated from the surrounding fruit flesh. Stone ease was described as

- 1 = Easy
- 2 = Mediocre
- 3 = Tough

The **sweet/sour taste type** of cherries is classified into five categories:

- 1 = very sour
- 3 = sour
- 5 = balanced/harmonic
- 7 = sweet
- 9 = very sweet

The **general type of taste** includes characteristics such as

- 1 = bland
- 2 = subtly aromatic
- 3 = aromatic
- 4 = scented
- 5 = bitter
- 6 = off flavor

The **sweetness** and **acidity** could separately be classified into nine categories, with the following range:

- 1 = missing
- 2 = very low
- 3 = low
- 4 = low to medium
- 5 = medium
- 6 = medium to high
- 7 = high
- 8 = high to very high
- 9 = very high

4.2.2.3 Stone characteristics

The stones were eased from the fruit flesh after the test for fruit flesh firmness. Afterwards they were cleaned with a paper towel as neat as possible and placed in the position on the tray, where their fruits lay before.

Seen from **lateral view** the stone can be shaped rounded (1), pointed (2) or egg-shaped (3).

Table 19: Lateral stone shape can be round, pointed or egg-shaped (after SZALATNAY, 2006; pictures private)

Rounded = 1	Pointed = 2	Egg-shaped = 3
		

From **ventral view**, the stone can be shaped narrow elliptic (1), broad elliptic (2) or rounded (3).

Table 20:The ventral view on the stone can show a narrow elliptic, broad elliptic or rounded shape (after SZALATNAY, 2006; pictures private)

Narrow elliptic = 1	Broad elliptic = 2	Rounded = 3
		

Finally, the **tip of the stone** can be classified as missing, straight or hooked.

Table 21: The stone tip of sweet cherries can be missing, straight or hooked (after SZALATNAY, 2006; pictures private)

Missing = 1	Straight = 2	Hooked = 3
		

4.3 Cultivar photographs

Two photographs were taken per cultivar: a first with fruits and a leaf, afterwards a picture of the stones. They are supposed to show the average qualitative characteristics of a cultivar from as many as possible angles. The camera adjustments were manually set on an aperture of 7.1 and an exposition of $\frac{1}{50}$ s.

For the first photograph, six fruits and one leaf per cultivar were selected. The leaf and fruits should not be damaged or show symptoms of disease. They should reflect the average phenotype of the cultivar.

For the pictures a white sheet of paper with a black and white scale on it is put into a sheet protector and duct taped to the photograph station.

The six cherries are shown from six different angles: pistil side (1), stalk side (2), seam side (3), lateral side (4), open cherry from the seam side (5) and open cherry from the lateral side (6). Additionally, a drop of juicy (7) is placed in the middle of the arrangement. The leaf (8) is placed flat on the pad with the upper surface facing up.

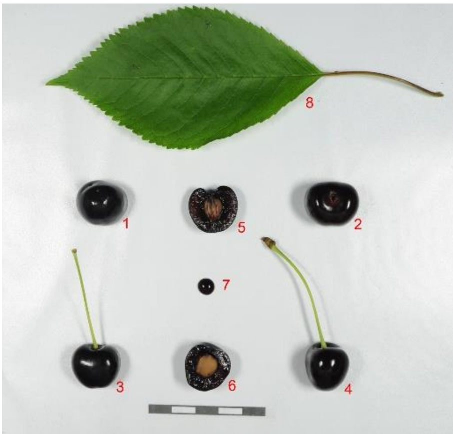


Figure 11: Example picture of a cultivar photograph showing different angles of the cherry (modified after SZALATAY, 2006;

Figure 12: Example picture of the stone photograph, showing the stones from different angles (picture private)

The six stones are shown from similar angles as the fruits: lateral view (1), seam side (2), back side (3), stalk side (4) and pistil side (5).

5. Results and discussion – vegetative parameter

5.1 Mapping

During the dates of June 26th, July 3rd and July 10th 75 trees were taken into the catalogue for being interesting. However, samples were only taken from 30 trees; one tree (S20) was sampled three times. The reasons for this reduced numbers were low fruit load, unripeness, over ripeness or strong disease symptoms on the fruits. Some trees were special cases: K3 is a tree with different grafts and therefore could not be evaluated considering growth from, tree top shape, etc. S20 is a relatively young tree of 'Germersdorfer Riesenkirsche' and R3 is a tree of 'Große Schwarze Knorpelkirsche'. Both trees have been described in the literature many times.

Figure 13: Aerial picture of an alley planted with sweet cherry trees (picture private)

The example picture (figure 13) shows an alley close to a commercial sweet cherry planting. The trees found here were generally older than 80 years and in mediocre condition.

5.2 Tree evaluation

5.2.1 Tree age

As aforementioned, tree age had to be estimated in many cases. Only trees with an age higher than 40 years were taken into the catalogue. The only exception is K1, a seedling in Kronberg, which was interesting for its fruit characteristics. For 9 cases, no age is in the dataset. The remaining 21 trees' ages are as follows:

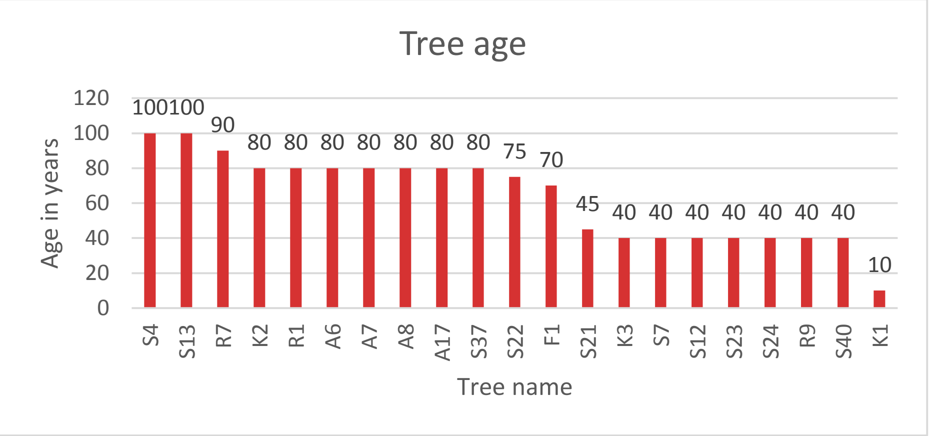


Figure 14: Age of the sampled trees, n=21

5.2.2 Trunk circumference

Trunk circumference was measured in 25 of the 30 samples. It was not measured in case of the trunk not being accessible (stinging-nettles, too high). The following graph shows, that more than 50% of the trees had a trunk circumference higher than 151 cm and therefore categorized as medium. Three trees (F1, S22, S13) had a big circumference with more than 201 cm. No single tree showed a very big circumference. A general correlation between tree age and circumference is visible.

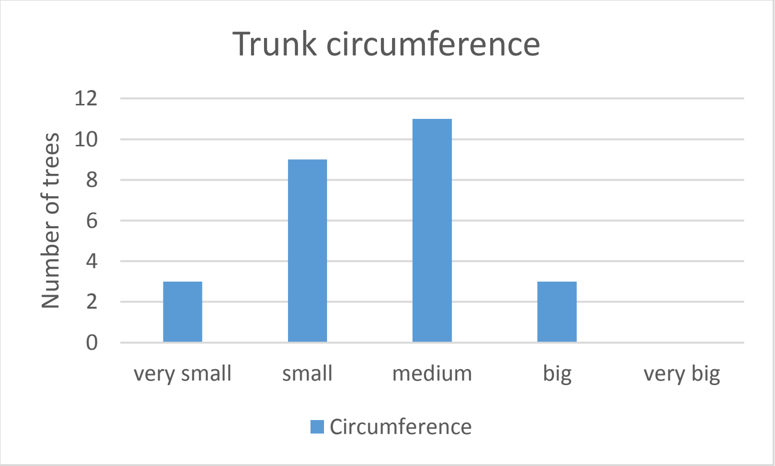


Figure 15: Trunk circumference of the sampled trees; <100cm = small, 101-150cm = small, 151-200cm = medium, 201-250cm = big, >250cm = very big ; n=25

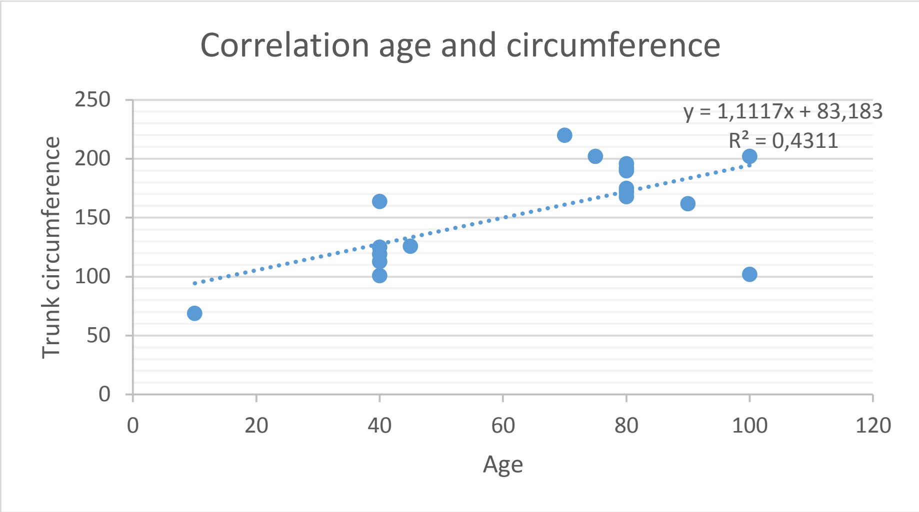


Figure 16: Correlation of tree age and circumference displayed in a scatter plot, n=17

5.2.3 Trunk height

The height of the trunk could be measured on 25 tree. The difference of five trees was for the same reasons as for trunk circumference. 80% of the trees had a trunk higher than 1.5 m. Tree A17, a tree belonging to the morphogenetic group of Rainkirsche had the highest trunk with circa 4 m. The branches of this tree could only be reached to cut a fruit sample due to the fact that it grows on a slope.

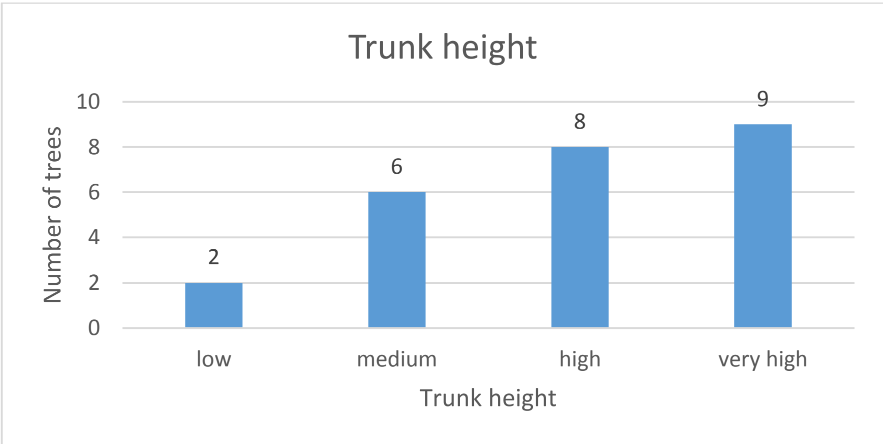


Figure 17: Trunk height of the sampled trees, ranging from low to very high; n=25

5.2.4 Tree top shape

27 trees could be rated on their tree top shape. In some cases, the tree top was so damaged or wrongly cut, that abstract thinking was not enough to estimate the original tree top shape. For these cases, no value could be taken.

With 37%, the high pyramidal tree top shape had by far the biggest share of all the shapes, followed by pyramidal and columnar shape with each just under 15%. Flat pyramidal, reverse pyramidal and flat spherical each only appeared once, whereas no single tree with an umbrella-shaped tree top was found in Scharten.

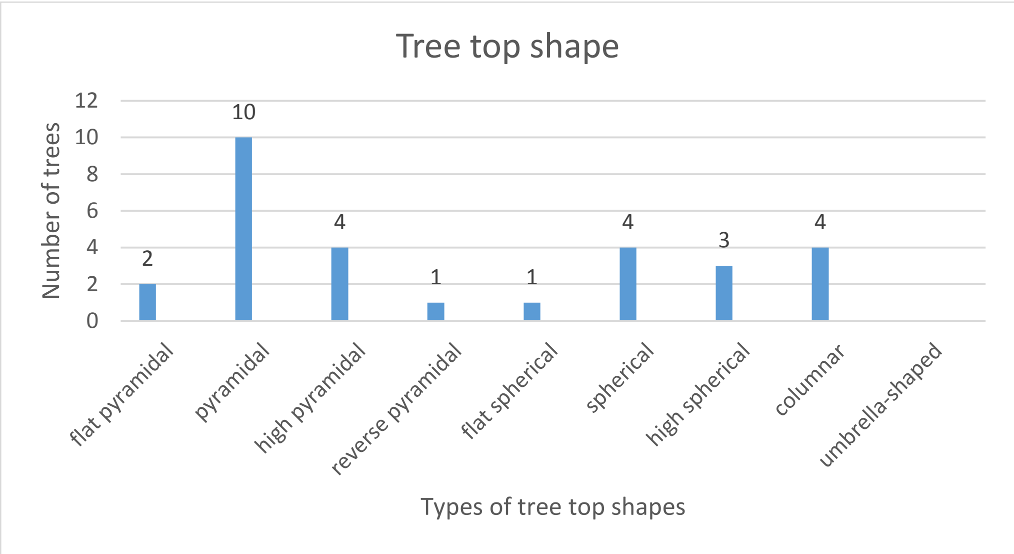


Figure 18: Tree top shapes found in the sampled trees, n=29

5.2.5 Growth form

The most common growth form throughout the sampled trees was a semi-drooping growth form with 41%, followed by a spreading form with 37%. Drooping or semi-upright growth form were less common with 15% and 7% respectively. This difference can either be due to varietal characteristics or tree age. With higher age and longer branches, the weight of the fruits and branches itself can pull down the branches physically.

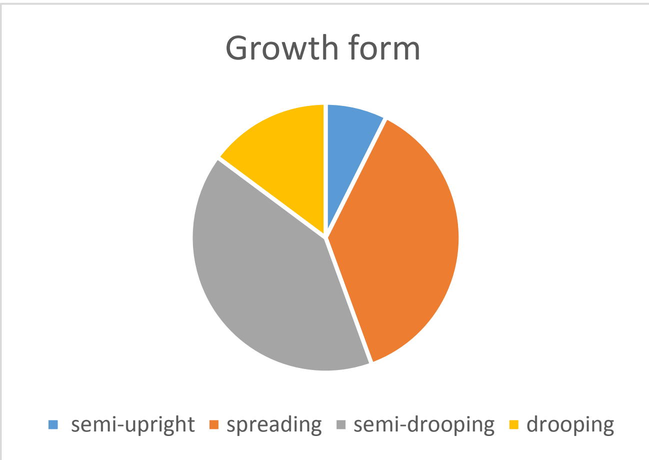


Figure 19: Growth forms of the sampled trees, n=29

Additionally, the correlation of tree age and growth form was examined. For this, fewer samples were used (n=20), since not for all of the above used samples' age was given. Some values were the same for several trees and overlap in the graph. The graph's trendline shows an incline and can be read as older trees usually having more drooping growth forms.

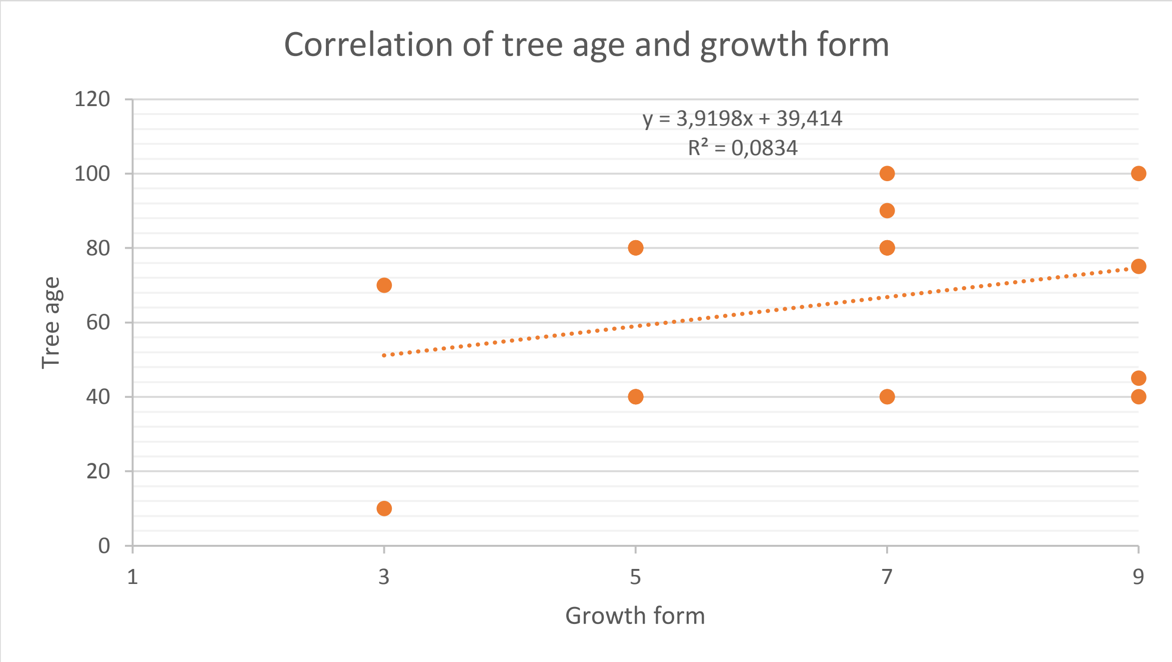


Figure 20: Scatter plot diagram of the correlation of age and growth form in the sampled trees, n=20

5.2.6 Fruit load

27 trees were examined on their fruit load. The most common fruit load was a medium one, with almost half of all trees falling into this category (48%). Also, many trees showed a high fruit load (37%), fewer a low fruit load (11%). Only one tree (S39) showed a very high fruit load.

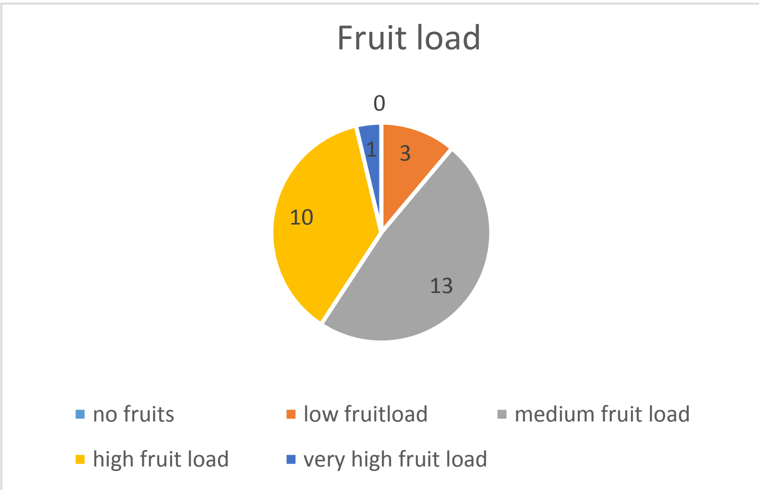


Figure 21: Fruit load evaluation of the sampled trees, n=30

5.2.7 Vitality

From all 24 trees which were evaluated for their vitality, none was in as bad a shape as dying off. This was most probably due to our selection methods. With 46% almost half of the trees showed a medium vitality. Another 42% of the trees had low vitality. The remaining 12% were trees with high vitality.

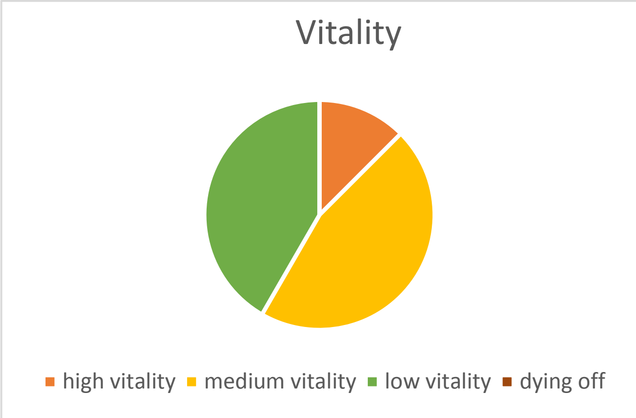


Figure 22: Diagramm of the vitality of the sampled trees, n=24

Looking at the correlation between vitality and age of the trees it is quite obvious, that vitality decreases with increasing age of the tree.

Vitality does not necessarily have an effect on fruit load; higher fruit load can also appear on trees with low vitality and vice versa.

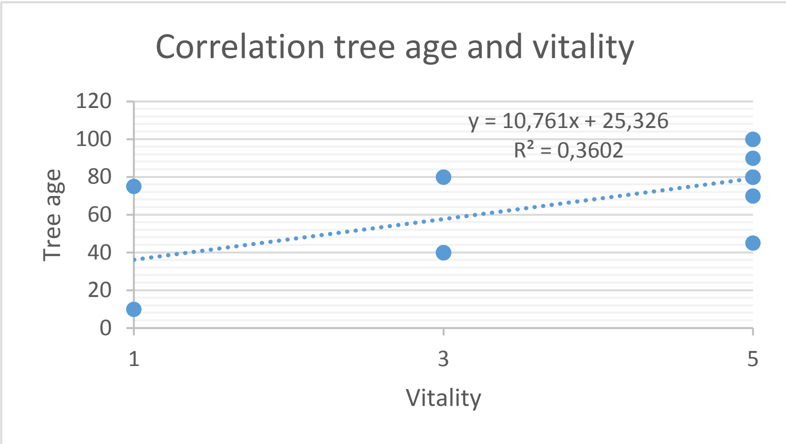


Figure 23: Correlation of tree age and vitality, n =20

5.2.8 Graft position

The graft was only visible in 14 cases. In many of the other trees grafting is very probable, because the trees are or were used intentionally for fruit production. Some trees however are also seedlings: K1, A17 and S39. Most of the found graftings were located on the tree top base, followed by the stem base. A considerable amount of trees was categorized as grafted, even if it was not possible to determine the graft position. This categorization was made by

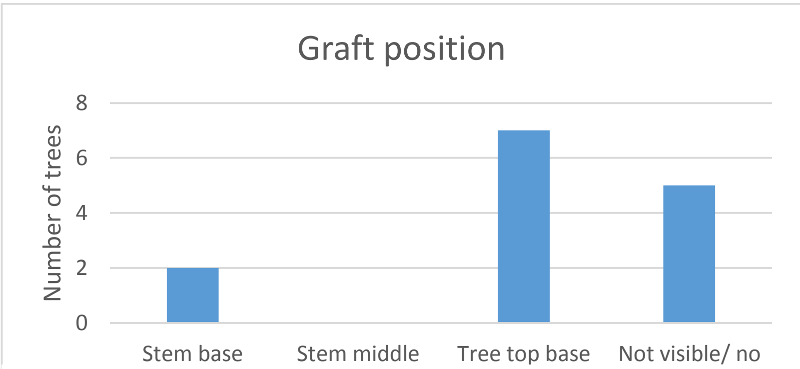


Figure 24: Distribution of the graft position, n=14

appearance of the tree and/or information of the owner.

5.2.9 Dead wood

Five of the 30 sampled trees were not evaluated on dead wood. With 19 cases, more than half of the trees displayed none or only few dead wood in their tree top. The only tree which had lost half of its tree top was S4, a “Rainkirsche” tree of high age. No more severe case than this was found in the samples. Altogether, the trees used for this work were in a good condition, considering dead wood percentage.

