HAMK
HÄMEEN AMMATTIKORKEAKOULU

Effect of Raw Materials (Currants and Apples) on the Processability and Quality of Finnish Country Fruit Wines

Sanna Lento, Tuija Pirttijärvi and Mikko Hasu

Effect of Raw Materials (Currants and Apples) on the Processability and Quality of Finnish Country Fruit Wines

Sanna Lento, Tuija Pirttijärvi ja Mikko Hasu

Final Report
Ministry of Agriculture and Forestry Doc. no. 4535/504/2006

Funded by:
Ministry of Agriculture and Forestry, Rural Policy Committee
HAMK University of Applied Sciences
Finnish Wine Growers' Association

HAMK University of Applied Sciences

Sanna Lento, Tuija Pirttijärvi and Mikko Hasu
Effect of Raw Materials (Currants and Apples) on the Processability and Quality of Finnish Country Fruit Wines

ISBN 978-951-784-525-0 (PDF)
ISSN 1795-424X
HAMKin e-julkaisuja 11/2010

Cover picture: Tuija Rosvall ("Currants")

JULKAISIJA – PUBLISHER
HAMK University of Applied Sciences
PO BOX 230
13101 Hämeenlinna, Finland
Tel. +358 (0)3 6461
julkaisut@hamk.fi
www.hamk.fi/julkaisut

Format and layout: HAMK Publications

Hämeenlinna, September 2010

Abstract

Effect of raw materials (currants and apples) on the processability and quality of Finnish country fruit wines

In the last 15 years, country fruit wineries have become established as a common rural commercial enterprise in Finland. The sector is subject to limited sales licences. Winemakers have acquired practical experience of the basic competence required in production and of the use of diverse raw materials. However, empirical data is needed for the development of products and thus the improvement of competitiveness.

The aim of this project was to investigate the significance of the most common raw materials – apple and currant varieties – on the winemaking process and the quality of the end product. The study encompassed fruit varieties that were already commonly in use, as well as new varieties that had shown promise in cultivation tests. In all, the study looked at 16 apple varieties and 21 currant varieties. There was no prior research data on the suitability of different varieties for country fruit winemaking or on their effect on the sensory properties of apple and currant wines.

The research involved making apple and currant wines from different varieties according to the Finnish country fruit wine process. The research project spanned three years, allowing for differences between harvests to be taken into account. The juice content chosen for apple wines was 50 %, while for currant wines it was 25 % due to their higher acidity. The target alcohol content was 12 % by volume. The conditions for pressing, fermentation and aging were constant. The products were sweetened to have the same sugar content per fruit type, and evaluated in a blind tasting. The evaluation considered the properties of the wine that come from the raw ingredients, such as the depth of colour, the fruitiness of the aroma, and the acidity, full-bodiedness, length and fruitiness of the flavour.

All raw ingredients were processed without problems and resulted in technically good fruit wines. In the apple wines, as in the currant wines, the dif-

ferences in variety and crop year were most clearly reflected in the depth of the wine's colour. The effects of varieties on apple wines were small.

The deepest colour was produced by the following varieties: 'Åkerö' apples, 'Ranetka Purpurovaja' crab apples, 'Mortti' blackcurrants, 'Venny' and 'Vilma' greencurrants and 'Rovada' and 'Punahilkka' redcurrants. Rovada wine was significantly more acidic than the other redcurrant wines. 'Strain 85' by Agrifood Research Finland produced the least acidic whitecurrant wine. The apple variety was found to affect the full-bodiedness of flavour and the fruitiness of the aroma. Bottle aging (14 months) somewhat reduced the flavour of apple wines. However, aging was found to have a positive effect on the colour, aroma and flavour of blackcurrant wines.

The project also investigated the effect of water on wine quality. Ordinary, good-quality tap water from three different regions was used in whitecurrant wine production. No effects arising from the water were observed in sensory testing.

The project's main funding came from the Rural Policy Committee of the Ministry of Agriculture and Forestry.

Keywords currants, apple, berry wine, country fruit wine, processing, sensory evaluation, quality

Contents

Foreword

This project required contributions from many people. The research was based on raw materials – apples and currants – which came from the Piikkiö unit of Agrifood Research Finland. I particularly wish to thank Professor Risto Tahvonen and Senior Researcher Jorma Hellsten for their assistance. Research Assistant Paula Vanhatalo and student Lotta Kaila deserve great thanks for carrying out the research. I would like to thank winemaker Urpo Koivusalo and Sirpa Villanen for providing the water samples for the research, as well as Anneli Pehrman for supplying the necessary quantity of 'White Finn' currants. The sensory evaluation of the wines involved many people, and I thank them all for their participation.

Thank you also to our sponsors, the Rural Policy Committee of the Ministry of Agriculture and Forestry, the Finnish Wine Growers' Association and HAMK University of Applied Sciences.

Sanna Lento

Hattula, 29 April 2010

1 Project Background

Small-scale country fruit winemaking in Finland began, subject to licence, in 1995. A Government decision on fruit wines (852/1995) had the aim of increasing the use of Finnish raw materials in alcoholic beverage production, revitalising the countryside and creating new rural jobs. Retail licences are only granted to producers of fruit wines and home-brewed beer whose manufacturing and sales operations form a part of the local region's agricultural industry.