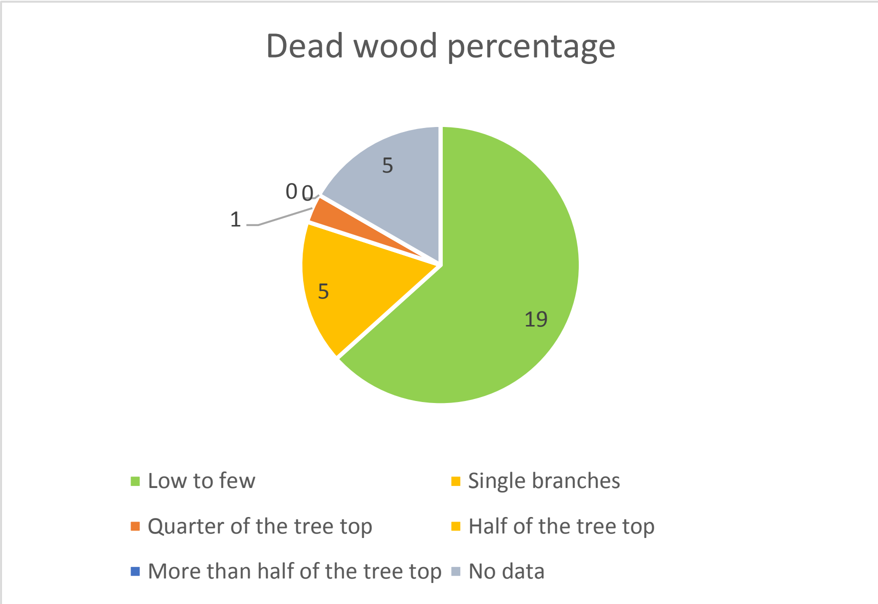


Figure 25: Dead wood percentage, n=30

5.2.10 Shot hole disease

From the 30 sampled trees, 20 were evaluated on the occurrence of shot hole disease. In the other ten cases the tree top was too high so conduct an examination. Another ten samples showed no symptoms of shot hole disease. The remaining ten trees showed mild symptoms in five, medium in 3 and strong

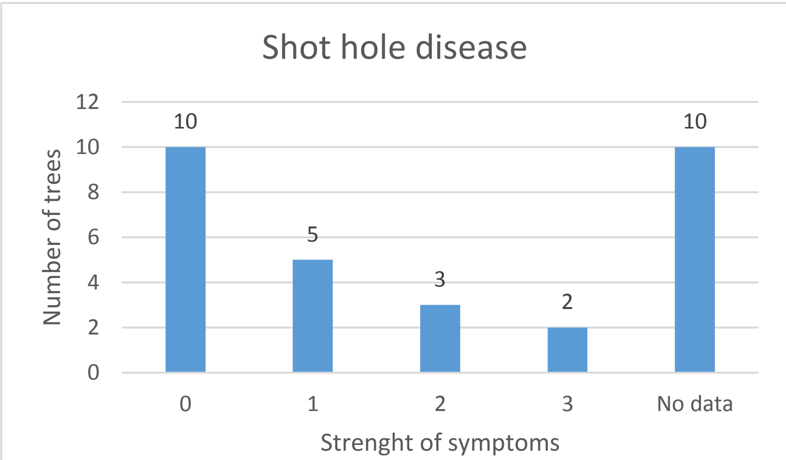


Figure 26: Shot hole disease strength in the sampled trees with 0=no symptoms, 1=mild symptoms, 2=medium symptoms, 3=strong symptoms; n=30

symptoms in 2 cases. Generally, shot hole disease occurred only in mild form on the leaves of the sampled trees. No fruit symptoms were observed.

Figure 27: Shot hole disease lesions on a leaf of S39, which was classified as having strong symptoms (private picture)

6. Results and discussion - generative parameter

6. 1 Qualitative characteristics

The qualitative characteristics were tested on clusters with the statistics program PASW 18.0 In the hierarchic cluster analysis with the method “linkage between the groups” the samples were tested on their similarities according to parameters like fruit shape, skin color, white veining, etc. The F1 sample does not appear in the clustering, since it could not fully be categorized during the evaluation. This circumstance was caused by a very small fruit number of this sample. The number of eleven clusters was preselected to mirror the found varieties. The resulting clusters can be found in two tables (Table 25 and 26).

It is important to mention, that the results seem to be biased by the subjective evaluations during the tasting. This led to an unsatisfying cluster performance (Table 25). In a second try the parameters most prone to bias were not used: taste type sweet/sour, taste type, sweetness, acidity and stone ease. In the second group, clusters of “Rainkirsche” and “Pfelzer (LB)” are developing (Table 26).

To simplify the overview of the clusters, the results of the second clustering were formed into a table listing up the single clusters (Table 27). It can be seen, that all samples of “Rainkirsche” belong to cluster 2 and 3, “Pfelzer (LB)” samples were mostly in cluster 7 with only one exception in cluster 5. Surprisingly, many of the ‘Große Germersdorfer’ samples were clustered with ‘Große Prinzessinkirsche’ and “Sämling von Büttners (AB)”. The latter two were categorized as similar in skin, flesh and juice color. ‘Große Germersdorfer’ on the other hand showed different colors of all tissues. The main similarity might be in the shape of fruits or stones. The irregular fruits of “Unregelmäßige (AB)” fulfill their name and do not belong to the same cluster. Another interesting finding is, that the samples of S23 and S24, both identified as ‘Alfa’ variety, do not belong to the same cluster.

The resulting clusters were then presented with a dendrogram (Figure 14). In a dendrogram, similar varieties are positioned close together, whilst varieties with big differences lie more far apart. Groups of similarity are connected with lines. The dendrogram fuses the subgroups over several steps to higher superorders. The dendrogram shows the already mentioned clusters, which were additionally highlighted (red boxes). The uppermost box shows the clusters of “Pfelzer (LB)” samples, which are in a higher level super-grouped (orange boxes) with ‘Hedelfinger’ samples. The clustered “Rainkirsche” samples can be seen in the middle; they were super-grouped with one ‘Alfa’ sample and the black seedling “Schwarzer Sämling (AB)”. The lowermost highlighted clustering is the one consisting of ‘Große Germersdorfer’ and ‘Große Prinzessinkirsche’.

Table 22: Cluster analysis of all samples with all parameters (fruit shape, skin color, stalk side shape, width, inclinaton and depth, pistil side shape, pistil size, position and location, seam, seam to pistil, shape seen from above, stone parameters)

Clusters, 1st try

Case	Cluster
1:Sämling von Büttners (AB)	1
2:Schartener Rainkirsche	2
3:Große Prinzessinkirsche	3
4:Schartener Rainkirsche	2
5:Beta	4
6:Germersdorfer	5
7:Germersdorfer	3
8:Unregelmäßige (AB)	4
9:Germersdorfer	4
10:Alfa	2
11:Alfa	6
12:Schartener Rainkirsche	2
13:Große Schwarze Knorpelkirsche	2
14:Pfelzer (LB)	4
15:Schartener Rainkirsche	2
16:Hedelfinger	7
17:Pfelzer (LB)	8
18:Prinzessinkirsche	3
19:Große Germersdorfer	3
20:Große Germersdorfer	3
21:Kaiser Franz	9
22:Schartener Rainkirsche	7
23:Pfelzer (LB)	5
24:Unregemäßige (AB)	10
25:Schwarzer Sämling (AB)	11
26:Pfelzer	4
27:Große Germersdorfer	1
28:Pfelzer (LB)	4
29:Hedelfinger	4
30:Dreieckiger Sämling (AB)	8
31:Hedelfinger	5

Table 23: Cluster analysis of all samples with selected parameters to avoid subjective bias

(without taste type sweet/sour, taste type, sweetness, acidity and stone ease)

Clusters, 2nd try

Case	Cluster
1:Sämling von Büttners (AB)	1
2:Schartener Rainkirsche	2
3:Große Prinzessinkirsche	1
4:Schartener Rainkirsche	3
5:Beta	4
6:Germersdorfer	5
7:Germersdorfer	1
8:Unregelmäßige (AB)	4
9:Germersdorfer	4
10:Alfa	3
11:Alfa	6
12:Schartener Rainkirsche	3
13:Große Schwarze Knorpelkirsche	5
14:Pfelzer (LB)	7
15:Schartener Rainkirsche	3
16:Hedelfinger	8
17:Pfelzer (LB)	7
18:Prinzessinkirsche	1
19:Große Germersdorfer	1
20:Große Germersdorfer	1
21:Kaiser Franz	9
22:Schartener Rainkirsche	2
23:Pfelzer (LB)	5
24:Unregemäßige (AB)	10
25:Schwarzer Sämling (AB)	11
26:Pfelzer	7
27:Große Germersdorfer	1
28:Pfelzer (LB)	7
29:Hedelfinger	7
30:Dreieckiger Sämling (AB)	7
31:Hedelfinger	5

Table 24: Simplified display of the second clustering from table 23

Tree Code	Variety	Cluster
K1	“Sämling von Büttners (AB)”	1
K3	‘Große Prinzessinkirsche’	1
S20_1	‘Große Germersdorfer’	1
S13	‘Große Prinzessinkirsche ‘	1
S20_2	‘Große Germersdorfer	1
S26	‘Große Germersdorfer’	1
S20_3	‘Große Germersdorfer’	1
K2	‘Rainkirsche’	2
A6	‘Rainkirsche’	2
S4	‘Rainkirsche’	3
S23	‘Alfa’	3
R1	‘Rainkirsche’	3
R7	‘Rainkirsche’	3
S7	‘Beta’	4
S21	‘Unregelmäßige (AB)’	4
S22	‘Große Germersdorfer’	4
S12	‘Große Germersdorfer’	5
R3	‘Große Schwarze Knorpelkirsche’	5
A7	“Pfelzer (LB)”	5
S40	‘Hedelfinger’	5
S24	‘Alfa’	6
R4	“Pfelzer (LB)”	7
S5	“Pfelzer (LB)”	7
S2	“Pfelzer (LB)”	7
S37	“Pfelzer (LB)”	7
S38	‘Hedelfinger’	7
S39	“Dreieckiger Sämling (AB)”	7
R9	‘Hedelfinger’	8
S29	‘Kaiser Franz’	9
A8	“Unregelmäßige (AB)”	10
A17	“Schwarzer Sämling (AB)”	11

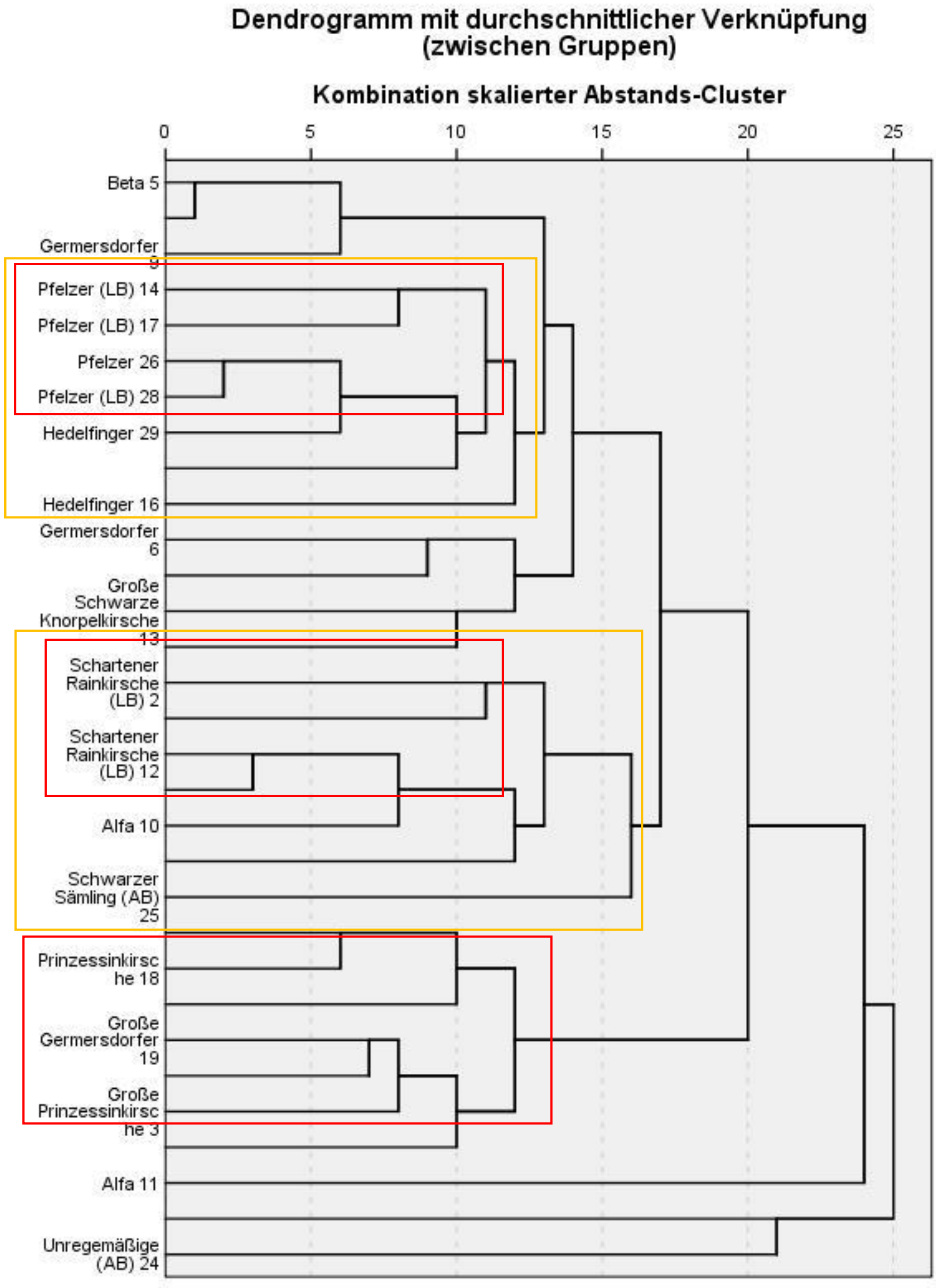


Figure 28: Hierarchic cluster analysis of quantitative fruit characteristics with the method linkage between the groups, displayed via dendrogram

6.2 Qualitative outer characteristics

6.2.1 Fruit shape

With 14 samples, a kidney shape was definitely the most common fruit shape in the sampled material. All of the „Rainkirsche“ were labeled kidney-shaped, as well as S7 ‘Beta’, S23 ‘Alfa’ and some of the “Pfelzer (LB)” samples. No single fruit was classified as flat-spherical, possibly due to a close resemblance to the kidney shape. Four cherry samples were categorized as spherical in fruit shape. An oval fruit shape was found in six of the samples, mostly in “Pfelzer (LB)”, ‘Hedelfinger’ and the S13 ‘Große Prinzessinkirsche’.

The only sample which could not be classified, was F1 “Unregelmäßige (AB)”. Only few fruits were obtained from this tree, and the fruits showed great inhomogeneity.

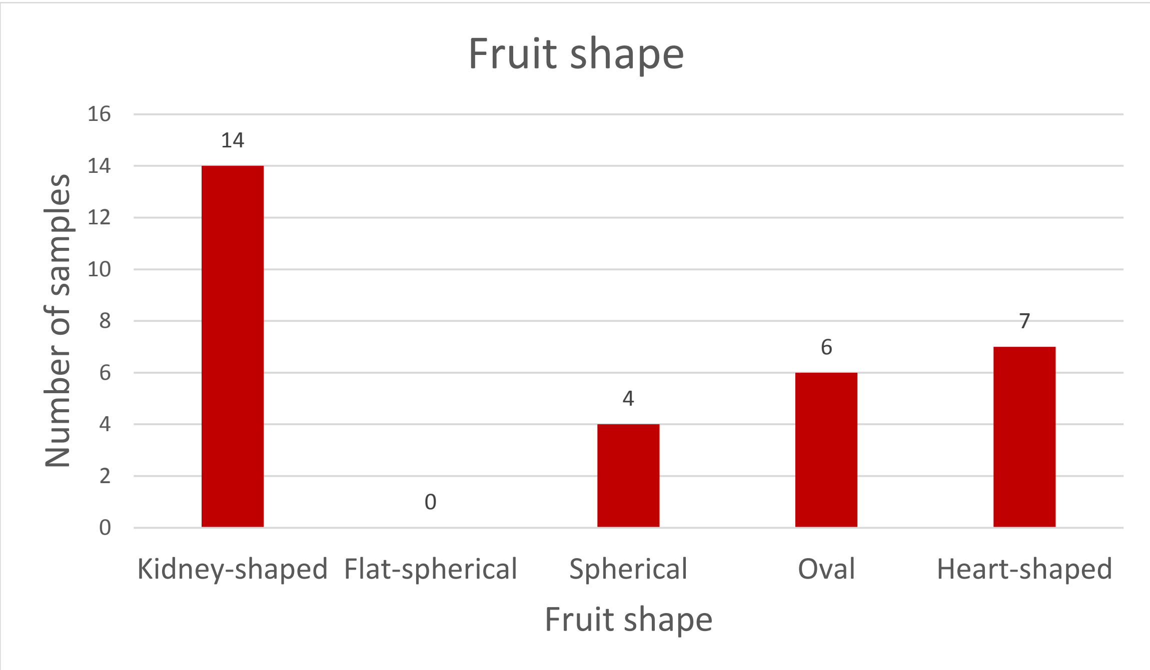


Figure 29: Display of the found fruit shapes in the samples, n=32

6.2.2 Fruit shape index

An univariate ANOVA analysis of the fruit shape index shows that about two thirds of all samples have a flat fruit shape. Especially ‘Große Schwarze Knorpelkirsche’ has a very flat shape with a FSI <0.8. The most oblong shaped sample was ‘Große Germersdorfer’ from the first harvest date (26.6.2013).

All samples of “Rainkirsche“ show a flat fruit shape. On the other hand, fruits of “Pfelzer (LB)”, ‘Hedelfinger’ and ‘Große Germersdorfer’ showed inhomogeneous fruit shapes, which may be due to the harvest date, location differences or simply a genotypically big variety in fruit shape.

It is interesting to see, that S20 shows an oblong shape at the first harvest date, then develops into a more flat fruit shape, with the last harvest bringing in the flattest samples. This is probably due to the fact, that cell elongation in the ripening of cherry fruits starts later than cell division. In the ripening progress, the fruits therefore tend to get broader i.e. flatter (WHITING, 2007).

Table 25: Univariate ANOVA analysis of the fruit shape index (FSI), n=320

Classification	Fruit number	Fruit variety	Average FSI value	Subgroup
< 1 flat	R3	Große Schwarze Knorpelkirsche	0.79	**a**
	S29	Kaiser Franz	0.86	**ab**
	A6	„Rainkirsche“	0.87	**ab**
	S4	„Rainkirsche“	0.88	**abc**
	S23	Alfa	0.88	**abc**
	K2	„Rainkirsche“	0.89	**bcd**
	S7	Beta	0.89	**bcde**
	S13	Große Prinzessinkirsche	0.90	**bcdef**
	K1	Sämling von Büttners (AB)	0.90	**bcdef**
	R7	„Rainkirsche“	0.90	**bcdef**
	S24	Alfa	0.92	**bcdefg**
	S20 (10.7.2013)	Große Germersdorfer	0.93	**bcdefg**
	K3	Große Prinzessinkirsche	0.93	**bcdefg**
	S37	Pfelzer (LB)	0.94	**bcdefg**
	R9	Hedelfinger	0.94	**bcdefg**
	R1	„Rainkirsche“	0.95	**bcdefg**
	A8	Unregelmäßige (AB)	0.95	**bcdefg**
	S21	Unregelmäßige (AB)	0.96	**bcdefg**
	S12	Große Germersdorfer	0.96	**bcdefg**
	S22	Große Germersdorfer	0.96	**bcdefg**
	A7	Pfelzer (LB)	0.98	**bcdefgh**
	S5	Pfelzer (LB)	0.98	**bcdefgh**
1 round	F1	Unregelmäßige (AB)	1.00	**cdefgh**
	S2	Pfelzer (LB)	1.00	**cdefgh**
	S38	Hedelfinger	1.01	**defgh**
	S20 (3.7.2013)	Große Germersdorfer	1.01	**efgh**
>1 oblong	S26	Große Germersdorfer	1.02	**fgh**
	A17	Schwarzer Sämling (AB)	1.03	**fgh**
	R4	Pfelzer (LB)	1.03	**ghi**
	S39	Dreieckiger Sämling (AB)	1.09	**hi**
	S40	Hedelfinger	1.11	**ij**
	S20 (26.6.2013)	Große Germersdorfer	1.15	**j**

6.2.3 Stalk length

The stalk length was analyzed via univariate ANOVA analysis to recognize subgroups. The shortest stalks were measured for ‘Große Schwarze Knorpelkirsche’, which had a very short stalk. Ten of the samples showed medium stalk length, almost two thirds (n=19) long stalks. The longest stalks were measured for the variety Alfa, which both showed stalks longer than 51 mm.

Most samples of ‘Große Germersdorfer’ (S20, S22, S26) fell into the group of medium stalks, the rest was in the group of long stalks. “Rainkirsche“ showed similar groupings, with S4 and R7 having medium stalk length and K2, A6, R1 showing long stalks. “Pfelzer (LB)” showed also in stalk length inhomogeneity. The samples distributed over the group of medium and long, but no grouping was visible. The shortest stalks were measured on S4, the longest on R1. With 32.4 and 46.2 mm length respectively, they show a difference of almost 10 mm. The average stalk length of all samples is 41.97 mm, categorized as long.

Table 26: Univariate ANOVA analysis of the sampled stalk length, n=320

Classification	Tree code	Fruit variety	Average stalk length	Subgroup
< 30 mm: very short	R3	Große Schwarze Knorpelkirsche	29.40	a
31 – 40 mm: medium	A17	Schwarzer Sämling (AB)	32.10	ab
	S4	Schartener Rainkirsche	32.40	ab
	S21	Unregelmäßige (AB)	35.70	bc
	S20 (26.6.2013)	Große Germersdorfer	35.80	bc
	F1	Unregelmäßige (AB)	36.60	bc
	R7	Schartener Rainkirsche	36.60	bc
	R4	Pfelzer (LB)	38.10	bcd
	S20 (10.7.2013)	Große Germersdorfer	39.60	cde
	S22	Große Germersdorfer	40.10	cdef
	S26	Große Germersdorfer	40.20	cdef
41 – 50 mm: long	S13	Große Prinzessinkirsche	40.60	cdef
	S39	Schwarzer Sämling (AB)	40.60	cdef
	S12	Große Germersdorfer	40.80	cdef
	K2	„Rainkirsche“	40.90	cdef
	S38	Hedelfinger	40.90	cdef
	R9	Hedelfinger	41.00	cdef
	S20 (3.7.2013)	Große Germersdorfer	42.30	cdefg
	K3	Große Prinzessinkirsche	42.50	cdefg
	S29	Kaiser Franz	43.50	cdefg
	S5	Pfelzer (LB)	43.60	cdefg
	A6	Schartener Rainkirsche	44.50	defgh

	S40	Hedelfinger	44.70	defgh
	R1	Schartener Rainkirsche	46.20	efghi
	S7	Beta	46.60	efghi
	A8	Unregelmäßige (AB)	47.60	fghi
	A7	Pfelzer (LB)	47.90	fghi
	K1	Sämling von Büttners (AB)	49.10	ghi
	S37	Dreieckiger Sämling (AB)	49.20	ghi
	S2	Pfelzer (LB)	49.60	ghi
>51 mm: very long	S24	Alfa	51.50	hi
	S23	Alfa	52.70	i

A boxplot graphic shows the median, the quartiles and minimum and maximum value of one or several samples. The box represents the medium 50% of the values with a line as median. The upper end lower edge of the box symbolize the boarders to the 1st and 4th quartile. The “whiskers” or antennae show the minimum and maximum value. A circle symbolizes mild outliers and a circle extreme outliers.

The boxplot graphic for the stalk length shows some interesting values that could not be seen in an ANOVA analysis. Extreme outliers can be found in the samples of S5, S20_3 and S20_1. This can be interpreted as an inhomogeneous value distribution inside the sample.

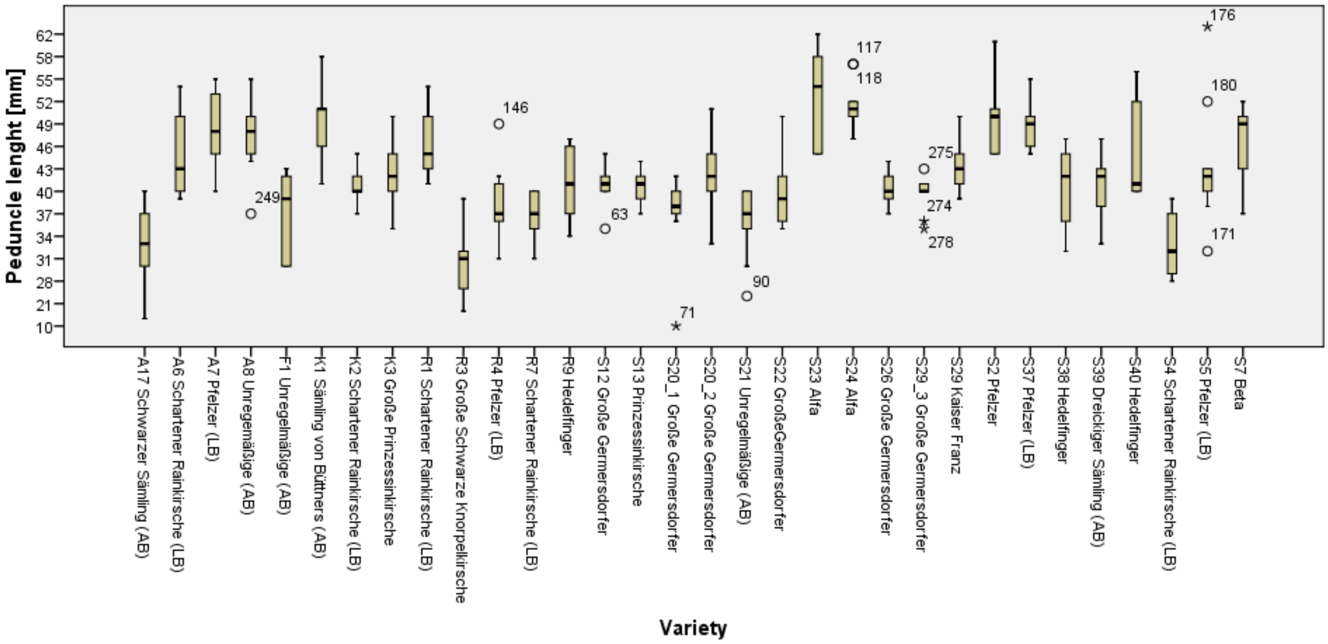


Figure 30: Boxplot display of the sampled stalk length (n=32). Circles stand for mild outliers, stars for extreme outliers

6.2.4 Stalk release force

With 16 samples, half of all samples showed a high stalk release force; 8 samples had a low release force, 6 of the cherry samples showed medium stalk release force and 4 samples showed high release force. The lowest stalk release force was measured in “Schwarzer Sämling (AB)”. With only 252 g this variety is remarkably low under the other cultivars. The highest stalk release force on the other hand was measured on ‘Kaiser Franz’. This sample had the extraordinary release force of 1263 g and would therefore most definitely not be harvestable mechanically.

The grouping of the “Rainkirsche“ is quite explicit; all samples showed a low or medium stalk release force. Therefore, this variety is easily harvestable by shaking like in mechanical harvest.

All samples of “Pfelzer (AB)” had a high to very high stalk release force, ranging from 515 – 917 g. Between these values, all five samples of “Pfelzer (LB)” are distributed evenly. Due to their high release force, mechanical harvest would not be recommended.

Table 27: Univariate ANOVA analysis of the sampled stalk release force, n=320

Classification	Tree code	Variety	Average value stalk release force [g]	Subgroup
< 400 g: low	A17	Schwarzer Sämling (AB)	252.8	a
	K3	Große Prinzessinkirsche	277.27	ab
	S4	„Rainkirsche“	341.49	abc
	R7	„Rainkirsche“	353.72	abc
	R1	„Rainkirsche“	353.72	abc
	S24	Alfa	379.21	abc
	A8	Unregelmäßige (AB)	388.38	abcd
401 – 500g: medium	A6	„Rainkirsche“	402.65	abcd
	S39	Dreieckiger Sämling (AB)	431.19	abcde
	K2	„Rainkirsche“	435.27	abcde
	S23	Alfa	435.27	abcde
	S40	Hedelfinger	494.39	abcdef
501 – 600g: high	A7	Pfelzer (LB)	514.78	abcdefg
	S7	Beta	550.46	bcdefg
	R3	Große Schwarze Knorpelkirsche	593.27	cdefg
	K1	Sämling von Büttners (AB)	595.31	cdefg
> 601g: very high	S21	Unregelmäßige (AB)	622.83	cdefg
	F1	Unregelmäßige (AB)	632.01	cdefg
	S22	Große Germersdorfer	667.69	defgh
	R4	Pfelzer (LB)	671.76	defgh
	S2	Pfelzer (LB)	692.15	efgh
	S26	Große Germersdorfer	701.32	efghi

	S38	Hedelfinger	704.38	efghi
	S12	Große Germersdorfer	750.26	fghi
	S20_3	Große Germersdorfer	781.86	fghi
	S13	Große Prinzessinkirsche	797.15	ghi
	S37	Pfelzer (LB)	797.15	ghi
	R9	Hedelfinger	800.2	ghi
	S20_1	Große Germersdorfer	801.22	ghi
	S5	Pfelzer (LB)	917.43	hi
	S20_2	Große Germersdorfer	970.44	i
	S29	Kaiser Franz	126.99	j

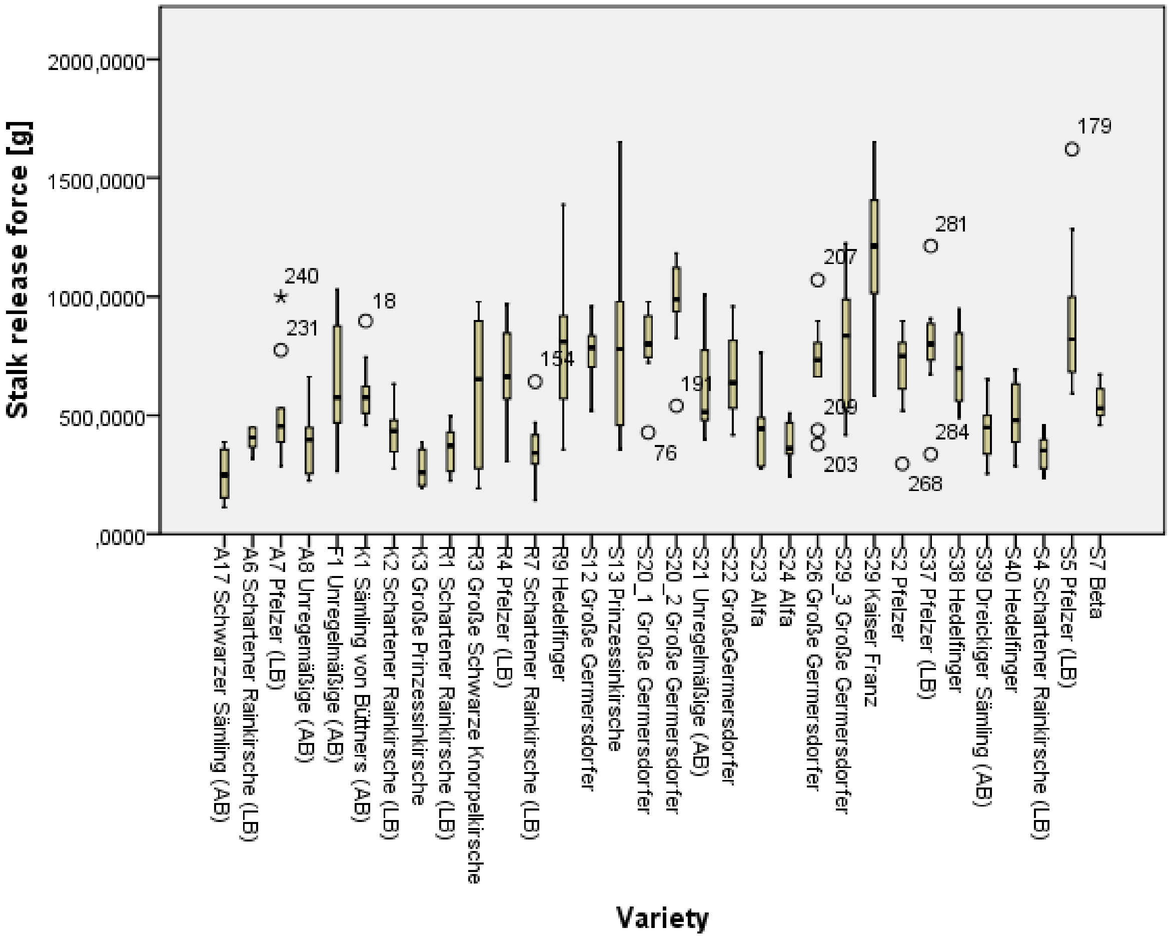


Figure 31: Boxplot display of the sampled stalk release force (n=32)

6.2.5 Fruit weight

The sampled cherry trees did not bring forth very lightweight fruits; varietal average fruit weight was never below 4 g. Six samples however had a low fruit weight, four of these „Rainkirsche“. The fifth of the „Rainkirsche“ was only scarcely in the next higher class. This variety can therefore be categorized as generally small. The class of medium weight cherries contains eleven of the samples, roughly one third. This group includes three of five “Pfelzer (LB)” and two of three “Unregelmäßige (AB)”. Nine samples were categorized as high weight fruits and the lasting six samples belong to the class of fruits with very high weight. This last group consists only samples of the varieties ‘Hedelfinger’ and ‘Große Germersdorfer’. These varieties can therefore be said to have fruits of high and very high weight.

The boxplot graphic of the fruit weight values shows, that the R9 sample of ‘Hedelfinger’ had one extreme outlying value. Otherwise the variance in this sample is small. The greatest variance can be seen in the sample of S13 ‘Große Prinzessinkirsche’.

The three samples of S20 ‘Große Germersdorfer’ show an increase of fruit weight during the three harvest dates from 7.36 g to 8,79 g to 9,29 g. This equates an increase of fruit weight of 19,4% between 1st and 2nd, of 5,7% between 2nd and 3rd and of 26.3% between 1st and 3rd harvest date.

Table 28: Univariate ANOVA analysis of the sampled fruit weight, n=320

Classification	Tree code	Variety	Average value fruit weight [g]	Subgroup
4 – 4,9g: lightweight	S39	Dreieckiger Sämling (AB)	4.16	a
	S4	„Rainkirsche“	4.31	ab
	R1	„Rainkirsche“	4.50	abc
	R7	„Rainkirsche“	4.58	abc
	A6	„Rainkirsche“	4.62	abc
	F1	Unregelmäßige (AB)	4.79	abc
5 – 6,4g: medium	K2	„Rainkirsche“	5.02	bcd
	K1	Sämling von Büttners (AB)	5.08	bcd
	K3	Große Prinzessinkirsche	5.31	cd
	A8	Unregelmäßige (AB)	5.68	de
	A7	Pfelzer (LB)	6.11	ef
	R4	Pfelzer (LB)	6.11	ef
	S21	Unregelmäßige (AB)	6.14	ef
	A17	Schwarzer Sämling (AB)	6.27	fg
	S24	Alfa	6.30	fg
	S2	Pfelzer (LB)	6.38	fg
	S22	Große Germersdorfer	6.49	fgh
6,5 – 7,9g: heavy	S23	Alfa	6.59	fghi
	S13	Große Prinzessinkirsche	6.87	fghij

	S7	Beta	6.99	fghij
	S37	Pfelzer (LB)	7.08	ghij
	S38	Hedelfinger	7.28	hij
	S20_1	Große Germersdorfer	7.36	ij
	R3	Große Schwarze Knorpelkirsche	7.42	j
	S5	Pfelzer (LB)	7.50	j
	S29	Kaiser Franz	7.62	j
>8g: very heavy	S12	Große Germersdorfer	8.31	k
	S40	Hedelfinger	8.33	k
	R9	Hedelfinger	8.36	k
	S26	Große Germersdorfer	8.54	k
	S20_2	Große Germersdorfer	8.79	kl
	S20_3	Große Germersdorfer	9.29	l

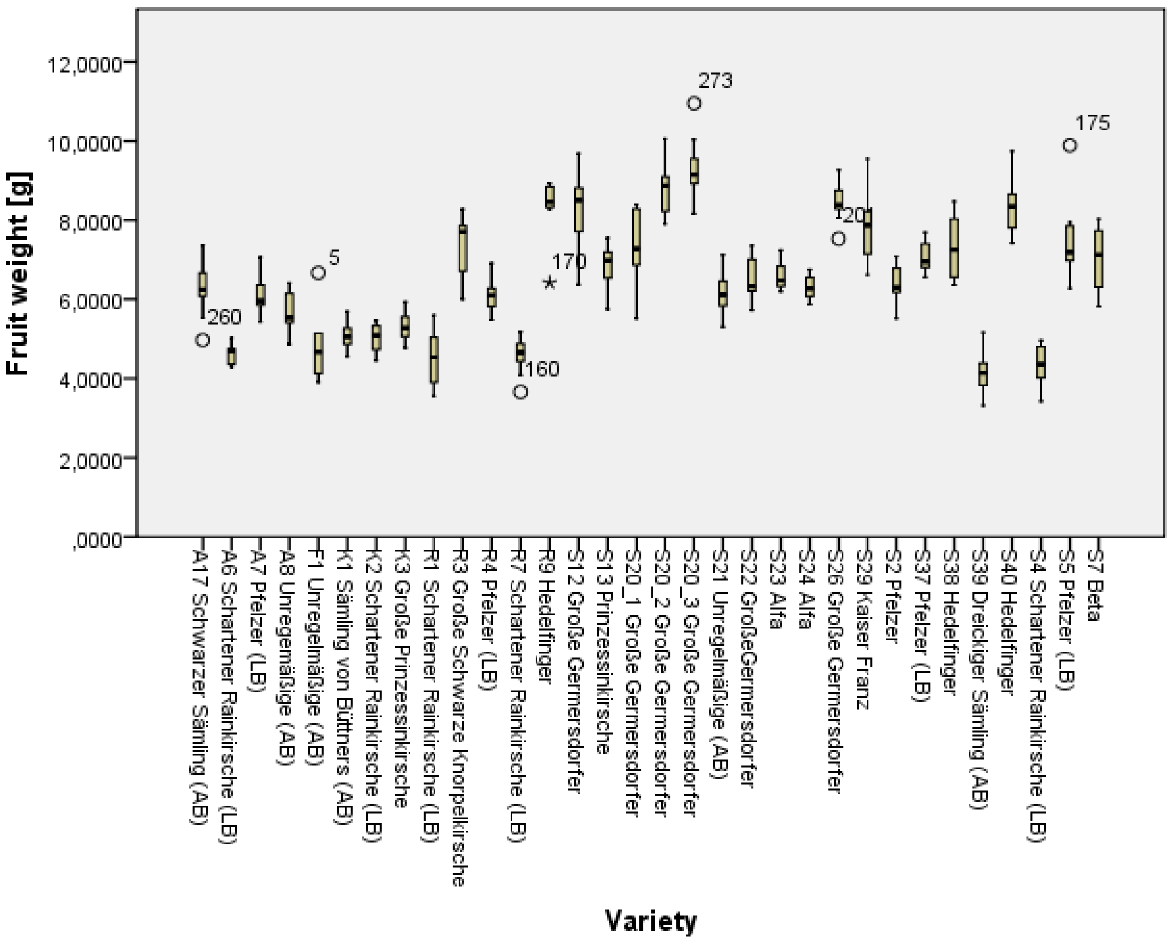


Figure 32: Boxplot display of the sampled fruit weight, n=320

6.2.6 Fruit flesh firmness (FFF)

Only one sample, S39, showed a soft fruit flesh. With 12 samples, 37.5% of the samples were classified as medium firm. With 19 samples and almost 60% of all samples, the firm fleshed cherries make the biggest share. The highest FFF was measured in S20_2 of the variety 'Große Germersdorfer' with a value of 2425 g. There is no obvious explanation, why the FFF of this sample shows so much higher values compared to earlier and later harvested fruits of the same tree.

All three sample of the tree S20 are classified as firm fleshed. Therefore the FFF can be estimated as independent of the harvest date for this variety.

The samples of "Rainkirsche“ were altogether in the category of medium fruit flesh firmness, ranging from 642 – 858 g. These samples show only small deviations from the average and to each other. This variety hence has a promising character for processed products like jams and cakes, but is less suitable for transportation.

All "Pfelzer (LB)" and almost all of the 'Große Germersdorfer' samples have a firm fruit flesh. These fruits have a good transportability.

Table 29: Univariate ANOVA analysis of the fruit flesh firmness (FFF) [g], n=320

Classification	Tree code	Variety	Average value FFF [g]	Subgroup
< 500 g: soft	S39	Dreieckiger Sämling (AB)	497.45	a
501 – 1000 g: medium	A8	Unregelmäßige (AB)	592.25	ab
	S24	Alfa	628.95	ab
	R1	„Rainkirsche“	642.20	ab
	A17	Schwarzer Sämling (AB)	679.92	abc
	S4	„Rainkirsche“	710.50	abc
	S23	Alfa	723.75	abcd
	K3	Große Prinzessinkirsche	793.07	abcde
	A6	„Rainkirsche“	805.30	abcde
	S40	Hedelfinger	851.17	bcdef
	K2	„Rainkirsche“	858.31	bcdef
	F1	Unregelmäßige (AB)	917.43	bcdefg
	S22	Große Germersdorfer	939.86	bcdefgh
> 1001 g	S21	Unregelmäßige (AB)	1013.25	cdefgh
	S38	Hedelfinger	1014.27	cdefgh
	K1	Sämling von Büttners (AB)	1066.26	defghi
	S7	Beta	1111.11	efghij
	R7	„Rainkirsche“	1117.23	efghij
	S37	Pfelzer (LB)	1175.33	fghijk
	R3	Große Schwarze Knorpelkirsche	1234.45	ghijk
	S20_3	Große Germersdorfer	1274.21	hijk

	S2	Pfelzer (LB)	1364.93	ijk
	S13	Große Prinzessinkirsche	1433.23	jk
	S29	Kaiser Franz	1435.27	jk
	S12	Große Germersdorfer	1460.75	k
	A7	Pfelzer (LB)	1797.15	l
	S20_1	Große Germersdorfer	1827.73	l
	R9	Hedelfinger	1939.86	lm
	S5	Pfelzer (LB)	2089.70	mn
	S26	Große Germersdorfer	2206.93	no
	R4	Pfelzer (LB)	2271.15	no
	S20_2	Große Germersdorfer	2425.08	o

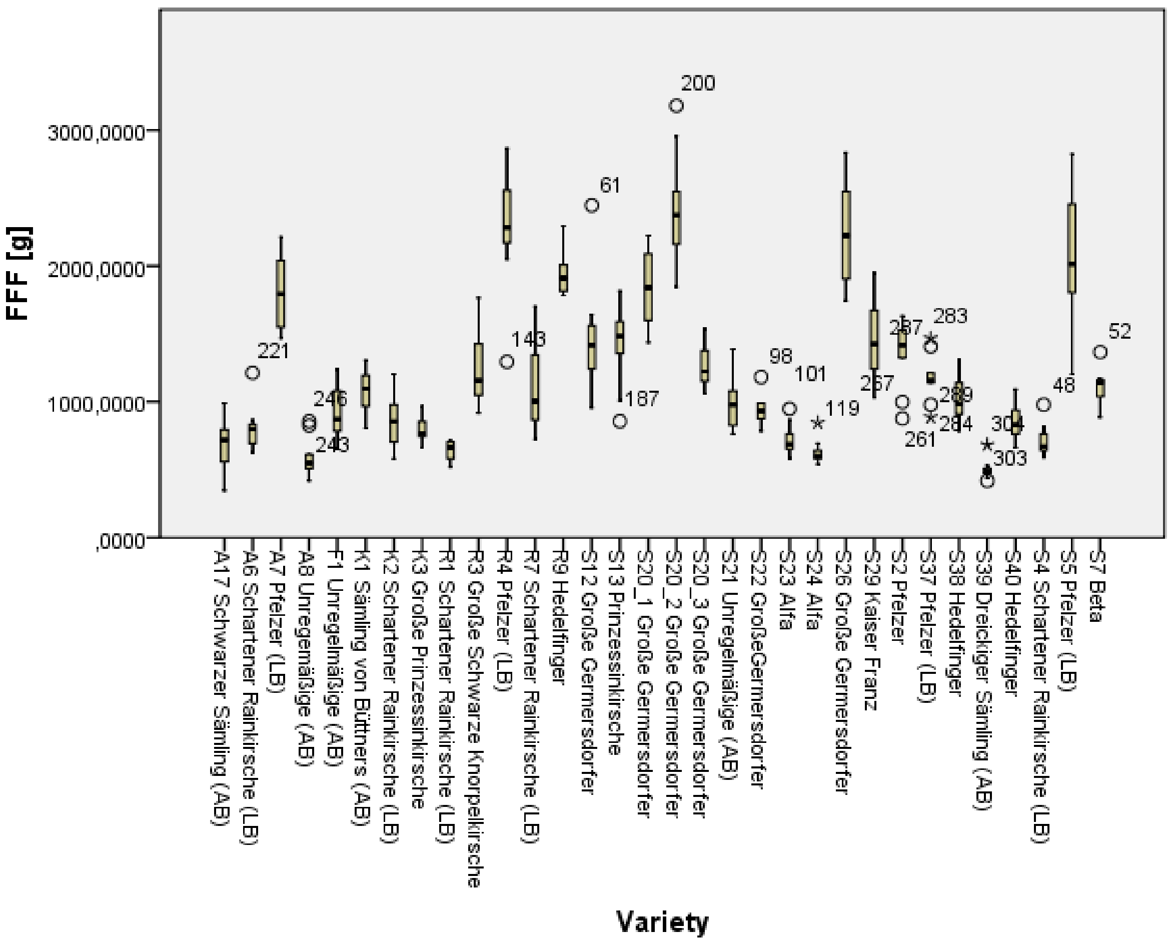


Figure 33: Boxplot display of the sampled fruit flesh firmness (FFF), n=320

6.3 Qualitative Inner parameters

6.3.1 Stone shape index

All of the sampled cherry stones had an elongated shape with a stone shape index >1. The smallest stone shape indices were measured for the variety of „Rainkirsche“. Each of the five samples belongs to the subgroup a, with an index <1.5. To this group belongs also the S29 ‘Kaiser Franz’. The samples of “Pfelzer (LB)” differed significantly in their stone shape index, with values ranging from 1.74 to 1.85. Also the ‘Hedelfinger’ samples showed significant differences; indices were calculated from 1.67 to 2.29. The last value is also the highest calculated index of the samples. Both samples of ‘Große Prinzessinkirsche’ showed very high values with S13 having and stone shape index of 2.07 and K3 of 2.17. The sample K1, which looks quite similar to ‘Große Prinzessinkirsche’ from the outer parameters differs significantly from both S13 and K3 with an index of 1.84.