Country fruit wine production is a part of agriculture in Finland and is significant in terms of national rural policy. According to the Finnish Alcohol Decree (1344/1994), the berries and fruit used as raw materials in production, as well as the plant matter used for flavouring, must come from a growth zone within the European Economic Area, whose typical characteristics arise to the north of the latitude 60 degrees North. At least 50 per cent of the raw materials must come from cultivated areas owned or managed by the licensee.

According to the National Supervisory Authority for Welfare and Health (Valvira), there were 40 retail licences for country fruit wines at the end of 2009.

The raw materials for fruit wines are usually plants that are readily available and cultivated in Finland. Fruit wineries operate in diverse parts of the country, which is a challenge and also an opportunity for each entrepreneur to specialise in ingredients typical to the local area. The main ingredients of Finnish country fruit wines are currants (black, red, white and green) and apples.

Winemakers have acquired practical experience of the basic competence required in production and of the use of diverse raw materials. Financially viable wine production cannot, however, be based on experimentation with various available raw materials. Producers need clear information on the suitability of plant species and varieties for Finnish country winemak-

ing and production processes, and on their effects on the sensory properties of country fruit wines.

Raw materials research that includes the perspective of how the materials can be used can help growers and parties involved in further processing in their work, and can increase market orientation. It is hoped that good Finnish raw materials can be used more extensively in industry. Research data related to raw materials and their processability may be widely applicable for interested parties.

The recent adoption of a unique quality classification for berry and fruit-based alcoholic beverages has also increased the need for research data for use in developing country fruit wine production. According to the system, a country fruit wine may be classified as a varietal wine, a type wine, a regional wine or a house wine.

The quality system and winemaking experience have created a need to identify the most suitable varieties for country fruit wine production. Finding the optimal varieties to use in low-volume, unique Finnish country fruit wines would bring added value and thus increase the competitiveness of wineries. New raw materials may also lead to product innovations.

2 Project Aims

The aim of the project was to identify the currant and apple varieties that are most suitable for country fruit wines and the winemaking process. The study was to produce information on how specific raw materials affect the basic characteristics and sensory properties of berry and fruit wines, and how they behave during the production process. One test batch was also used to investigate the effect of water quality on the sensory properties of berry and fruit wines. The proportion of water used in fruit wines is usually between 60 and 75 per cent.

3 Project Management and Funding

3.1 Organisation and Personnel

The organisation in charge of the project was HAMK University of Applied Sciences (HAMK), Lepaa unit. The project was conducted between 1 April 2007 and 31 July 2010. The project team comprised the following persons:

Project Manager: Sanna Lento, MSc (Tech.), Production Assistant, HAMK

Project Assistant: Paula Vanhatalo, Bachelor of Natural Resources, HAMK

Researcher: Tuija Pirttijärvi, Doctor of Food Sciences, Principal Lecturer, HAMK Degree Programme in Biotechnology and Food Engineering

Project Specialist: Mikko Hasu, Wine Instructor, Bachelor of Natural Resources, Bachelor of Engineering (Biotechnology and Food Technology) (on leave of absence 1 December 2007 – 29 June 2010)

The sensory evaluation of the wines was conducted by an evaluation panel (of seven members) trained within the project that created the national quality classification for Finnish country fruit winery products, as well as five persons from businesses in the sector and from among the project team.

3.2 Partners

The project was supervised by the following persons:

Veli-Pekka Reskola, Senior Advisor, Ministry of Agriculture and Forestry

Professor Risto Tahvonen, Varieties Specialist, Agrifood Research Finland Horticulture

Jouni Huusari, Winegrower, Tyryn Viini Oy, Mäntyharju

Paula Arki, Product Development Specialist, Oy Roberts Ab, Turku

Kaarina Hänninen, PhD, Head of Degree Programme, HAMK representative

Jorma Ahonen (Marjatta Kariniemi), HAMK Project Services Group

Sanna Lento, Project Manager, HAMK

3.3 Partners

The project's partners were Finnish country wineries, the Finnish Wine Growers' Association, Agrifood Research Finland (Piikkiö) and the Bioeconomy Education and Research Centre and the Degree Programme in Biotechnology and Food Engineering at HAMK University of Applied Sciences.

3.4 Funding

The total cost of the project was EUR 150,000. The project's main funding (92 %) came from the Rural Policy Committee of the Ministry of Agriculture and Forestry. Other funding was provided by HAMK University of Applied Sciences (6 %) and the Finnish Wine Growers' Association (2 %). The Piikkiö unit of Agrifood Research Finland donated the currants and apples used as raw materials in the research.

4 Research Methods and Materials

4.1 Raw Materials

The basic ingredients of country fruit wine production in Finland – apples and currants – were chosen as the raw materials for the research. The raw material choices were made by the Piikkiö unit of Agrifood Research Finland. The researchers wanted to use varieties that were already professionally cultivated and used in fruit wine production, as well as new cultivars. The selection criteria for the apple varieties was that they must have colour, aroma, acidity and sugar content. With the exception of the type varieties, there was no prior research data on the suitability of apple and currant varieties for winemaking.