The S20 sample of ‘Große Germersdorfer’ showed an interesting development considering its stone shape. The earliest (26.6.2013) and the last sample date (10.7.2013) brought forth stone of very similar shape, with indices of 1.84 and 1.85 respectively. The sample of the middle harvest date (3.7.2013) on the other hand showed a significantly different stone shape, with an index of 1.72 and therefore a less elongated shape compared to the other two samples. A reason for this variance is difficult to find, especially, since two of the samples are so similar. The harvest date could have an influence on the stone shape, but after the endocarp hardening, to further shape changes will take place (HARTMANN, 1948; COOMBE, 1976) and only further lignification takes place. All of the samples were collected significantly after endocarp hardening. Finally, the reason might simply be a variance in the genetic expression.

Table 30: Univariate ANOVA analysis of the sampled stone shape index, n=320

Classification	Tree code	Variety	Average value stone shape index	Subgroup
>1 = elongated	R1	„Rainkirsche“	1.43	a
	S4	„Rainkirsche“	1.43	a
	K2	„Rainkirsche“	1.44	ab
	A6	„Rainkirsche“	1.48	abc
	R7	„Rainkirsche“	1.50	abcd
	S29	Kaiser Franz	1.53	abcde
	S24	Alfa	1.57	bcdef
	R3	Große Schwarze Knorpelkirsche	1.58	bcdefg
	A8	Unregelmäßige (AB)	1.60	cdefgh
	S12	Große Germersdorfer	1.61	cdefgh
	A17	Schwarzer Sämling (AB)	1.64	defghi

	S21	Unregelmäßige (AB)	1.65	defghi
	R9	Hedelfinger	1.67	efghij
	S23	Alfa	1.69	efghijk
	S20_2	Große Germersdorfer	1.72	fghijkl
	F1	Unregelmäßige (AB)	1.73	ghijklm
	R4	Pfelzer (LB)	1.74	hijklm
	S22	Große Germersdorfer	1.75	hijklm
	S7	Beta	1.78	ijklm
	S5	Pfelzer (LB)	1.78	ijklm
	S37	Pfelzer (LB)	1.79	ijklm
	S2	Pfelzer (LB)	1.82	jklmn
	S20_1	Große Germersdorfer	1.84	klmn
	K1	Sämling von Büttners (AB)	1.84	klmn
	S20_3	Große Germersdorfer	1.85	klmn
	S38	Hedelfinger	1.85	klmn
	A7	Pfelzer (LB)	1.86	lmn
	S26	Große Germersdorfer	1.89	mn
	S39	Dreieckiger Sämling (AB)	1.95	n
	S13	Große Prinzessinkirsche	2.07	o
	K3	Große Prinzessinkirsche	2.17	p
	S40	Hedelfinger	2.30	q

It was also examined how the stone index and fruit shape index correlate. The null hypothesis was, that the stone index does not influence the fruit shape index. The alternative hypothesis was, that the stone shape index does have an influence on the fruit shape. A scatter plot was used to show the correlation between the two indices. The R^2 of 0,168 implies that the stone shape index indeed does have a certain influence on the fruit shape index. As can be seen in the graph, fruits with high fruit shape index tend to contain stones with a high stone index. This means, that elongated fruit stones were commonly found in oblong shaped fruits, round stones on the other hand were more common in round or kidney-

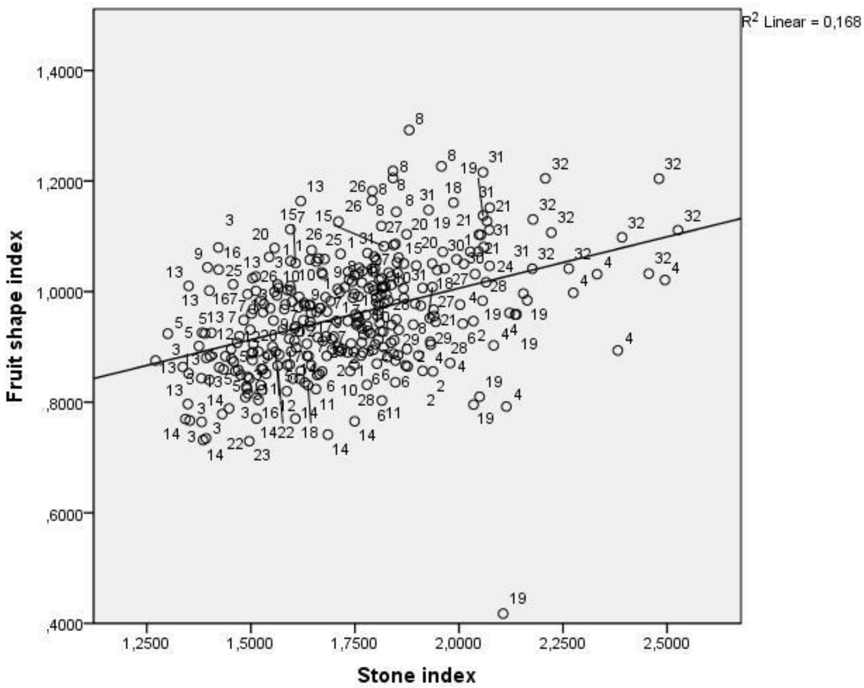


Figure 34: Scatter plot display of the correlation between fruit shape index and stone shape index, n=320

shaped fruits. The S13 sample (graph: 19) produced on outlier point; this fruit had a quite flat fruit shape but contained an elongated stone.

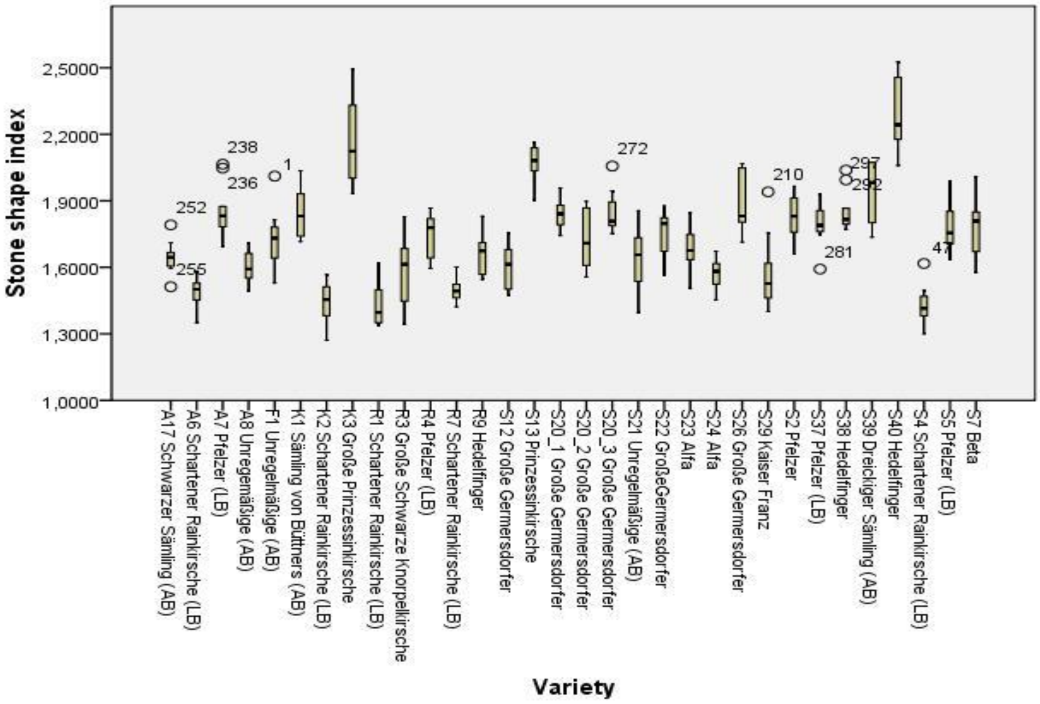


Figure 35: Boxplot display of the sampled stone shape indices, n=320

6.3.2

6.3.2 Stone weight

According to the classification of LEIFER (2002), the stones found in Scharten were all relatively high in weight. A possible explanation could be, that the stones were weighed directly after removing of the fruit flesh. Remaining juice and water inside the stone and on its surface could bias the measurement. On the other hand, the works used for comparison (LEIFER, 2002; PILZ, 2012; SPÖRR, 2013) were all conducted in Burgenland, a region of Austria with significantly less precipitation. Under this climate, smaller stones and fruits may develop.

The lowest stone weight was measured for S38 'Hedelfinger', with an average value of 0.26 g. S38 therefore is the only sample, which belongs to the category of medium weight stones. The category of heavy stones contains four samples, and 26 samples (81.25%) belong to the group of very heavy stones.

Both samples of 'Große Prinzessinkirsche' and the seedling "Sämling von Büttners (AB)" show similar values, with 0.276 g, 0.294 g and 0.291 g respectively. Their stone weight does not differ significantly.

The samples of “Rainkirsche“ show a variance concerning their stone weight. One sample (R7) belonged to the category of stones of heavy weight, the four others have very heavy stones. Their average weights range from 0.289 (R7) to 0.370 (A6).

As already before, also in stone weight the fruits of S23 ‘Alfa’ and S24 ‘Alfa’ differ from each other. The both belong to the group of heavy stones, but vary significantly concerning the subgrouping.

The “Pfelzer (LB)” samples also show a significant variance of stone weight, ranging from 0.397 g to 0.437 g. All of the five samples’ stones are classified as heavy.

All of the stone samples of ‘Große Germersdorfer’ are classified as very heavy in weight, with weights from 0.401 g to 0.465 g. The stones sampled on the last harvest date (10.7.2013) were more lightweight than the earlier samples (26.6.2013, 3.7.2013). The weight loss between earlier and later harvest dates could be due to water loss in the endocarp tissue. On the other hand, lignification of the pit during the development stage after endocarp hardening leads to a weight gain for peach and plum pits (CALLAHAN, 2009), and may possibly apply also on sweet cherries. Further sampling might give answers to the question if the weight loss during the last ripening stage is only a spontaneous incident or sampling mistake, or if a morphogenetic regulation stands behind it.

The heaviest average stone weight was measured for the sample of S29 ‘Kaiser Franz”, weighing 0.5 g, which is 192% the weight of the most lightweight sample, S38.

Table 31: Univariate ANOVA analysis of the sampled stone weight [g], n=320

Classification	Tree code	Variety	Average value stone weight [g]	Subgroup
0,23 – 0,27= medium	S38	Hedelfinger	0.26	a
0,28 – 0,32= heavy	K3	Große Prinzessinkirsche	0.28	ab
	R7	„Rainkirsche“	0.29	abc
	K1	Sämling von Büttners (AB)	0.29	abc
	S13	Große Prinzessinkirsche	0.29	abc
	S39	Dreieckiger Sämling (AB)	0.33	bcd
>0,33= very heavy	K2	„Rainkirsche“	0.33	cd
	S4	„Rainkirsche“	0.34	cde
	R9	Hedelfinger	0.34	cdef
	R1	„Rainkirsche“	0.35	cdef
	S23	Alfa	0.35	cdef
	S40	Hedelfinger	0.36	defg
	S24	Alfa	0.36	defgh
	A8	Unregelmäßige (AB)	0.36	defgh
	A6	„Rainkirsche“	0.37	defghi
	S7	Beta	0.38	defghij
	S2	Pfelzer (LB)	0.40	efghijk

	S12	Große Germersdorfer	0.40	fghijkl
	F1	Unregelmäßige (AB)	0.40	fghijkl
	A7	Pfelzer (LB)	0.40	fghijkl
	S21	Unregelmäßige (AB)	0.40	fghijkl
	S37	Pfelzer (LB)	0.41	fghijkl
	R3	Große Schwarze Knorpelkirsche	0.41	ghijkl
	S20_3	Große Germersdorfer	0.42	ghijkl
	R4	Pfelzer (LB)	0.43	hijkl
	S26	Große Germersdorfer	0.43	hijkl
	S22	Große Germersdorfer	0.43	ijkl
	S5	Pfelzer (LB)	0.44	jkl
	A17	Schwarzer Sämling (AB)	0.45	kl
	S20_2	Große Germersdorfer	0.46	klm
	S20_1	Große Germersdorfer	0.47	lm
	S29	Kaiser Franz	0.50	m

Also the parameter stone weight was examined on its correlation with fruit weight. It was to be analyzed, if for example a higher stone weight leads to fruits with higher fruit weight. The scatter plot with the stone weight as constant and fruit weight as variable brings forth a regression line and an R² of 0.195. Hence, the stone weight has a general influence on the fruit weight. As can be seen in the scatter plot, fruits with higher stone weight also tend to be of higher fruit weight.

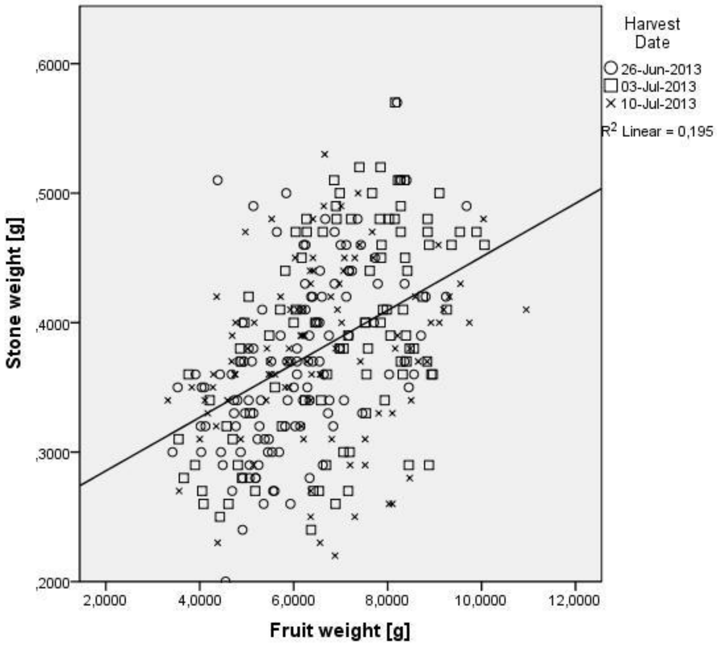


Figure 36: Scatter plot display of the correlation between stone weight [g] and fruit weight [g], n=320

6.3.3 Stone share

The cherry sampled with the lowest average stone share was the S38 sample of 'Hedelfinger', with a share of 3.57%. It was the only sample classified as having a very small stone share. The two other 'Hedelfinger' samples, R9 and S40, were in the next higher class, still having a small stone share. ‘Hedelfinger’ was therefore the variety with the lowest average stone share throughout the sampled cherries.

Fruits of ‘Große Germersdorfer’ were mostly classified as of small stone share (S20, S12, S26). The only exception was S22, in which the average stone share was categorized as high. In S20, the stone share decreased during the ripening period from high to small, showing that stone growth comes to a halt at a certain point, while fruit flesh growth still goes on.

The “Pfelzer (LB)” samples formed into a group (S37, S5, S2, R7) with values ranging from 5.76 to 6.31%, and one outlier (A7) with a stone share of 6,59%. The outlier value could be caused by low vitality and bad condition of tree A7.

The small fruits of ‘Rainkirsche’ were classified into high (K2, R4) and very high (R1, S4, A6) concerning stone share. This decreases their quality as fruit for fresh consumption or processing.

The seedlings A17 “Dreickiger Sämling (AB)” and S39 “Schwarzer Sämling (AB)” were both categorized as having a very high stone share. High stone shares are very common in seedlings. The seedling K2 “Sämling von Büttners (AB)” on the other hand showed only a medium stone share and makes it therefore interesting for further investigation.

The highest value finally was found in the F1 sample of “Unregelmäßige (AB)”. With a stone share of 8.39% it was categorized as extremely high. This tree was found to be of medium vitality, low fruit set and infested with shot hole disease. All of these factors can have negative influence on the fruit development, resulting in high stone shares.

Table 32: Average stone share classification of the sampled cherries, n=32

Classification	Tree code	Variety	Average stone share [%]
< 4%= very small	S38	Hedelfinger	3.57
4.1 - 5 % = small	R9	Hedelfinger	4.12
	S13	Große Prinzessinkirsche	4.28
	S40	Hedelfinger	4.31
	S20_3	Große Germersdorfer	4.53
	S12	Große Germersdorfer	4.83
	S26	Große Germersdorfer	5.00
5.1 - 6% = medium	K3	Große Prinzessinkirsche	5.20
	S20_2	Große Germersdorfer	5.20
	S23	Alfa	5.26
	S7	Beta	5.38
	R3	Große Schwarze Knorpelkirsche	5.57
	K1	"Sämling von Büttners (AB)"	5.73
	S24	Alfa	5.76
	S37	"Pfelzer (LB)"	5.76
	S5	"Pfelzer (LB)"	5.83

6.1 - 7%= high	S2	"Pfelzer (LB)"	6.23
	R7	"Pfelzer (LB)"	6.31
	S20_1	Große Germersdorfer	6.32
	A8	"Unregelmäßige (AB)"	6.40
	S21	"Unregelmäßige (AB)"	6.56
	S29	Kaiser Franz	6.57
	A7	"Pfelzer (LB)"	6.59
	K2	Rainkirsche	6.63
	S22	Große Germersdorfer	6.67
	R4	Rainkirsche	6.98
7.1 - 8% = very high	A17	"Dreickiger Sämling (AB)"	7.12
	R1	Rainkirsche	7.67
	S4	Rainkirsche	7.78
	S39	"Schwarzer Sämling (AB)"	7.89
	A6	Rainkirsche	8.00
> 8.1% = extremely high	F1	"Unregelmäßige (AB)"	8.39

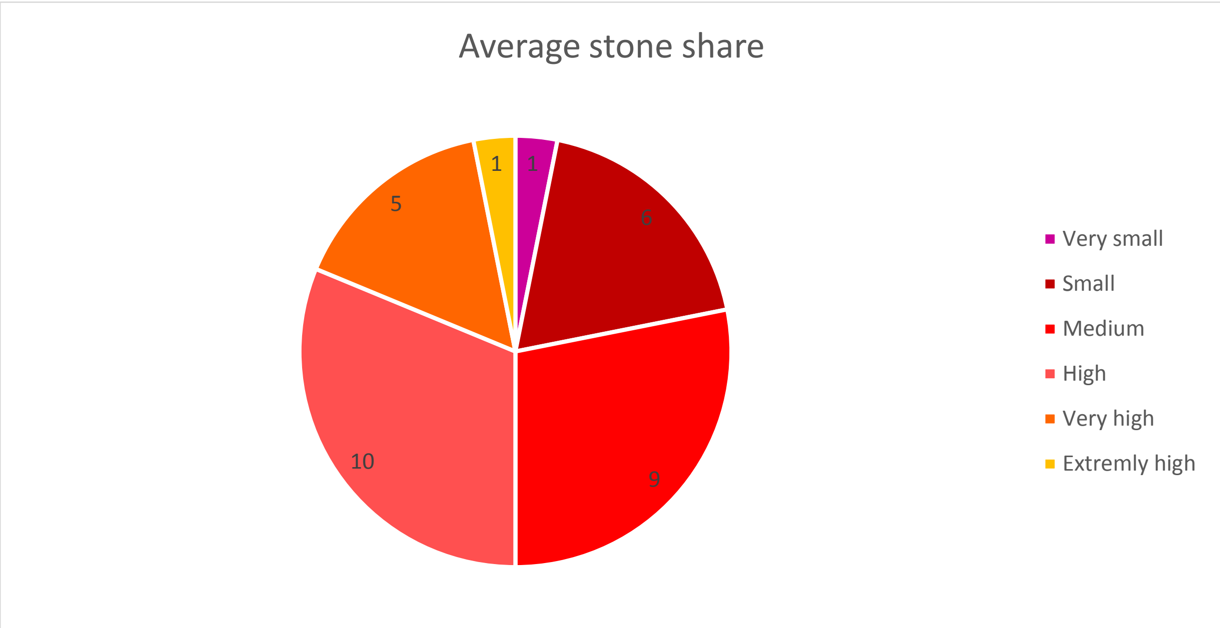


Figure 37: Average stone share of the sampled cherries, n=32

6.3.4 pH

The classification for the pH was used according to the work of SPÖRR (2013). This work was conducted in Burgenland, a part of Austria with warmer climate compared to Upper Austria, where sweet cherries with higher pH and soluble solids content can be produced. This can explain why the samples of this work were mostly categorized as having a low pH.

The highest pH was measured in the S4 sample of “Rainkirsche“ and amounts to 4.01. The lowest value with 3.50 belonged to the R9 sample of ‘Hedelfinger’. 12 samples had a higher pH than the average value of 3.74, the remaining 20 lay below.

The samples of “Rainkirsche“ showed values between 3.73 and 4.01. The average pH of these samples is 3.88, which would still be categorized as strongly sour, but is the cultivar with the highest pH of all samples, “Pfelzer (LB)” samples showed values ranging from 3.66 to 3.94. The average pH of the five samples was calculated as 3.8, which is not too far apart from the pH of the „Rainkirsche“. In the tasting however, “Pfelzer (LB)” cherries were categorized as more sourly, which can be explained by their lower soluble solids content. ‘Große Prinzessinkirsche’ (3.6) and ‘Große Germersdorfer’ (3.7) are both classified as strongly sour.

Table 33: Univariate ANOVA analysis of the sampled pH, n=32

Classification	Tree code	Variety	Average value pH
3,46-3,59 = dominantly sour	R9	Hedelfinger	3.50
	S13	Große Prinzessinkirsche	3.55
	S20_1	Große Germersdorfer	3.55
3,60-3,99 = strongly sour	S20_2	Große Germersdorfer	3.60
	S29	Kaiser Franz	3.62
	A17	Schwarzer Sämling (AB)	3.62
	S38	Hedelfinger	3.63
	K3	Große Prinzessinkirsche	3.64
	S21	Unregelmäßige (AB)	3.64
	S12	Große Germersdorfer	3.65
	S5	Pfelzer (LB)	3.66
	S23	Alfa	3.66
	S22	Große Germersdorfer	3.68
	S7	Beta	3.68
	S24	Alfa	3.69
	S2	Pfelzer (LB)	3.71
	S40	Hedelfinger	3.72
	A6	„Rainkirsche“	3.73
	S26	Große Germersdorfer	3.74
	A8	Unregelmäßige (AB)	3.77
	S20_3	Große Germersdorfer	3.78
	S39	Dreieckiger Sämling (AB)	3.78
	K2	„Rainkirsche“	3.78
	A7	Pfelzer (LB)	3.83
	F1	Unregelmäßige (AB)	3.87
	R4	Pfelzer (LB)	3.90
	K1	Sämling von Büttners (AB)	3.90
	R3	Große Schwarze Knorpelkirsche	3.90
	R1	„Rainkirsche“	3.93
	S37	Pfelzer (LB)	3.94
	R7	„Rainkirsche“	3.95
4,01-4,19 = pleasantly sour	S4	„Rainkirsche“	4.01

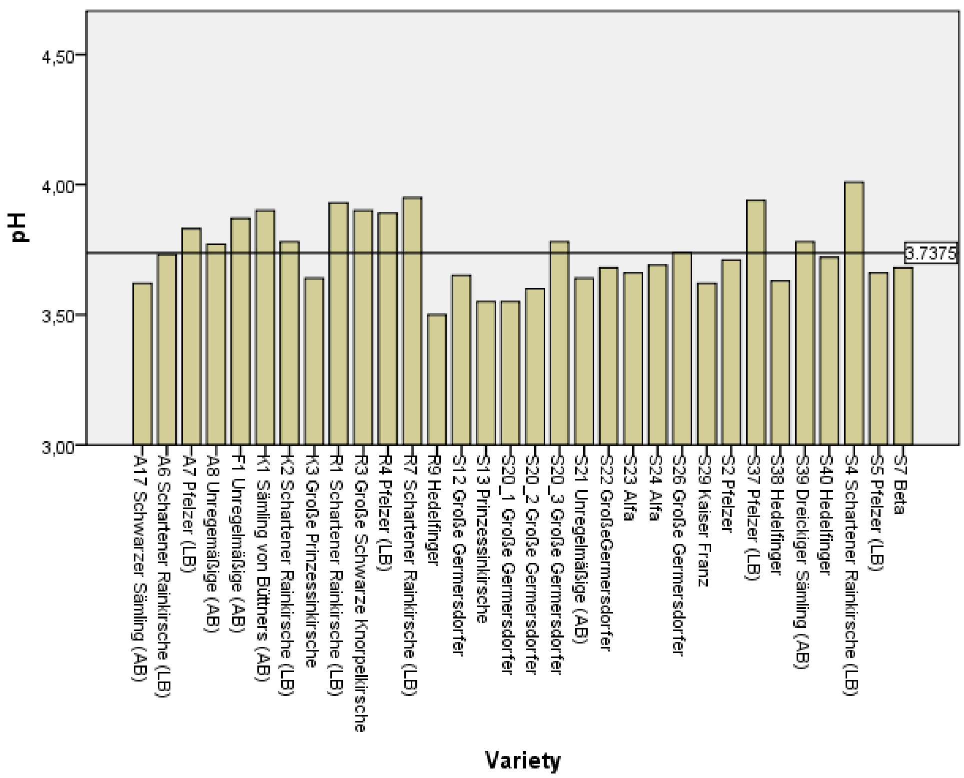


Figure 38: Diagramm of the sampled pH values with line as average value (3.7375), n=32

It was also examined, if the actual pH value of the samples was reflected in the subjectively evaluated acidity of the sample.

The scatter plot however shows, that the categories for subjective acidity can contain samples with very different pH values. The R7 sample for example is categorized as of high acidity, whilst the actual pH with 3.95 is quite high in comparison to the other samples. The same applies for the sample S4 which measured the highest pH of the samples, but was still categorized as medium to high acidity. On the other hand, some samples were categorized as low to medium in acidity, while their pH was relatively low, for example S23. A quite correct subjective categorization was made for R9 'Hedelfinger', which had a pH of 3.5 and was also classified as high in acidity. Possible reasons for these inconsistencies are subjectivity during the tasting, a too small sample size for the pH and for the acidity evaluation

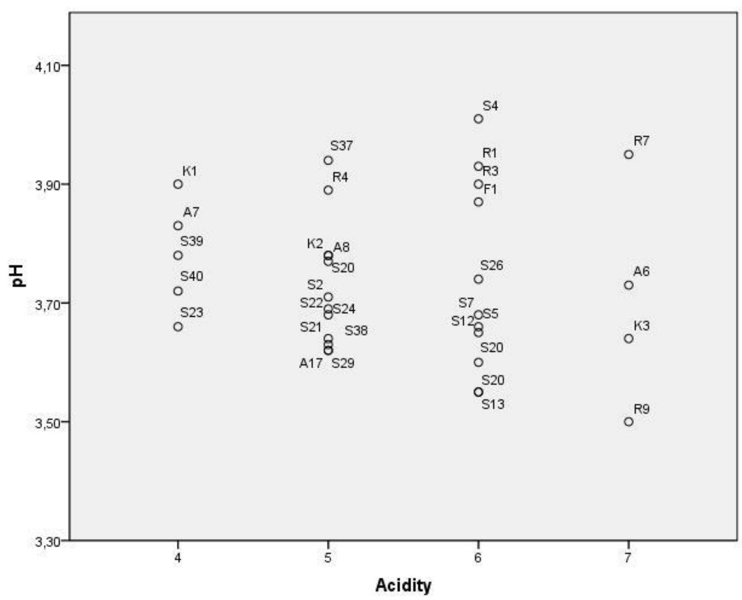


Figure 39 Scatter box diagramm of the correlation between pH and subjective Acidity, n=32

and also the bias due to the sugar content in the fruits. Fruits which are low in sugar, are generally categorized as more sour, compared to fruits with high sugar contents.

Since for the pH only average values were given, an univariate ANOVA analysis was not possible. Instead, a regression curve was worked out. It was to show, if the pH and the soluble solids content [°Brix] had a significant correlation. The soluble solids contents was chosen, as a possible expression of ripeness with the assumption, that a higher SS content generally shows a higher ripeness. The null hypothesis was, that pH and SS content do not show a significant correlation. The alternative hypothesis was, that SS content and pH do show a correlation.

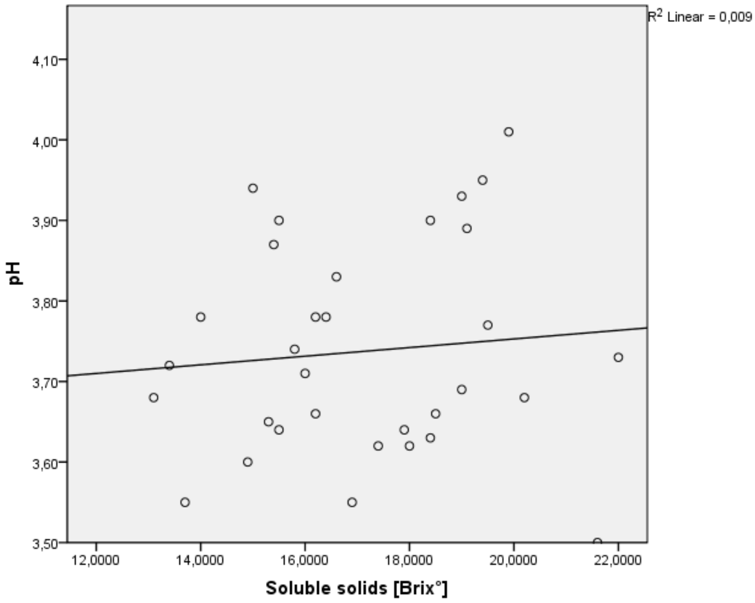


Figure 40: Scatter box diagramm of the correlation between the sampled pH (n=32) and soluble solids content [°Brix] (n=320)

The regression produced an $R^2 = 0.009$. This must be interpreted as high probability that both variables do not have a significant correlation. In a farther interpretation this means, that the pH is not correlating with the content of soluble solids.

It was also examined, if the pH correlates to the malic acid content in the measured cherries. Therefore, a further regression curve was implemented.

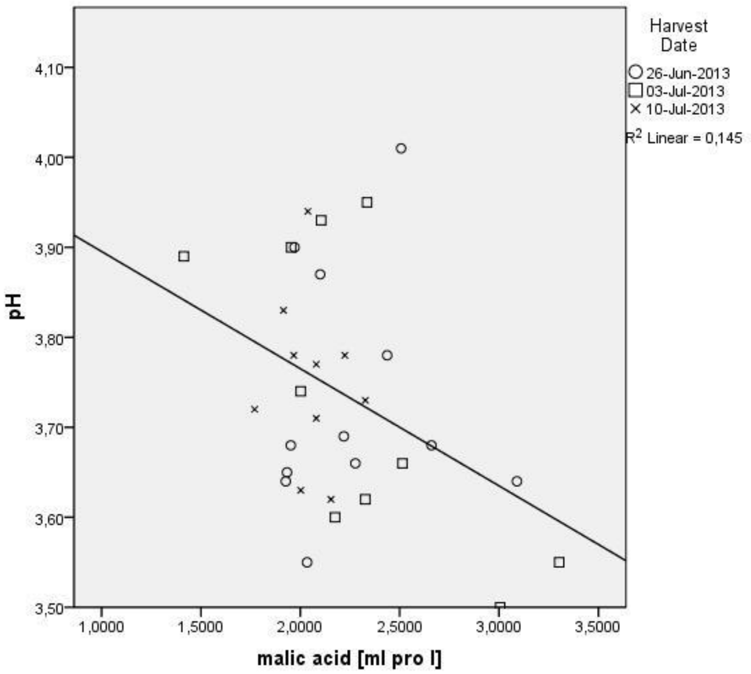


Figure 41: Scatter box diagram of the correlation between malic acid content [mg/l] and the pH (n=32)

The null hypothesis was, that the acid content has no influence on the pH. The alternative hypothesis says that the acid content correlates with the pH.

The resulting regression produces an $R^2 = 0.145$ and thus it can be considered, that the amount of malic acid in the fruit sample has an influence on the pH in the juice.

6.3.5 Soluble solids

Of all 32 samples, six belonged to the category of moderate sweetness, three of them of the variety ‘Große Germersdorfer’. The lowest value is measured for the S22 sample of ‘Große Germersdorfer’. The group of medium sweet cherries only involves three samples, the group of richly sweet five. The biggest share of the samples is located in the class of especially richly sweet cherries, three of them belonging to the variety „Rainkirsche“. The next higher group, intensively richly sweet cherries, contains six samples and the group with values above 19.3° Brix holds three samples. The highest value was measured for the A6 sample of „Rainkirsche“.

The samples of „Rainkirsche“ showed values from 16 to 20° Brix and all belongs with an average of 17,6 of all samples to the category of especially richly sweet cherries.

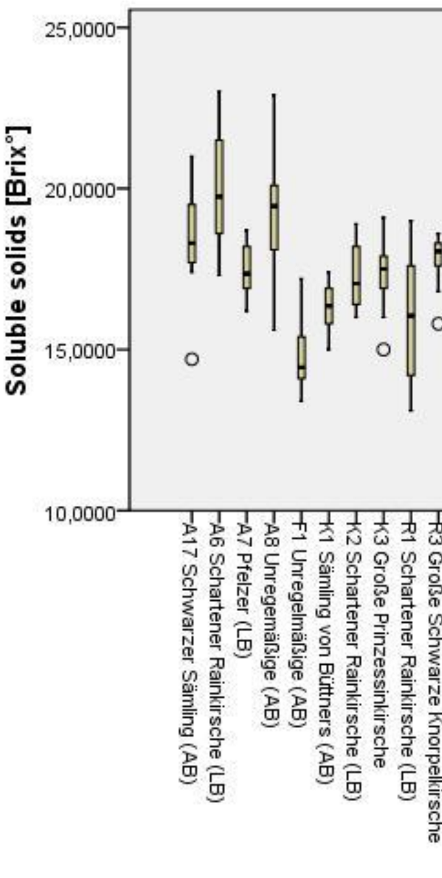
“Pfelzer (LB)” samples displayed soluble solid contents from 15.5 to 19.2 with an average of 17.5. They can be categorized as especially richly sweet

The lowest values were remarked for the samples of ‘Große Germersdorfer’, ranging from 12.8 to 16.5. The average of the ripe samples has a value of 15.2° Brix and is thus categorized as medium sweet.

Table 34: Univariate ANOVA analysis of the sampled soluble solids (SS) content [°Brix], n=320

Classification	Tree code	Variety	Average value SS [°Brix]	Subgroup
< 15: moderate sweetness	S22	Große Germersdorfer	12.80	a
	S20_1	Große Germersdorfer	13.61	ab
	S40	Hedelfinger	14.17	abc
	S39	Dreieckiger Sämling (AB)	14.61	bcd
	S20_2	Große Germersdorfer	14.76	bcd
	F1	Unregelmäßige (AB)	14.97	bcde
15,0 – 15,8; medium sweetness	S26	Große Germersdorfer	15.52	cdef
	S37	Pfelzer (LB)	15.53	cdef
	S21	Unregelmäßige (AB)	15.64	cdef
15,9 – 16,9: rich sweetness	S12	Große Germersdorfer	15.97	cdefgh
	R1	„Rainkirsche“	15.99	cdefg
	K1	Sämling von Büttners (AB)	16.28	defgh
	S20_3	Große Germersdorfer	16.52	defghi
	S2	Pfelzer (LB)	16.76	efghi

17,0 – 17,9: especially rich sweetness	S13	Große Prinzessinkirsche	17.18	fghij
	S4	„Rainkirsche“	17.20	fghij
	K2	„Rainkirsche“	17.25	fghij
	K3	Große Prinzessinkirsche	17.27	fghij
	S29	Kaiser Franz	17.33	fghij
	A7	Pfelzer (LB)	17.43	fghijk
	R7	„Rainkirsche“	17.44	fghijk
	R3	Große Schwarze Knorpelkirsche	17.78	ghijk
	S23	Alfa	17.83	ghijkl
18,0 – 19,2: intensive rich sweetness	S38	Hedelfinger	18.04	hijkl
	A17	Schwarzer Sämling (AB)	18.29	hijklm
	S5	Pfelzer (LB)	18.47	ijklm
	S24	Alfa	18.53	ijklm
	R9	Hedelfinger	19.12	jklm
	R4	Pfelzer (LB)	19.20	jklm
>19,3: extraordinary rich sweetness	A8	Unregelmäßige (AB)	19.38	klm
	S7	Beta	19.71	lm
	A6	„Rainkirsche“	20.05	m



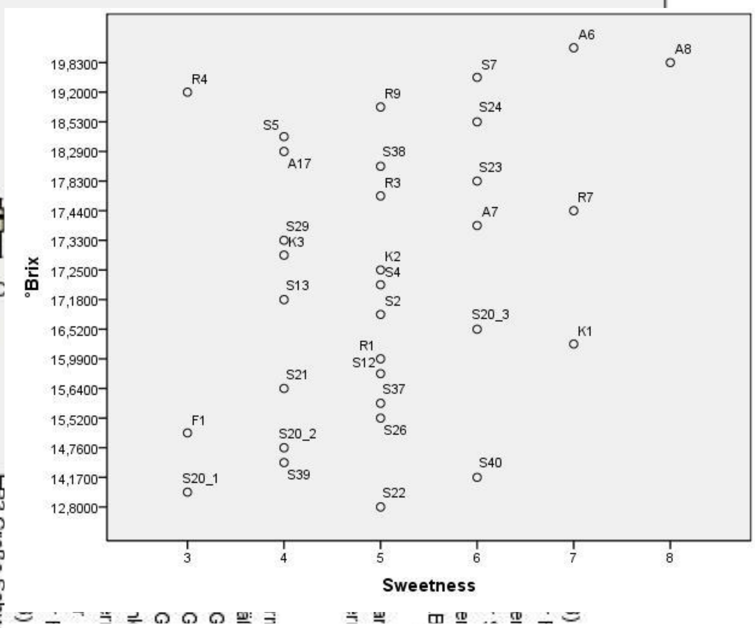


Figure 43: Scatter plot diagram of the correlation between soluble solids content [°Brix] and subjective Sweetness

Figure 42: Boxplot diagram of the sampled soluble solids content [°Brix], n=320

Also for the content of soluble solids, the objective data was compared to the subjective evaluation. A scatter plot of soluble solids [°Brix] and the subjective sweetness was worked out. As can be seen, also here the statistical spread of the values is relatively high, but the most distinct samples show obvious positions in the graph. The highest contents of soluble solids were measured in A6, S7 and A8; these samples were categorized as having an extremely rich sweetness according to their content of soluble solids. But while A8 was also classified as of high to very high sweetness, A6 and S7 were classified as less sweet in the subjective evaluation. The earliest sample of S20 had a low content of soluble solids and was categorized as moderate sweet and its classification was similarly as low sweetness. In spite of S22 having the lowest content of soluble solids, it was categorized as of medium sweetness. This might probably be due to a medium pH value, since low pH values lead to a higher classification according to sweetness from test persons. A curious case was also the sample of R4, which was classified as low in sweetness, but had a relatively high content of soluble solids. Also in this case the pH might have biased the evaluation, but under closer investigation, the pH of this sample turned out as relatively high. A possible explication for this case might be a inhomogeneous sample with fruits of different pH and soluble solids content; possibly for the evaluation only fruits with a low pH and/or low soluble solids content were left.

6.3.6 Antioxidative capacity

The results of the measurement of the antioxidativen capacity show, that the highest values were measured for the R7 sample of „Rainkirsche“. The lowest values were measured for the K2 sample of „Rainkirsche“ and the S5 sample of “Pfelzer (LB)”. They contained only one third of the content of Trolox equivalents compared to R7. A6 showed values similarly high as R7.

Table 35: Anioxidative capacity of the selected samples, n=5

Tree code	Variety	Antioxidative capacity [µmolTE/ml]
K2	“Rainkirsche”	2.24
R7	“Rainkirsche”	6.27
S5	“Pfelzer (LB)”	2.24
A6	“Rainkirsche”	6.22
A17	“Schwarzer Sämling (AB)”	5.78

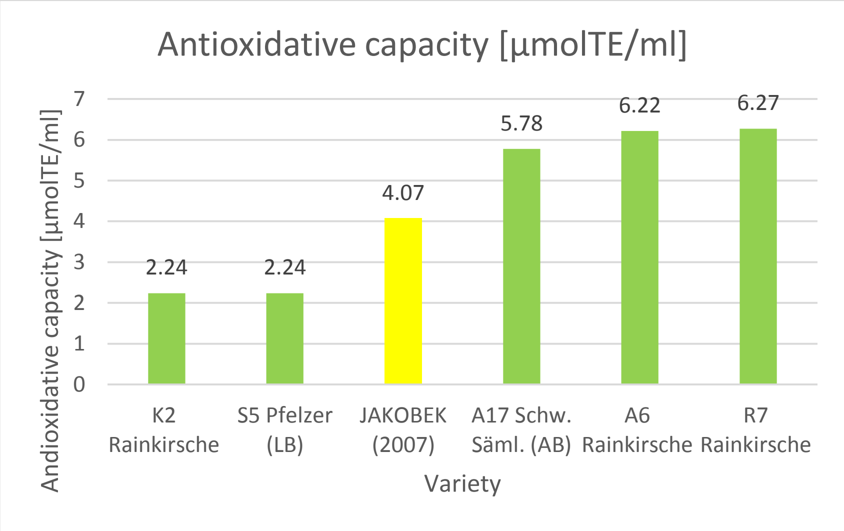


Figure 44: Antioxidative capacity of the selected samples (green) compared to the findings of JAKOBEK (2007)(yellow)

As already mentioned in the methods, the extraction of the measured material was conducted in a very simple way and will not hold all of the possible antioxidants the fruits contained. Therefore, these results can only be compared to studies with similar sample material. JAKOBEK et al. (2007) prepared a juice from Slovenian sweet cherry fruits which was tested on its antioxidative capacity with a DPPH assay similar to the one used in this work. The cherry juice that was tested by JAKOBEK et al. contained 4.07 µmol TE/ml. This value lies in the middle of the results that were measured in this work.

6.3.7 Cyanidin equivalent content

The measured values for cyanidin equivalent content (CEC) in the samples can be seen in table 35.

Table 36: Cyandin equivalent content of the selected samples, n=5

Tree code	Variety	Content of cyanidin equivalent [mg/l]
K2	“Rainkirsche”	567
R7	“Rainkirsche”	1848
S5	“Pfelzer (LB)”	225
A6	“Rainkirsche”	1051
A17	“Schwarzer Sämling (AB)”	1547

The measured content of cyanidin and its equivalents in this work ranged from 225 to 1848 mg/l. The highest content was again measured in the R7 sample of „Rainkirsche“, followed by A17, whose name “Schwarzer Sämling (AB)” already points at its dark fruit flesh and therefore possibly high polyphenol content. S5 of “Pfelzer (LB)” was the sample with the least dark fruit flesh and was thus already estimated to contain less cyandin than the other samples measured. The average polyphenol content of the three samples of “Rainkirsche“ was 1155 mg/l.

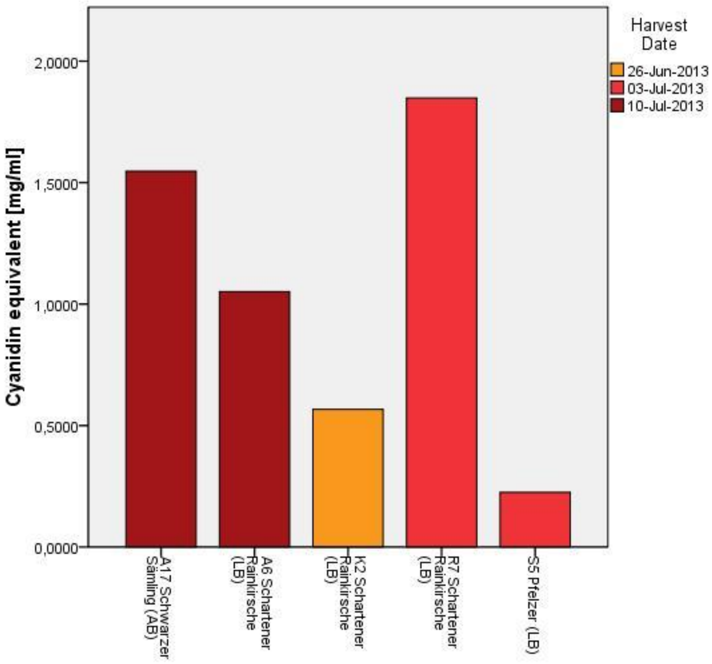


Figure 45: Content of cyanidin equivalents in the samples, n=5

The correlation of the antioxidative capacity and the content of cyanidin equivalent in the samples S5, K2, R7, A6 and A17 was displayed by a scatter plot diagram. It shows, that the samples, which are low in antioxidative capacity are also low in content of cyanidin equivalents. This applies on the S5 “Pfelzer (LB)” as well as on K2 „Rainkirsche“. The samples of R7, A6 and A17 on the other hand are high in antioxidative capacity and content of cyanidin equivalents. The $R^2 = 0.778$ of the regression shows that antioxidative capacity and cyanidin equivalent content correlated strongly in the sampled juices. This is matching with the results of LAPIDOT et al. (1999), who found a strong correlation of antioxidants and phenolics content in red wine.

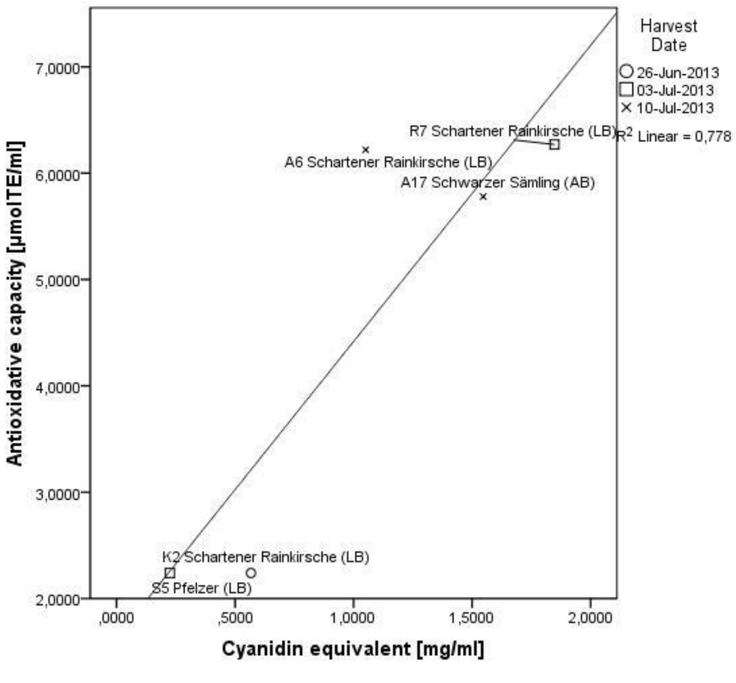


Figure 46: Scatter plot diagram of the correlation between the antioxidative capacity and the cyanidin equivalent content of the selected samples, n=5

It was proven, that the pH of a medium can have an influence on the anthocyanin content and breakdown in a solution (LAPIDOT, 1999; LEE, 2005). The closer the pH of a medium is to 1, the more stable anthocyanins are. With rising pH, the anthocyanins irreversibly change into a colorless hemiketal form (LEE, 2005). The correlation of pH and cyanidin equivalent content was examined in the work of LEE (2005). Similar to these findings, in CHAOVANALIKIT's work (2003), cherries varieties with lower pH had significantly higher contents of Trolox equivalents. The sweet cherry variety "Rainier", with a pH of 4.11, had only one fifth the TE content in the edible part compared to the variety "Montmorency", in which a pH of 3.52 was measured. Since only five samples were measured in this work on their CEC, it is hard to make a statement about the influence of the pH. Also factors like harvest date and ripeness, storage and processing method may have influenced the outcomes of the measurement. The highest CEC was found in R7, together with a relatively high pH. On the other hand, the second highest CEC, in A17, was paired with a significantly lower pH.

Table 37: Comparison of the samples that were measured on CEC

Tree code	pH	Malic acid content [g/l]	Cyandin equivalent content [mg/l]	Antioxidative capacity [µmolTE/ml]
K2	3.78	3.64	567	2.24
R7	3.95	3.48	1848	6.27
S5	3.66	3.75	225	2.24
A6	3.73	3.47	1051	6.22
A17	3.62	3.21	1547	5.78

JAKOBEK et al. (2007) examined their cherry juice on the anthocyanin content, but by HPLC analysis. JAKOBEK et. al measured a value of 256.60 ± 2.5 mg/l. This value is clearly smaller than most of the measured values of this work.

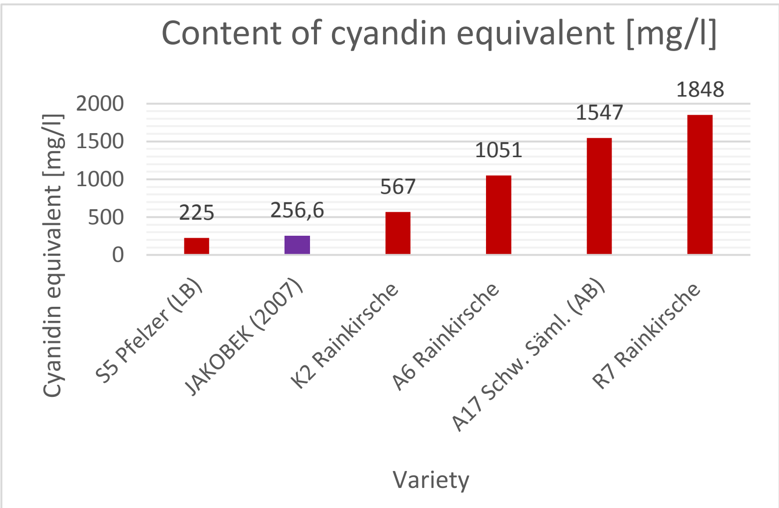


Figure 47: Cyanidin equivalent content of the selected samples (red) compared to the findings of JAKOBEK (2007)(purple)

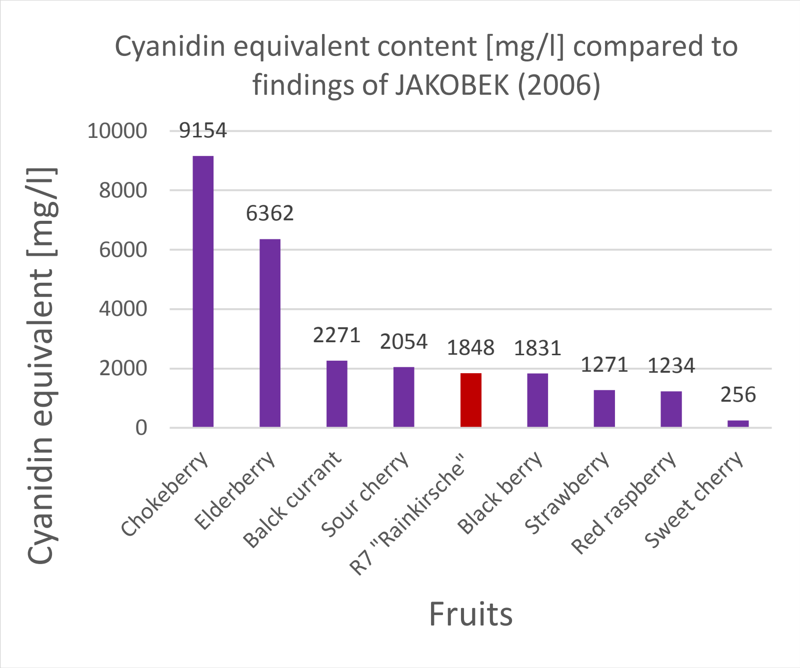


Figure 48: Comparison of the cyanidin equivalent content of different fruits of JAKOBEK (2007)(purple) and R7 sample of "Rainkirsche" (PUTZ, 2013)(red)

The work of JAKOBEK et al. also measured the polyphenol content of other fruits: elderberry (*Sambucus nigra*), chokeberry (*Aronia melanocarpa*), black currant (*Ribes nigrum*), sour cherry (*Prunus cerasus*), blackberry (*Rubus fructicosus*), red raspberry (*Rubus idaeus*) and strawberry (*Fragaria x ananassa*).

Whilst chokeberry and elderberry show outstanding values for the content of polyphenols, the values for black currant, sour cherry, blackberry, strawberry, red raspberry and the sample R7 from this work do show some variance. The sample R7 can be classified into the same group of polyphenol contents as black currant, sour cherry and black berry. Chokeberry and elderberry may contain high amounts of cyanidin equivalents, but they are mainly used for juice production, since their fruits are bitter or astringent and are seldom used for fresh consumption (OCHMIAN, 2009). The fruits with lower contents of cyanidin equivalents tend to have a more pleasant taste and are consumed as fresh fruits, as well as juices.

7. Description and discussion of selected trees and varieties

The following pages are dedicated to describe the found trees and varieties and to compare them with literature if possible. Names which are marked with (LB) are local terms, (AB) stand for working title. Unfortunately, not every interesting tree was taken on photograph. The tree description can only contribute to a part to make up for the missing pictures. The pictures in the description table are all private photographs. The pictures in the discussion are taken from the comparative literature. In summary, seven described varieties, two local varieties and four unknown varieties were found during the sample harvest of this work. The varieties and trees can be found in the following table:

Table 38: List of varieties and working titles found in the samples, n=30

Variety/ working title	Number of trees	Tree codes
Alfa	2	S23, S24
Beta	1	S7
"Dreickiger Sämling (AB)"	1	S39
Große Germersdorfer	4	S12, S20, S22, S26
Große Prinzessinkirsche	2	K3, S13
Große Schwarze Knorpelkirsche	1	R3
Hedelfinger	3	R9, S38, S40
Kaiser Franz	1	S29
"Pfelzer (LB)"	5	A7, R4, S2, S5, S37
"Sämling von Büttners (AB)"	1	K1
„Rainkirsche"	5	A6, K2, S4, R1, R7
"Schwarzer Sämling (AB)"	1	A17
"Unregelmäßige (AB)"	3	A8, F1, S21

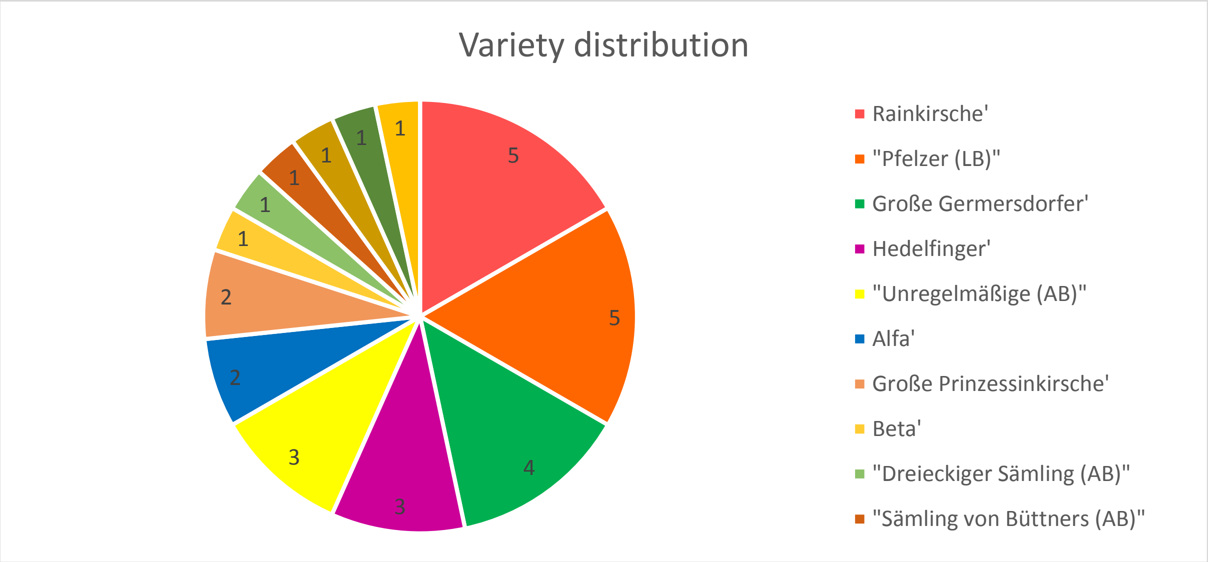


Figure 49: Graphical display of the variety distribiution of the sampled trees, n=30

7.1.1 S23 ‘Alfa’

S23 ‘Alfa’	Black bigarreau cherry with staining juice
Tree **Location:** Stainzer Hof, Scharten **Underground:** Meadow **Estimated age:** 40 years **Trunk height:** 1.50 m **Trunk circumference:** 1.13 m **Tree top shape:** pyramidal **Growth type:** semi-drooping **Fruit load:** medium **Vitality:** medium **Graft position:** stem base **Dead wood:** 1% **Pruning:** old **Shot hole disease:** strong symptoms **Maintenance:** low	
Fruit **Stalk length:** medium **Fruit shape:** kidney-shaped **Skin color:** black **Fruit size:** big **Fruit weight:** ~ 6.6 g **Shouldering:** medium **Fruit flesh color:** dark red **Juice color:** black-red **White veining:** few **Fruit flesh firmness:** medium	
Stone **Stone shape lateral:** round **Stone shape ventral:** round **Stone tip:** missing **Stone weight:** ~ 0.35 g **Stone ease:** easy	
Taste Harmonic, aromatic taste; small to medium acidity, medium to high sweetness	

Discussion

The S23 sample of 'Alfa' was compared to a cultivar description by AEPPLI (1982). The stalk depicted by AEPPLI is long and thin with a medium stalk release force. S23 in contrast showed stalks of medium length, but the stalk release force is also here categorized as medium. In the description of AEPLLI, 'Alfa' fruits are categorized as medium sized, with a weight of 5.4 – 5.9 g per fruit. The S23 sample showed an average fruit weight of 6.6 g, which can be classified as big of size. This difference can be caused by tree health, fruit load or climatic influences like precipitation amount. AEPLLI describes 'Alfa' fruits as oval to heart-shaped, but the depicted example fruits show rather a kidney or flat-round shape. Thus, the shape categorization may underlie a subjective bias. Seen from above, the fruit is described as flattened from bulge and back side, which coincides with the description of S23. The pistil side is described as rounded to even, and also S23 shows an even pistil side. The black skin color is in agreement with S23 and the literature. In the literature the fruit flesh is characterized as medium firm to firm. S23 showed a medium firm fruit flesh with an aromatic, harmonic taste. Sweetness and acidity of S23 are similar to the description of AEPLLI, who depicts 'Alfa' cherries as of moderate sweetness and refreshing acidity. The stone is described as oval to egg-shaped without stone tip and differs therefore from the S23 'Alfa' whose stone is rather round. The size dimensions of the stone described by AEPPLI (11.0 * 7.0 * 9.3 mm) are very close to the ones measured for S23 (10.9 * 7.5 * 9.3 mm).

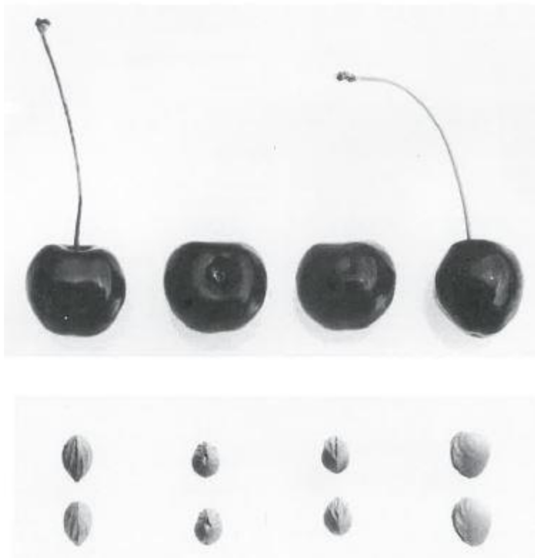


Figure 50: Photograph of 'Alfa' fruits and stones (AEPLLI, 1982)

For utilization, AEPPLI suggests to use the high quality fruits of 'Alfa' as table fruits, but also preservation is possible. Juice production is only a conditional option.

7.1.2 S7 ‘Beta’

S7 ‘Beta’	Dark-red bigarreau cherry with staining juice
<u>**Tree**</u> **Location:** Upper Scharten **Underground:** Meadow **Estimated age:** 40 years **Trunk height:** 0.5 m **Trunk circumference:** 1.64 m **Tree top shape:** flat pyramidal **Growth form:** spreading **Fruit load:** medium **Vitality:** high **Graft position:** unclear **Dead wood:** 0% **Pruning:** old **Damages:** **/**	
<u>**Fruit**</u> **Stalk length:** medium **Fruit shape:** kidney-shaped **Skin color:** dark red **Fruit size:** large **Fruit weight:** ~ 7.0 g **Shouldering:** strongly **Fruit flesh color:** red **Juice color:** red **Fruit flesh firmness:** high **White veining**: medium	
<u>**Stone**</u> **Stone shape lateral:** round **Stone shape ventral:** narrow elliptic **Stone tip:** straight **Stone weight:** ~ 0.38 g **Stone ease**: easy	
<u>**Taste**</u> Harmonic, aromatic taste; medium to high sweetness and acitdity	

Discussion

The here described sample of 'Beta' differs in some parameters from the one described in AEPLLI (1982). AEPPLI describes the stalk of 'Beta' as long, thin and with a high stalk release force. The high stalk release force was also observed in case of S7, but its stalk is described as medium long and the stalk is rather thick. AEPLLI et al. pictures fruits of 'Beta' as oval shaped and irregular, with brown-black to black skin color. S7 also shows an irregular fruit shape, but the shape was rather characterized as kidney shaped, than oval. The skin color, the weak shouldering and the horizontal stalk inclination are in agreement with the literature, and also the weak seam furrow coincides. The pistil side is even with an indented pistil position, both for the literature and S7. The fruit flesh of 'Alfa' is described by AEPPLI as firm and juicy with high sweetness and refreshing acidity. Also S7 has a firm fruit flesh, and was categorized as medium to high in sweetness and acidity. Literature and S7 both show a harmonic, aromatic taste and a dark juice color. The stone description by the literature depicts an oval stone of medium size (10.8 * 6.4 * 8.6 mm). The stones of S7 were classified as round and were slightly bigger and rounder (10.8 * 7.2 * 9.1 mm) than the literature measurements.

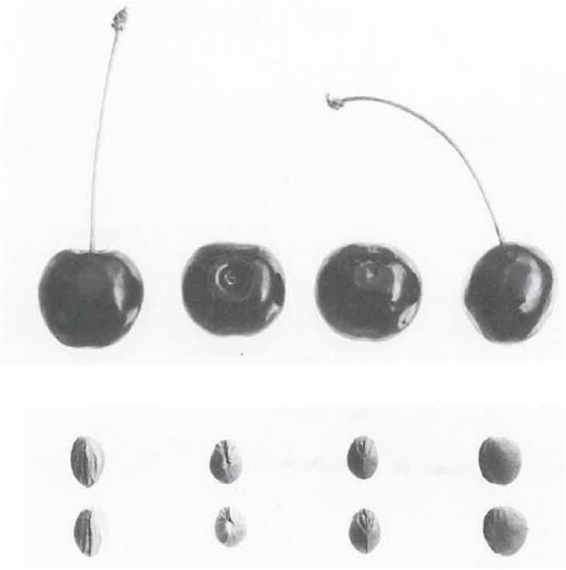


Figure 51: Photograph of 'Beta' fruits and stones (AEPPLI, 1982)

The by AEPPLI described utilization possibilities range from table fruits to private sale to juice production. The cultivar ripens in the gap between early and medium-early cultivars.

7.1.3 S39 "Dreieckiger Sämling (AB)"

S39 "Dreickiger Sämling (AB)"	**Black heart cherry with staining juice**
<u>Tree</u> **Location:** Upper Scharten **Underground:** Meadow **Estimated age: /** **Trunk height:** 1.20 m **Trunk circumference:** 1.80 m **Tree top shape:** high spherical **Growth type:** semi-drooping **Fruit load:** very high **Vitality:** medium **Graft position:** / **Dead wood:** 5% **Pruning:** old **Maintenance:** low	
<u>Fruit</u> **Stalk length:** medium **Fruit shape:** oval to heart-shaped **Skin color:** black **Fruit size:** small **Fruit weight:** ~ 4.2 **Shouldering:** medium **Fruit flesh color:** red **Fruit flesh firmness:** soft **Juice color:** brown-red **White veining:** medium	
<u>Stone</u> **Stone shape lateral:** pointed **Stone shape ventral:** narrow elliptic **Stone tip:** straight **Stone weight: ~** 0.33 g **Stone ease:** medium	
<u>Taste</u> balanced but bland taste with low to medium sweetness and acidity	

Discussion

S39 “Dreieckiger Sämling (AB)” was first categorized as seedling, because of its small fruits. But after a closer look into old literature by LÖSCHNIG (1914) about Austrian cherry cultivars, a cultivar was found, that was described as quite similar to S39. The cultivar from the literature is called “Dreikantkirsche” (“triangular cherry”) and was found in Linz on the cherry fair in 1914.

LÖSCHNIG describes the “Dreikantkirsche” as remarkably triangular when seen from above. The cultivar picture does not make it easy to recognize, but also S39 showed a triangular outline when seen from above, as well as when seen from the pistil side. With an average fruit weight of 4.4 g LÖSCHNIG describes the fruits as big, which is not an up to date classification, since breeding increased cherry sizes during the last century. But with an average fruit weight of 4.2 g, S39 is quite close to the literature. The elongated fruit of “Dreikantkirsche” shows a moderate seam in a furrow; the seam side is flattened. Also S39 has an elongated fruit shape, its seam is medium expressed and lies in a weak furrow on a flattened seam side. In LÖSCHNIG’s description of the “Dreikantkirsche”, the pistil is positioned either elevated or even, without indention. In contrast, S39’ pistil is either even or slightly indented. Its fruit flesh is red to dark red with few white veining; “Dreikantkirsche” also has red to dark-red fruit flesh, no white veining and a pleasantly sweet taste with a musky note. Unfortunately, S39 did not show as promising taste, as described in the literature.

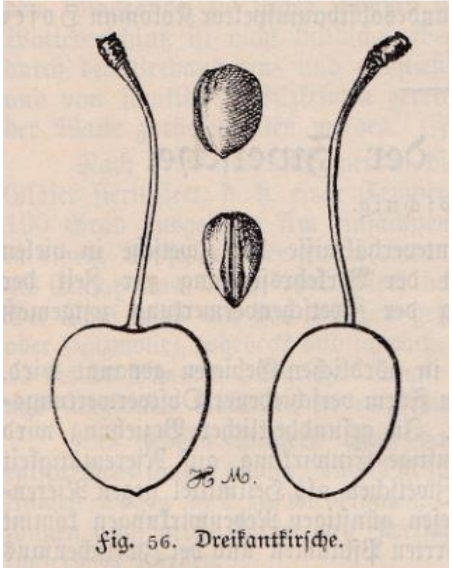


Figure 52: Illustration of "Dreikantkirsche" fruits and stones (LÖSCHNIG, 1924)

It is possible, that the similarities of S39 and “Dreikantkirsche” were purely coincidental. Another possibility is that S39 is a seedling of “Dreikantkirsche”.

7.1.4 S20 'Große Germersdorfer'

S20 'Große Germersdorfer'	**Brown-red bigarreau cherry with more or less staining juice**
<u>Tree</u> **Location:** Upper Scharten, Kirschblütenhalle **Underground:** meadow/field **Estimated age:** young **Trunk height:** ~ 1.00 m **Trunk circumference:** ~ 0.30 m **Tree top shape:** spherical **Growth type:** semi-upright **Fruit load:** medium **Vitality:** medium **Graft position:** / **Dead wood:** / **Pruning:** / **Damages:** /	
<u>Fruit</u> **Stalk length:** medium **Fruit shape:** spherical to heartshaped **Skin color:** dark red **Shouldering:** strong **Fruit size:** very big **Fruit weight:** ~ 8.8 g **Fruit flesh color:** pink **Fruit flesh firmness:** very high **Juice color:** pink **White veining:** medium	
<u>Stone</u> **Stone shape lateral:** pointed to egg-shaped **Stone shape ventral:** narrow elliptic **Stone tip:** straight **Stone weight:** ~ 0.46 g **Stone ease:** bad	
<u>Taste</u> Harmonic and aromatic taste with medium to high acidity and low to medium sweetness	

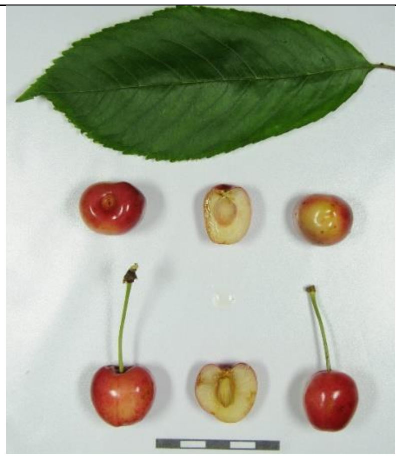
Discussion

Figure 53: Photograph of 'Große Germersdorfer' fruits and stones (www. arche-noah.at, 09.12.2013)

The samples of S20 were compared with literature by Arche Noah (www.arche-noah.at) and TRAXLER (1940). Synonyms for ‘Große Germersdorfer’ are ‘Germersdorfer Riesen’, ‘Bigarreau de Germersdorf’, ‘Mertschings Sämling’. Both, TRAXLER and Arche Noah depict a very similar description of ‘Große Germersdorfer’. The sources categorize the stalk of cherries of ‘Große Germersdorfer’ as long and thick. S20 in contrast showed medium stalk length in all three sample dates. Both sources describe ‘Große Germersdorfer’ as a fruit of broad heart-shape and strong shouldering with red to brown-red skin, which coincides with S20. Also S20’s big size and high weight is agreement with the literature. The fruit flesh changes its color during the ripening period from pink to red. This change of color was also observed in S20. Fruit flesh firmness was classified as medium to high by Arche Noah; S20 was found very firm. The juice is described by Arche Noah as red to dull red and weak to medium staining. TRAXLER on the other hand characterizes it as non-staining. The juice of S20 was found pink and non-staining, even at the latest harvest date. Arche Noah specifies the taste of ‘Große Germersdorfer’ as harmonically, spicy sourly and with mild sweetness. All of these specifications fit perfectly on S20. The stone finally is depicted by Arche Noah as elongated to blunt egg-shaped to oval without or with only weak stone tip. Stone ease was classified as medium to easy. S20 showed compared to that pointed to egg-shaped stones with straight tip and medium stone ease.

The utilization of ‘Große Germersdorfer’ is described by TRAXLER and Arche Noah as wide ranged. The fruit is valuable due to its excellent taste and characteristics. It can be used for private and professional orchards. Its good transportability allows a shipping to markets and retailers. In processing, ‘Große Germersdorfer’ is suited for preservations, spirits and drying.

7.1.5 S13 ‘Große Prinzessinkirsche’

S13 ‘Große Prinzessinkirsche’	**Multicolored white-heart cherry with non-staining juice**
<u>Tree</u> **Location:** Upper Scharten **Underground:** Meadow **Estimated age:** 100 years **Trunk height:** 1.65 m **Trunk circumference:** 2.02 m **Tree top shape:** pyramidal **Growth type:** semi-drooping **Fruit load:** medium **Vitality:** low **Graft position:** tree top base **Dead wood:** 7% **Pruning:** old **Maintenance:** none	
<u>Fruit</u> **Stalk length:** medium **Fruit shape:** oval to heart-shaped **Skin color:** red on yellow base **Fruit size:** very big **Fruit weight:** ~ 6.7 g **Shouldering:** medium shouldering **Fruit flesh color:** yellow **Juice color:** colorless **Stone ease:** easy	
<u>Stone</u> **Stone shape lateral:** pointed **Stone shape ventral:** narrow elliptic **Stone tip:** straight **Stone weight:** ~ 0.29 g	
<u>Taste</u> Sourly, mildly aromatic taste with low to medium sweetness and medium to high acidity	

Discussion

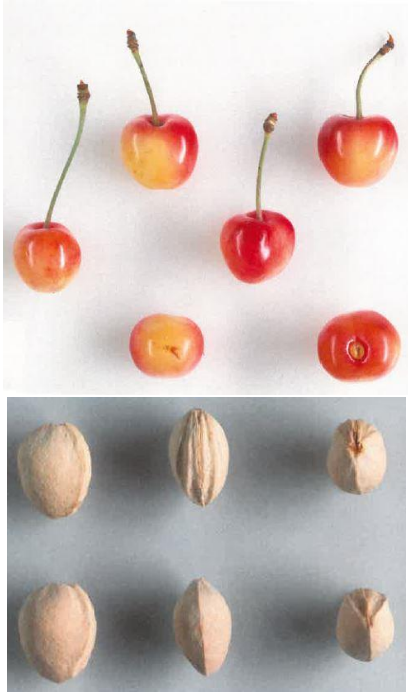
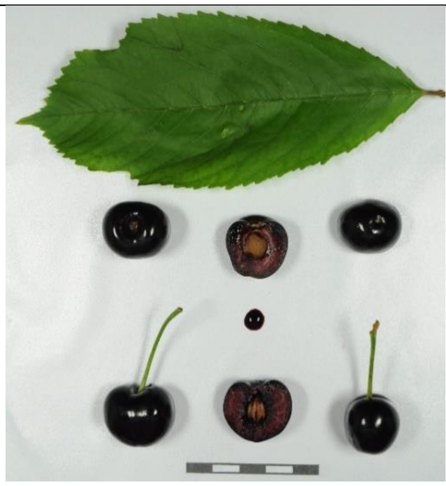


Figure 54: Photographs of 'Große Prinzessinkirsche' fruits (above) and stones (below) (BRAUN-LÜLLEMANN, 2010)

S13 was compared to literature by TRAXLER (1940) and BRAUN-LÜLLEMANN (2010). The medium long stalk of S13 coincides with the descriptions of TRAXLER and BRAUN-LÜLLEMANN. The fruit size is described as medium to big (BRAUN-LÜLLEMANN) or very big (TRAXLER). S13 showed very big fruits. Both sources depict 'Große Prinzessinkirsche' as broad heart-shaped to round heart-shaped with yellow base skin color and a red hue, which can be lined, spotted or marbled; the seam can be underplayed with a red band (TRAXLER, 1940). All of these characteristics were also found in S13. TRAXLER categorized the shouldering of 'Große Prinzessinkirsche' as flat, BRAUN-LÜLLEMANN as flat to medium. S13 was characterized as medium shouldered. Both sources describe the pistil as small or small to medium sized and positioned even or slightly indented on the pistil side. The pistil of S13 was found to be small and indented. The fruit flesh of 'Große Prinzessinkirsche' is white to whitish-yellow and firm with a colorless juice after the literature. S13 is in accordance with this. While the taste of 'Große Prinzessinkirsche' is described as very aromatic, spicy and of weak acidity. S13 was rather categorized as sourly and only mild aromatic; the acidity was recorded as medium to high. S13's stones show the typical characteristics of stones of 'Große Prinzessinkirsche' with a pointed oval shape with a small, straight stone tip and well stone ease.

TRAXLER classified 'Große Prinzessinkirsche' as one of the biggest cherries with the ability to be utilized as table cherry, for pastries and preservation but also for drying and preparation of juice and liqueur.

7.1.6 R3 'Große Schwarze Knorpelkirsche'

R3 'Große Schwarze Knorpelkirsche'	**Brown-red bigarreau cherry with staining juice**
Tree **Location:** Roithen **Underground:** Meadow **Estimated age:** 40 years **Trunk height:** 0.5 m **Trunk circumference:** 1.5 m **Tree top shape:** pyramidal **Growth type:** spreading **Fruit load:** medium **Vitality:** high **Graft position:** tree top base **Dead wood:** 1% **Pruning:** old	
Fruit **Stalk length:** short **Fruit shape:** round to heart-shaped **Skin color:** dark red **Fruit size:** big **Fruit weight:** ~ 7.4 g **Shouldering:** medium **Fruit flesh color:** red **Fruit flesh firmness:** high **Juice color:** purple **White veining:** medium	
Stone **Stone shape lateral:** round **Stone shape ventral:** round **Stone tip:** missing **Stone weight:** ~ 0.41 g **Stone ease:** medium	
Taste Harmonic, mild aromatic taste with medium sweetness and medium to high acidity	

Discussion

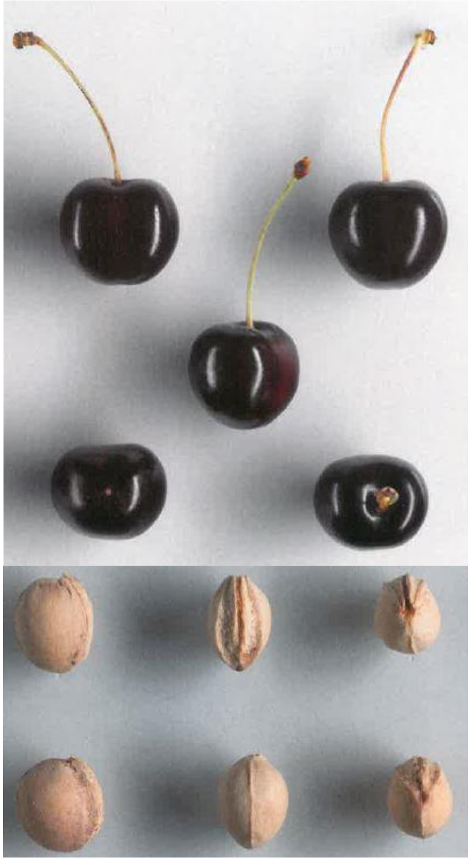


Figure 55: Photographs of 'Große Schwarz Knorpelkirsche' fruits (above) and stones (below) (BRAUN-LÜLLEMANN, 2010)

Comparative literature was used by TRAXLER (1940), FISCHER (1995) and BRAUN-LÜLLEMANN (2010). The literature describes the stalk of ‘Große Schwarze Knorpelkirsche’ as short with a reddish hue (BRAUN-LÜLLEMAN) or medium long and of red-brown color. R3’s stalk was found of medium length and of bright green color without red hue. TRAXLER states an average fruit weight of 4.8 g, whereas FISCHER mentions 6-7 g weight per fruit. Both values were overcome from R3 with 7.4 g. Fruit size was categorized as medium by FISCHER; R3 yielded big fruits. The shape is always described as roundish globular with even pistil side and flat shouldering. R3 showed medium shouldering, but otherwise the aforementioned characteristics of fruit shape. BRAUN-LÜLLEMANN characterizes the pistil of ‘Große Schwarze Knorpelkirsche’ as typically big and bright, positioned even or in a very small indent. The pistil of R3 was also of big size and sat in a small indent. According to the literature, the fruit flesh of ‘Große Schwarze Knorpelkirsche’ is firm and dark red around the stone; closer to the skin the fruit flesh is toned more light. R3 showed red fruit flesh with medium white veining. The color change from stone to skin can also be seen. The juice color is categorized as black-red and highly staining by TRAXLER while the juice found in R3 was categorized as brown-red. TRAXLER also describes ‘Große Schwarze Knorpelkirsche’ as cherry of excellent, spicy taste with high sweetness and light acidity. R3 did not show as promising taste, but with a harmonic, mild aromatic taste and medium sweetness and medium to high acidity it is still a very good tasting cherry. A bitter not, as stated by BRAUN-LÜLLEMANN was not found in R3. The stone is characterized by TRAXLER as round with typically broad and flat edges, which is in accordance with the stones of R3. BRAUN-LÜLLEMANN adds to these characteristics the typical “hook” at the stalk side, which could also be seen on the stones of R3.

Both FISCHER and TRAXLER associate ‘Große Schwarze Knorpelkirsche’ as table cherry and fit for preservation.

7.1.7 S40 ‘Hedelfinger‘

S40 ‘Hedelfinger’	**Brown-red bigarreau cherry with staning juice**
<u>Tree</u> **Location:** Upper Scharten, Bienenlehrpfad **Underground:** Meadow, field **Estimated age:** 40 years **Trunk height:** 1.90 m **Trunk circumference:** 1.01 m **Tree top shape:** high pyramidal **Growth type:** semi-drooping **Fruit load:** medium **Vitality:** medium **Graft position:** / **Dead wood:** 1% **Pruning:** old **Shot hole disease:** mild symptoms **Maintenance:** well	
<u>Fruit</u> **Stalk length:** medium **Fruit shape:** oval, elongated **Skin color:** red **Fruit size:** big **Fruit weight:** ~ 8.3 g **Shouldering:** medium **Fruit flesh color:** red **Fruit flesh firmness:** medium **Juice color:** brown-red **White veining:** medium	
<u>Stone</u> **Stone shape lateral:** pointed to egg-shaped **Stone shape ventral:** narrow elliptic **Stone tip:** straight **Stone weight:** ~ 0.36 g **Stone ease:** bad	
<u>Taste</u> Sweet, mild aromatic taste with low to medium acidity and medium to high sweetness	

Discussion

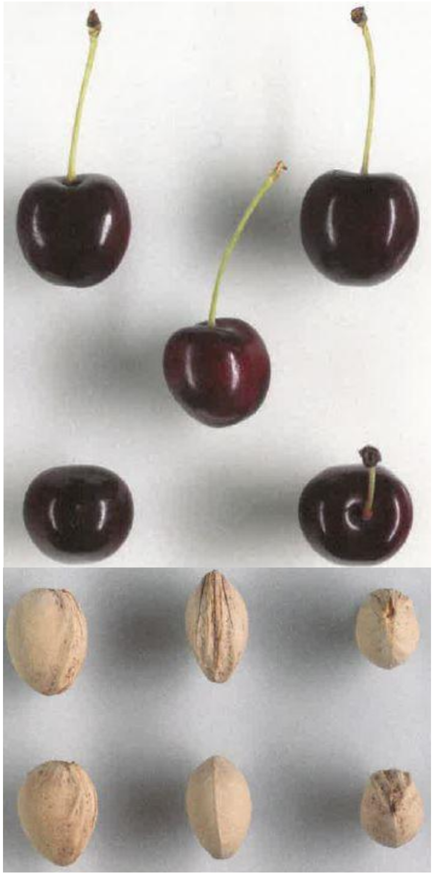
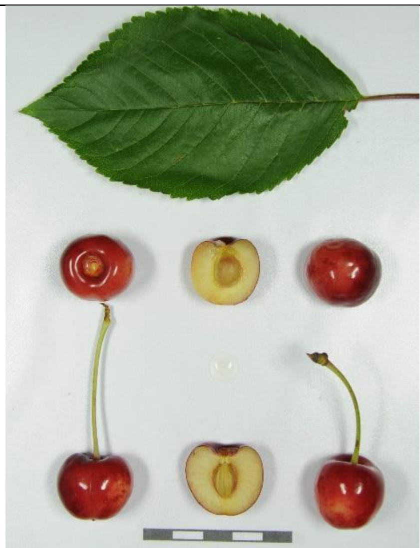


Figure 56: Photographs of 'Hedelfinger' fruits (above) and stones (below) (BRAUN-LÜLLEMANN, 2010)

For the discussion, literature of BRAUN-LÜLLEMANN (2010), FISCHER (1995) and AEPPLI (1982) was used. Common synonyms for ‘Hedelfinger’ are ‘Hedelfinger Riesenkirsche’ or ‘Wahlerkirsche’. The stalk of ‘Hedelfinger’ cherries is described as short to medium with mediocre stalk release force (BRAUN-LÜLLEMANN, AEPPLI) or long (FISCHER). A stalk inclination towards the fruit is expressed by BRAUN-LÜLLEMANN and FISCHER. S40’s stalk was found medium long without inclination and with a medium stalk release force. All three sources describe ‘Hedelfinger’ as medium to big or even very big (AEPPLI) in fruit size. The fruits of S40 were big and very heavy. S40’s shape was oval and rather elongated with weak to medium shouldering and a rounded or slightly indented pistil side. The literature also describes ‘Hedelfinger’ cherries as oval to elongate with weak shouldering and rounded or even pistil side. The small pistil typically sits in a flat indent, which was also found in S40. ‘Hedelfinger’ cherries characteristically have a dark red to brown-red skin color than can be stippled in the time before full ripeness. The fruit flesh of ‘Hedelfinger’ is described as bright red (BRAUN-LÜLLEMANN, AEPPLI) to dark red (FISCHER) and firm. S40 had a red fruit flesh with medium firmness and brown-red juice. Only AEPPLI addressed the juice of ‘Hedelfinger’ in detail and described it as rather bright in color. The description of the taste of ‘Hedelfinger’ varies in the literature. Whereas BRAUN-LÜLLEMANN speaks of only weak aroma, AEPPLI characterizes the taste as harmonic with mild spiciness and moderate acidity and sweetness. FISCHER finally praises ‘Hedelfinger’ as very spicy and palatable, often with an aftertaste of bitter almond. S40’ taste was found sweet and mild aromatic with low to medium acidity and medium to high sweetness. The taste characteristics can depend on year, climate and fruit load. FISCHER described the bitter almond taste as especially expressed in dry years or in years with high fruit load. The stone of ‘Hedelfinger’ is depicted by the literature as medium sized and of elongate oval shape, no stone tip (AEPPLI) and bad stone ease (FISCHER). The stones of S40 showed a pointed to egg-shape with a straight tip and also bad stone ease.

‘Hedelfinger’ is best used as table cherry, since the humble juice color does not make it suitable for preservation, juice or distillation.

7.1.8 S29 ‘Kaiser Franz’

S29 ‘Kaiser Franz’	**Red white-heart cherry with non-staining juice**
<u>Tree</u> **Location:** Upper Scharten **Underground:** Meadow, field **Estimated age:** / **Trunk height:** 2.50 m **Trunk circumference:** 1.27 m **Tree top shape:** flat spherical to spherical **Growth type:** semi-drooping **Fruit load:** high **Vitality:** medium **Graft position:** tree top base **Dead wood:** 5% **Pruning:** old **Maintenance:** low	
<u>Fruit</u> **Stalk length:** medium **Fruit shape:** kidney-shaped **Skin color:** bright red **Fruit size:** big **Fruit weight:** ~ 7.6 g **Shouldering:** medium **Fruit flesh color:** yellow **Fruit flesh firmness:** high **Juice color:** colorless	
<u>Stone</u> **Stone shape lateral:** round to pointed **Stone shape ventral:** broad elliptic **Stone tip:** missing **Stone weight:** ~ 0.5 g **Stone ease:** medium	
<u>Taste</u> Harmonic, fine aromatic taste with low to medium sweetness and medium acidity	

Discussion

Figure 57: Illustrations of 'Kaiser Franz' fruits on a branch (above), open fruit (below, left) and stones (below, right) (TRAXLER, 1940)

Literature for comparison was used from TRAXLER (1940). No detailed description is given by TRAXLER about the stalk of ‘Kaiser Franz’ but from the picture it is visible, that the stalk is not excessively long. The stalks found in S29 were of medium length. Further, fruits of ‘Kaiser Franz’ are described as being of big size and high weight with up to 10,5 g per single fruit. S29 showed big fruits and high fruit weight, but average fruit weight was 7,6 g, with 8,36 g being the highest value for a single fruit. Moreover, the fruit shape is categorized as broad-shaped, especially towards the stalk and is roundish to flat on the pistil side, so it can be set up straight without rolling. The shape of S29 was found very similar to this description, with a broad kidney-shape and the smallest fruit shape index found throughout all samples. The pistil side was either even or indented. The fruit skin was depicted by TRAXLER as red with bright spots on it. This coincides with the skin color found in S29. TRAXLER does not describe the fruit flesh color, but as can be seen in the picture, it is of bright, yellowish color. He categorizes the fruit flesh as firm with few and non-staining juice. S29’s fruit flesh was also classified as firm, the juice did not show color. Its taste was expressed as balanced with fine aroma, low to medium sweetness and medium acidity. TRAXLER explains ‘Kaiser Franz’ as tasting sweet and fine. The stone of ‘Kaiser Franz’ is described as medium sized and strongly furrowed. The pictures by TRAXLER show a roundish pointed lateral and a broad elliptic ventral shape. S29’ stones had the highest weight throughout all samples and were classified as laterally round to pointed, ventrally broad elliptic with missing stone tip and bad stone ease.

For utilization finally, TRAXLER suggests ‘Kaiser Franz’ as recommendable for purchase and fanciers. The variety however, has most probably already been overcome by more modern varieties and does not play big role in the fruit market anymore.

7.1.9 K3 "Naschbaum (AB)"

K3 "Naschbaum (AB)"	Sweet cherry tree with grafts of different cultivars
<u>**Tree**</u> **Location:** Kronberg **Underground:** Meadow **Estimated age:** 40 years **Trunk height:** / **Trunk circumference:** / **Tree top shape:** / **Growth type:** / **Fruit load:** / **Vitality:** medium **Graft position:** tree top base **Dead wood:** 0% **Maintenance:** well	 

Discussion

This tree was found in a private garden in Kronberg. The owner told, that it was used as an experimental tree for different varieties. At least two different cultivars could be found on the tree: 'Große Prinzessinkirsche' and 'Große Schwarze Knorpelkirsche'. Since there were several different cultivars on the tree, no tree top shape or growth type could be estimated, neither were trunk height or circumference measured. The tree was called "Naschbaum" after the German word "naschen" for eating titbits. The tree was well maintained by its owners and did not show dead wood or major damages. The vitality was medium high. Fruit load could not be estimated, since the cultivars were in different ripening stage and were partially already harvested.

7.1.10 S5 “Pfelzer (LB)”

S5 “Pfelzer (LB)”	**Brown-red bigarreau cherry with non-staining juice**
Tree **Location:** Scharten **Underground:** meadow **Estimated age:** > 80 years **Trunk height:** 1.50 m **Trunk circumference:** 0.60 m **Tree top shape:** high pyramidal **Growth form:** spreading **Fruit load:** high **Vitality:** medium **Graft position:** unclear **Dead wood:** 1% **Pruning:** old **Damages:** pruning wound	
Fruit **Stalk length:** short to medium **Fruit shape:** heart-shaped **Skin color:** dark red **Fruit size:** very big **Fruit weight:** ~ 7.5 g **Shouldering:** strong **Fruit flesh color:** dark red **Fruit flesh firmness:** very high **Juice color:** brown red	
Stone **Stone shape lateral:** egg-shaped **Stone shape ventral:** broad elliptic **Stone tip:** missing **Stone weight:** ~ 0.44 g **Stone ease:** well to medium	
Taste Very firm fruits with staining brown red juice and bland, acidic taste	

Discussion

Another very interesting morphogenetic variety was the group of “Pfelzer” cherries. The name Pfelzer traces back to a regional word for grafting. This is a very general denomination, since many of the cherry trees were found to be grafted. But many of these “Pfelzer” called cherry trees showed unique fruit characteristics and similar tree shape. In the literature, no variety was found matching “Pfelzer”.

All five sampled trees of Pfelzer had a pyramidal (A7, S2) or a high pyramidal (R4, S5, S37) tree top shape. The growth type was uniformly of a spreading type. Fruit load was medium (R4, S5, S37) or high (A7, S2). Vitality ranged from high (S2) to medium (R4, S5, S37) to low (A7). The graft position could not be found in any of the trees.

Figure 58: Typical bulge on the stalk side of a S5 "Pfelzer (LB)" cherry (picture private)

The stalk of the sampled “Pfelzer (LB)” cherries was either short (R4, S5, A7) or medium (S2, S37) released at high force. Fruit size was big for all samples. Fruit weight was medium (R4, S2, S37) or high (S5, S37) with single fruit weights from 6.1 g to 7.5 g. The shape of the sampled fruits was either kidney-shaped (S2, S37), oval (R4, A7) or heart-shaped (S5) and showed a red (R4, S5) to dark-red (A7, S2, S37) skin color, with the darker shades appearing on the later harvest dates. The stalk side was shouldered in most of the cases medium, but S37 showed strong shouldering. The pistil side was either pointed (R3, S5, S37) or even (A7, S2) with an in most cases medium sized pistil; S5 had a small pistil and A7’s pistil was categorized as big. The seam was found either expressed strongly (R4, S2, A7) or medium (S5, S37) and runs flat from stalk to pistil in all five samples. Seen from above, all samples were flat on seam and back side. The fruit flesh color was red in most cases, only R4 showed a dark-red fruit flesh. Juice color ranged from red (S5, S2) to brown-red (A7, S37) to black (R4). White veining was medium strong for A7, S2 and S37, weak in S5 and strong in R4.

The taste of the sampled “Pfelzer (LB)” cherries was sourly for the earlier harvested samples R4 and S5 and balanced for A7, S2 and S37 which were harvested on later dates. Some of the samples showed unpromising taste characteristics such as a bitter tone (R4) or a bland taste (S5). A7 on the other hand had a fine aromatic taste and S2 and S37 were aromatic. Sweetness ranged from low (R4), low to medium (S5) or medium (S2, S37) to medium to high (A7) degrees; also here the harvest date seemed to play a role. Acidity was found from low to medium (A7), medium (R4, S2, S37) and medium to high (S5) degree. In summary, the fruit taste improved during the ripening period.

The stone of the samples was pointed from lateral view in all cases, ventrally it showed narrow elliptic (R4, S2, S37) or broad elliptic (S5, A7) shapes. The stone tip was missing in all samples. Stone ease was found to be well in one sample (S2), medium in three (R2, S5, S37) and bad in A7. The stone weight ranged from 0.40 to 0.44 g.

The unique characteristics of S5 and "Pfelzer (LB)" cherries in general are the pronounced bulged on the stipe cavity. Also, the very high fruit firmness, combined with a relatively dry fruit flesh is typical for this variety. The stone is in many cases not completely adhered to the fruit flesh. Instead, the stone is covered with a separating layer that gives it a velvety surface. The expression of the bulge on the stalk side was high in R4, S5 and A7 samples and medium for S37, while S2 only showed a weak bulge. The degree of adherence of the stone to the fruit flesh varied from few (S5) to medium (A7) and was still high in most of the cases (R4, S2, S37). The fruit flesh firmness was either high (A7, S2, S37) or very high (R4, S5).

Figure 59: S5 "Pfelzer (LB)" cherry with typical stone cavity (picture private)

Summing up, the cherries of "Pfelzer (LB)" are big, heavy and firm fruits with red to brown-red fruit skin and red to dark red fruit flesh. Their taste is in the best cases harmonic and aromatic. Their firm fruit flesh makes them easy to transport, possibly also to preserve.

7.1.11 K1 “Sämling von Büttners (AB)”

K1 „Sämling von Büttners (AB)“	**Multicolored white-heart cherry with non-staining juice**
Tree **Location:** Kronberg **Underground:** Meadow, gravel **Estimated age:** 10 years **Trunk height:** 1.38 m **Trunk circumference:** 0.69 m **Tree top shape:** high pyramidal **Growth type:** semi-upright **Fruit load:** medium **Vitality:** high **Graft position:** seedling **Dead wood:** 0% **Pruning:** none	
Fruit **Stalk length:** medium **Fruit shape:** spherical to oval **Skin color:** red on yellow base **Fruit size:** medium **Fruit weight:** ~ 5.1 g **Shouldering:** weak **Fruit flesh color:** yellow **Fruit flesh firmness:** high **Juice color:** colorless	
Stone **Stone shape lateral:** oval to egg-shaped **Stone shape ventral:** narrow elliptic **Stone tip:** missing **Stone weight:** ~ 0.29 g **Stone ease:** bad	
Taste Sweet, aromatic taste low to medium acidity and high sweetness	

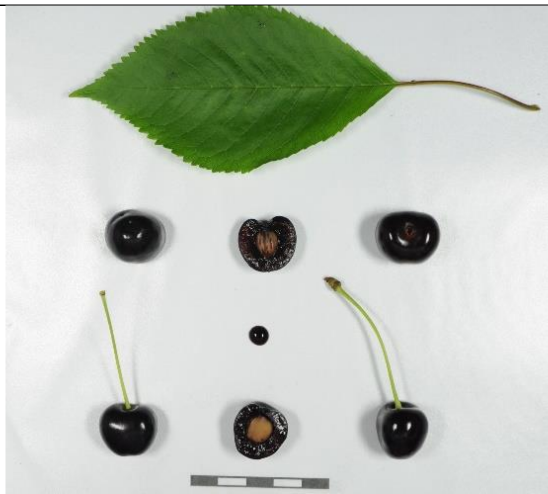
Discussion

K1 is a seedling, which sprouted wildly in the garden of its owner. Since its taste characteristics turned out to be well, the owner decided to keep the seedling. The fruits of K1 show attributes of 'Große Prinzessinkirsche' or 'Büttners Rote Knorpelkirsche'. After VON WETZHAUSEN (1819), these cultivars are very similar and even for pomologists hard to differentiate. The main differences are, that 'Büttners Rote Knorpelkirsche' tends to develop a bigger fruit gauge than 'Große Prinzessinkirsche' and that the stone is worse for 'Büttners Rote Knorpelkirsche' (VON WETZHAUSEN, 1819). Since these characteristics were also found in K1, the following comparison will be made with 'Büttners Rote Knorpelkirsche'. VON WETZHAUSEN classifies the stalk of 'Büttners Rote Knorpelkirsche' as medium long, which coincides with K1. The brightly yellow skin color with a red hue is also in agreement with the description of VON WETZHAUSEN, who explains that the bright red color only develops in full ripeness at the sun side of the fruit. The literature speaks for 'Büttners Rote Knorpelkirsche' as big to very big cherry; K1's fruits were only of medium size, probably because it is a seedling and not a cultivar. The shape is categorized by VON WETZHAUSEN as broad and heart-shaped. K1 showed fruits with roundish to oval shape, weak shouldering and a rounded pistil side. The pistil is positioned in a tiny indent. The fruit flesh of K1 had a yellow color and high fruit flesh firmness. 'Büttners Rote Knorpelkirsche' also has a brightly yellow, firm flesh with few juice. Its taste was described as sweet, spicy and light in acidity. This description fits also well on the fruits of K1 which were classified as sweet and aromatic, with low to medium acidity and high sweetness. The juice of K1 cherries is colorless. The stone of 'Büttners Rote Knorpelkirsche' was described as roundish, small and with bad stone ease by VON WETZHAUSEN. K1 had stones with ventrally oval to egg-shape, laterally narrow elliptic shape, missing stone tip and bad stone ease.

Figure 60: Illustration of 'Büttners Rote Knorpelkirsche' from seam side, pistil side and lateral side and ventral and lateral stone view (www.obstsortendatenbank.de, 11.12.13))

The fruits of K1 are used by its owner for fresh consumption and preservation.

7.1.12 A6 „Rainkirsche“

A6 „Rainkirsche“	**Black heart cherry with staining juice**
Tree **Location:** Aigen **Underground:** meadow **Estimated age:** 80 years **Trunk height:** 2.60 m **Trunk circumference:** 1.90 m **Tree top shape:** pyramidal **Growth form:** drooping **Fruit load:** medium **Vitality:** medium **Graft position:** unclear **Dead wood:** 1% **Pruning:** old **Damages:** pruning wounds	
Fruit **Stalk length:** medium **Fruit shape:** kidney-shaped **Skin color:** black-red **Fruit size:** small **Fruit weight:** ~ 4.6 g **Shouldering:** medium **Fruit flesh color:** dark red Fruit flesh firmness: **Juice color:** black red	
Stone **Stone shape lateral:** round **Stone shape ventral:** broad elliptic **Stone tip:** missing **Stone weight:** ~ 0.37 g **Stone ease:**	
Taste Soft fruits with highly staining dark red juice and harmonic, aromatic taste	

Discussion

The name “Rainkirsche” derives from the German word “Rain” or “Feldrain” for the edge of the field. As already described in the introduction, “Rainkirschen” are an old morphogenetic cultivar in Upper Austria. It is estimated, that the “Rainkirsche” was rather bred by seedlings than by pruning, as in a cherry exhibition in Linz in 1914 showed many different types of this cultivar (LÖSCHNIG, 1914; WERNECK, 1935).

The trees of the sampled “Rainkirsche” had tree top shapes from high pyramidal (K2, A6) over spherical (R7) and high spherical (R1) to columnar (S4). The growth type was usually classified as semi-drooping, only S4 showed a drooping growth. Fruit load ranged from low (R7) over medium (R1, A6) to high (K2, S4). Vitality was usually low (S4, R7, A6) or medium (K2, R1) and might depend on age and maintenance.

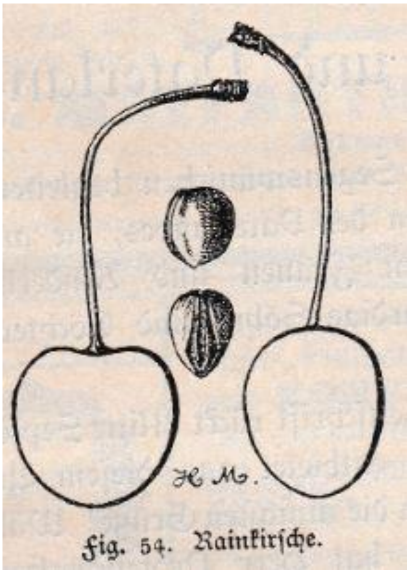


Figure 61: Illustration of "Rainkirsche" fruits and stones by LÖSCHNIG (1914)

After LÖSCHNIG, the stalk of “Rainkirsche” is long, thin and green, often with a red blush or ring at the stalk plate. The sampled fruits on the other hand had short (S4, R7) to medium long (K2, R1, A6) stalks. All five samples had a low stalk release force. LÖSCHNIG (1914) describes the “Rainkirsche” as a roundish heart cherry, flat at the stalk side and quite small. The pistil is small and flatly indented. The samples all showed kidney-shaped fruits with mainly medium shouldering; only S4 exhibited strong shouldering. All samples collected had a small fruit size and most had also low fruit weight; K2 as an exception had a medium fruit weight. All but one sample had a big sized pistil; only K2’s pistil was categorized as medium. The sampled fruits usually had an even pistil side shape only A6’s pistil side was shaped indented. Further, LÖSCHNIG describes the seam side as bulged, with distinct seam and a bulged back without furrow. The samples of Scharten had fruits with bulged seam and back side in most of the cases (K2, R1, R7). The literature describes the skin of “Rainkirsche” as black to dark black and glossy, which is agreement with all samples. The fruit flesh is described in the literature as dark red to black with no veining and dark juice. The fruit flesh color was throughout all of the samples dark red, the juice color brown-red in most cases; A6 displayed purple juice. White veining was found in a higher expression compared to the literature: three samples showed medium white veining (S4, R1, R7), the other two strong white veining (K2, A6). The taste of “Rainkirsche” is described by LÖSCHNIG as sweet-sour and pleasant. The five samples of „Rainkirsche“ presented a harmonic taste in most cases, with only R7 being of sweet taste type. The aroma ranged from fine aromatic (R1) to aromatic. Sweetness was medium for K2, S5 and R1 and high for R7 and A6, while acidity was high also for R7 and A6, medium to high in case of S4 and R1 and medium for K2. No detailed stone description is given by LÖSCHNIG for “Rainkirsche” but the picture shows a stone which is roundish from the lateral view, broad elliptic to round from the ventral side and that possesses a stone tip. The sampled cherries of “Rainkirsche“ were described as round (K2, S4, R1, A6) or egg-shaped (R7) from the lateral view, and round (K2, R1) or broad elliptic (S4, R7, A6) from the ventral view. The stone tip was missing in most of the cases, only R1 displayed a straight stone tip. Stone ease was medium for three samples (K2, R1, R7), good for S4 and only A6 showed a strong attachment of stone to flesh. The stone weight ranged from 0.29 g to 0.37 g.

The medium firm fruits of “Rainkirsche“ are not the most promising cultivar for transportation, but their excellent taste predestine them as table cherries. The dark fruit flesh and juice color also allow the production of preserves and liqueur with highly aromatic taste. “Rainkirsche“ is typically used for pastries in its region.

7.1.13 A17 “Schwarzer Sämling (AB)”

A17 “Schwarzer Sämling (AB)”	**Black heart cherry with highly staining juice**
<u>Tree</u> **Location:** Aigen **Underground:** Meadow, street **Estimated age:** 80 years **Trunk height:** 4.0 m **Trunk circumference:** 1.72 m **Tree top shape:** columnar **Growth type:** spreading **Fruit load:** medium **Vitality:** low **Graft position:** / **Dead wood:** 5% **Pruning:** old **Damages:** trunk damage	
<u>Fruit</u> **Stalk length:** short **Fruit shape:** oval to heart-shaped **Skin color:** black **Fruit size:** medium **Fruit weight:** ~ 6.3 g **Shouldering:** medium **Fruit flesh color:** dark red **Fruit flesh firmness:** medium **Juice color:** black	
<u>Stone</u> **Stone shape lateral:** egg-shaped to pointed **Stone shape ventral:** narrow elliptic **Stone tip:** missing **Stone weight:** ~ 0.45 g **Stone ease:** medium	
<u>Taste</u> Harmonic, fine aromatic taste with low to medium sweetness and medium acidity	

Discussion

The tree of A17 stands in line with many other sweet cherry trees along a street in Aigen. Unfortunately, the owner does not take care of the trees anymore, which led to bad maintenance and vitality conditions in many trees until the point of dying off. A possible comparative literature for A17 was found in LÖSCHNIG again. He describes a cultivar called “Ottensheimer Schwarze Herzkirsche” which was also found on the cherry fair in Linz in 1914 and originated from a seedling.

A17 has a columnar tree top shape, spreading growth type and medium fruit load. As already mentioned, the vitality of A17 is low, at the brink of dying off. A graft position could not be found, and the fruit characteristics led to the estimation, that it could be a seedling. An existing trunk damage may have also decreased the vitality of the tree.

The fruits of A17 sat on a short, bright green stalk which was inclined towards the seam side. The stalk released at medium force. LÖSCHNIG describes the stalk of “Ottensheimer Schwarze Herzkirsche” as medium long and bright green with a red stalk plate. Its fruits are of medium size with an average single weight of 4.6 g and a elongate heart shape. The fruits of A17 were categorized as medium sized with an oval to heart shape and black skin color. Also “Ottensheimer Schwarze Herzkirsche” was described as black-skinned with a distinct seam and flat bulging of seam and back side. On the back side runs a shallow furrow. A17’s fruits also show a flattened seam and back side, the seam is easily visible. The pistil of “Ottensheimer Schwarze Herzkirsche” is positioned flat or slightly elevated; A17’s medium sized pistil was positioned flat without indent. The fruit flesh of “Ottensheimer Schwarze Herzkirsche” was depicted as dark red to black in the literature with highly staining juice, which coincides with the fruit flesh of A17. The taste of “Ottensheimer Schwarze Herkirsche” was described as very sweet by LÖSCHNIG. A17 had displayed only low to medium sweetness and medium acidity while having a harmonic and fine aromatic taste. No details about the stone can be found in the description of LÖSCHNIG, but the stone illustrations shows a pointed lateral side and a broad elliptic ventral side. The stone tip seems straight. A17’s stone can be described as egg-shaped to pointed in lateral view, and narrow elliptic in the ventral view; the stone tip is missing. The stone ease was found to be medium in A17; the average stone weight amounts 0.45 g.

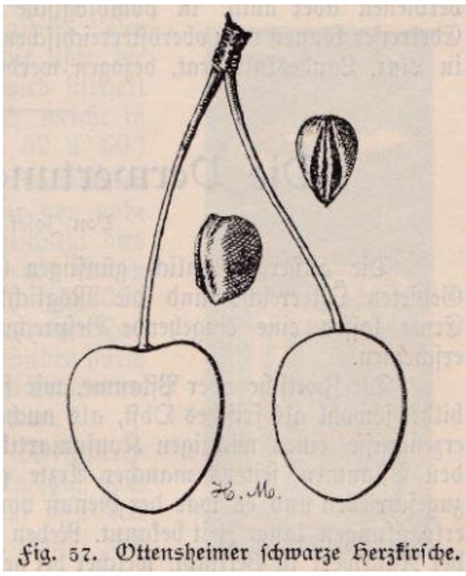
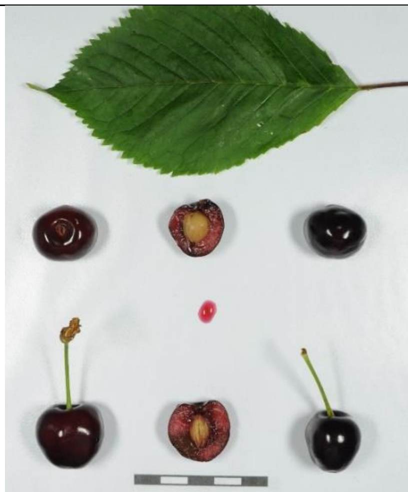


Figure 62: Ilustration of "Ottensheimer Schwarze Herzkirsche" fruits and stones (LÖSCHNIG, 1914)

To summarize, A17 and “Ottensheimer Schwarze Herzkirsche” share a similar outer appearance and inner characteristics, but the stone differs in many parameters. It is possible that A17 has similar ancestors as “Ottensheimer Schwarze Herzkirsche”.

7.1.14 S21 "Unregelmäßige (AB)"

S21 "Unregelmäßige (AB)"	Brown-red bigarreau cherry with non-staining juice
Tree **Location:** Scharten, Kirschblütenhalle **Underground:** Meadow, field **Estimated age:** 40-50 years **Trunk height:** 2.0 m **Trunk circumference:** 1.26 m **Tree top shape:** flat pyramidal? **Growth type:** drooping **Fruit load:** medium **Vitality:** low **Graft position:** tree top base **Dead wood:** 15% **Pruning:** old **Damages:** fracture on a leading branch **Maintenance:** few	
Fruit **Stalk length:** short **Fruit shape:** elongated to heart-shaped **Skin color:** dark-red **Fruit size:** big **Fruit weight:** ~ 6.1 **Shouldering:** medium **Fruit flesh color:** red **Fruit flesh firmness:** medium to high **Juice color:** red	
Stone **Stone shape lateral:** oval to egg-shaped **Stone shape ventral:** narrow elliptic **Stone tip:** missing **Stone weight:** ~ 0.40 **Stone ease:** easy	
Taste Harmonic, aromatic taste with low to medium sweetness and medium acidity	

Discussion

The fruits of F1, S21 and A8 were merged into the working title "Unregelmäßige (AB)". No literature was found to describe fruits like the three samples found.

Figure 64: Photographs of F1 fruits (above) and stones (below) (pictures private)

Figure 63: Photographs of A8 fruits (above) and stones (below) (pictures private)

The trees had different tree top shapes: high pyramidal (F1), flat pyramidal (S21) or spherical (A8). Growth form ranged from spreading (F1) over semi-drooping (A8) to drooping (S21). Fruit load was high for A8 and S21, but low in case of F1. All trees showed low maintenance and vitality. Shot hole disease symptoms were found in medium strength on F1 and A8; S21 did not show symptoms of the disease.

The stalk length of the samples of "Unregelmäßige (AB)" was found short (S21, F1) or medium (A8). The size of the sampled fruits was classified as medium (F1, A8) to big (S21) and their weight as medium (S21, A8) and low (F1). The fruit shape was described as kidney-shaped (F1, A8) and oval to heart-shaped (S21) with medium shouldering for all samples. The pistil side was even in all three samples, with a big pistil that is positioned even (S21) or indented (F1, A8). The seam was expressed weak (A8) to medium (S21, F1). Generally, all three samples show an irregular shape with a more or less bulged seam and back side and dimples scattered over the fruits. The fruit flesh of F1 and S21 was categorized red with red juice, whereas A8's fruit flesh was colored dark-red and possessed a black-red juice. F1 and S21 showed a medium to high fruit flesh firmness, whilst the flesh of A8 was rather soft. White veining was found strong in F1 and A8; S21 showed medium white veining. The taste of F1 and S21 was classified as balanced, A8 was labeled as highly sweet. The aroma ranged from mildly aromatic (F1) to aromatic (S21, A8). F1's sweetness was described as low, the acidity as medium to high. S21 showed low to medium sweetness and medium acidity. A8 finally had developed a high to very high sweetness and medium acidity. The taste differences may be due to different harvest date. The fruits of A8 were harvested later than F1's and S21's and showed higher sweetness and high aroma, as well as darker skin, fruit flesh and juice color. The stone was found oval to egg-shaped from lateral view in all three samples and narrow elliptic from the ventral view. Also the stone tip was categorized straight for all of the samples. Stone ease was described as easy (F1, S21) to bad (A8).

The fruits are of medium firmness, on the brink to high firmness. A transport would be possible. The fruits show promising taste qualities and are fit for fresh consumption. A utilization for preservation is thinkable for ripe fruits with high fruit flesh and juice color.

7.2 Comparison of “Rainkirsche” and “Pfelzer (LB)” with ‘Große Germersdorfer’

Finally, the land races “Rainkirsche” and “Pfelzer (LB)” shall be compared to a well-known standard cultivar, in this case ‘Große Germersdorfer’. All presented traits and characteristics are taken from the samples taken in Scharten. Especially in case of ‘Große Germersdorfer’ there may be small differences to the description in the literature. The values are an average of all found ripe samples.

Table 39: Comparison of selected characteristics of the sampled “Rainkirsche”, "Pfelzer (LB)" and 'Große Germersdorfer

Trait	“Rainkirsche”	“Pfelzer (LB)”	‘Große Germersdorfer’
Example picture	 	 	 
Fruit shape	kidney-shaped to round	heart-shaped	round to heart-shaped
Average fruit size [mm]	20.1 mm = small	23.4 mm = big	25.3 mm = very big
Average fruit weight [g]	4.6 g = lightweight	6.6 g = heavy	8.2 g = very heavy
Average stone weight [g]	0.34 g = very heavy	0.42 g = very heavy	0.42 g = very heavy
Average stone share [%]	7.4% = very high	6.1% = high	5.3% = medium
Skin color	black	dark red	red to dark red
Fruit flesh color	dark red	red	pink
Juice color	black red	red	pink
Taste type	harmonic, aromatic	balanced, fine aromatic, bitter tones can appear	harmonically with spicy acidity

8. Summary and conclusion

In this work, 75 trees were mapped in the community of Scharten and marked in aerial photographs. 30 of these trees were then evaluated and rated by several vegetative and various generative parameters. Cluster analysis showed strong clustering for some cultivars (“Rainkirsche”, “Pfelzer (LB)”), while other cultivars showed a wider variance and more loose clustering. A closer look on plant nutrients of five selected samples revealed that especially samples of “Rainkirsche” showed comparatively high antioxidative capacity and high amounts of cyanidin equivalents. In the end, seven common cultivars, two local varieties, three seedlings and one unknown variety were found. These were described and compared to existing literature.

As a future perspective, I suggest to conduct a complete cataloging of the sweet cherry trees existing in Scharten and the Nature Park *Obst-Hügel-Land*. Especially a more broad examination of the local cultivars “Rainkirsche” and “Pfelzer (LB)” could lead to interesting findings. The variance in the measured and evaluated samples makes it likely that several subgroups may be discovered in the local cultivars.

Scion wood should be gathered in time to preserve old and interesting cherry trees in bad condition or with low vigor. In Scharten, the authorities and private persons already work together to

Another proposal would be to start special marketing campaigns for these local sweet cherry cultivars. As already mentioned, the samples of “Rainkirsche” showed very promising contents in antioxidative capacity and cyanidin equivalents. Since these attributes are currently of high scientifically and media interest, “Rainkirsche” is an ideal candidate for promoting these values. Its small fruit weight and size and soft fruit flesh may be reducing the profits of “Rainkirsche” with usual marketing techniques. Special campaigns to promote the health and rationality aspects of “Rainkirsche” could help overcome this obstacle.

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Appendix

Table 40: Tree identification and location sheet

Tree code	Variety	Date	BBCH	Bloom intensity	Location	Comments

Table 41: Tree evaluation sheet, part 1

Tree code	Date	GPS	Fruit load	Ripeness	Growth type	Tree top shape	Comments

			Categories:				
			1 = missing	1 = unripe			
			3 = low	2 = marginally ripe			
			5 = medium	3 = ripe			
			7 = high	4 = overripe			
			9 = very high				

Table 42: Tree evaluation sheet, part 2

Tree evaluation						
Date						
Tree code						
GPS coordinates						
Variety						
Picture						
Owner						
Underground						
Age estimated						
Trunk circumference						
Trunk height						
Tree top shape						
Growth type						
Fruit load						
Condition						
Maintenance						
Vitality						
Overall impression						
Pruning						
Scion wood						
Dead wood						
Shot hole disease (0-5)						
Damages						
Pruning						
Pruning position						
Comments						

Table 43: Fruit measurement sheet

Fruit measurement										
Date			**Tree code**							
Variety										
Fruit nr.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Fruit length [mm]										
Fruit width [mm]										
Fruit gauge [mm]										

Stalk length [mm]										
Fruit skin color										
Stalk release force [N]										
Fruit weight [g]										
FFF [N]										
SS [°Brix]										
Juice color										
pH										
Stone length [mm]										
Stone width [mm]										
Stone gauge [mm]										
Stone weight [g]										
Titrable acid										

Table 44: Fruit evaluation sheet

Fruit evaluation									
Date		**Tree code**							
Variety									
Variety determined	yes	unclear		no	**By whom**:				
Comments									
Fruit shape	1	2	3	4	5				
Skin color	1	3	4	5	7	9			
Stalk side shape	1	2	3	4					
Stalk side width	3	5	7						
Stalk side inclination	1	2	3						
Stalk groove depth	1	3	5	7					
Stalk groove width	3	5	7						
Pistil side shape	1	2	3	4					
Pistil position	1	2	3	4					
Pistil location	1	2	3						
Pistil size	3	5	7						
Seam	1	3	5	7					
Seam side to pistil	1	3							
Fruit (seen from above)	1	3	5	7					
Tasting									
Ripeness	1	2	3	4					
Fruit flesh color	1	2	3	4	5				
Juice color	1	3	5	7	8	9			
White veining	1	2	3						
Stone ease	1	2	3						
Taste type sweet/sour	1	3	5	7	9				
Taste type	1	2	3	4	5	9			
Sweetness	1	2	3	4	5	6	7	8	9
Acidity	1	2	3	4	5	6	7	8	9
Comments									
Stone									
Stone lateral view	1	2	3						
Stone ventral view	1	2	3						
Stone tip	1	2	3						