Because of this lack of data on the effect of the variety on the processability and quality of apples and currants, and due to the researchers' wish not to exclude potentially promising varieties, a relatively large number of varieties was initially selected for the study. Each raw material had to fulfil the following criteria:

- a minimum of 4 kg (for currants) or 10 kg (for apples) of the raw material must be available (enough for one batch of approx. 9 l of wine)
- the raw material must be in cultivation and at least two reference samples must be available of the same variety in the following crop years (the reference samples could be from different years)

The intention was to reduce the number of varieties as the research progressed, with the aim of looking more closely at the most processable and aromatic varieties, such that at least three batches of wine per variety would be produced. The number of reference batches was limited, however, due to variations between crop years and the small volumes that were available of new cultivars. Due to some poor crop years, certain varieties were acquired from Lepaa and Pälkäne.

Sixteen apple varieties and 21 currant varieties were included in the study. Apples were processed at a level of ripeness ready for eating state, while currants were processed thawed after freezing. The amount of each variety ranged between 3 and 7 kg for currants and 10 and 20 kg for apples. Reference batches could be produced of some varieties.

The raw materials were subjected to sensory evaluation by 3 – 4 project team members, using the form in Appendix 1.

Below is a list of the apple and currant varieties used in the research study (in brackets are the crop year, the number of wine batches [if more than one] and the place of origin [if other than Piikkiö]). The apple varieties were classified according to their maturation.

Apples

Summer varieties

Petteri (2007, 2008)
Valkea Kuulas (2007, 2008:2 Lepaa)
Vuokko (2007, 2008:2 Lepaa)

Late season varieties

Heta (2007, 2008:2 Lepaa)
Raike (2007, 2008:2 Lepaa)
Samo (2007, 2008:2 Lepaa)

Winter varieties

Antonovka (2008:2 Lepaa)
Juuso (2007, 2008:2 Lepaa)
Konsta (2007:2, 2008:2 Lepaa)
Lepaan Liereä (2007 Lepaa)
Linda (2007)
Lobo (2007:2, 2008:2 Lepaa)
Punainen Atlas (2007:2, 2008:2)
Tobias (2008:2)
Åkerö (2008:2)
Ranetka Purpurovaja (marjaomena) (2007)

Currants

Blackcurrants

Marski (2007, 2008, 2009)
Mikael (2007, 2008, 2009)
Mortti (2007, 2008, 2009)
MTT:n jaloste 15 (2007, 2008, 2009)
MTT:n jaloste 36 (2007, 2009)

Redcurrants

MTT:n jaloste 103 (2005, 2006, 2009)
MTT:n jaloste 110 (2008, 2009)
Punainen Hollantilainen (2005, 2006, 2008, 2009)
Punahilkka (2006, 2007:2, 2008, 2009)
Rotes Wunder (2005)
Rovada (2008, 2009)

Whitecurrants

Blanka (2008, 2009)
Inkilän Annukka (2008)
MTT:n jaloste 81 (2005, 2006)
MTT:n jaloste 85 (2005, 2006, 2008)
MTT:n jaloste 97 (2005, 2006, 2008)
Valkea Jüterbog (2008)
Valkea Suomalainen (2005, 2006, 2007 Nurmijärvi (vesikoe 3*3 viinierää), 2008, 2009)

Greencurrants

Venny (2007 Pälkäne, 2008, 2009)
Vertti (2007, 2008, 2009)
Vilma (2007 Pälkäne, 2008, 2009)

4.2 Apple Variety Descriptions

4.2.1 Summer Varieties

Petteri (Lobo x Huvitus). The fruit is evenly round, medium or small in size, and with a waxy skin. The colour is intense red. Petteri gives an abundant yield each year, but as the tree ages, the size of the fruit will reduce unless the necessary pruning is done. Petteri is sensitive to winter damage so it is only suitable for cultivation in Zone 1. (Kinnanen et al. 2007, 181, 185.)

Valkea Kuulas is an old variety that originated in the Baltic region. Its fruit is round or slightly conical. The ground colour is yellow or pale. The flesh is crisp, fresh and spicy. Due to its thin skin, the variety is sensitive to surface damage. (Kinnanen et al. 2007, 181, 186 – 187.) The apples mature in August and may turn translucent when ripe (Blomqvist 2005, 127).

Vuokko (Melba x Huvitus). The fruit is large or medium-sized, with a conical to round or almost cylindrical shape. The yellow ground colour may develop a reddish-brown blush and cork spots are clearly visible. The flesh is juicy but relatively hard and coarse. The fruit is sugary but acidic. Vuokko is a high-yield variety that keeps well for an early-season apple. (Kinnanen et al. 2007, 181, 184 – 185.)

Figure 1. Summer varieties, from left: Petteri, Valkea Kuulas and Vuokko.

4.2.2 Late Season Varieties

Heta (Lobo x Huvitus). The fruit is large and roundly conical. The colour is red. Some red colouring may also be found in the flesh. The skin is shiny and waxy. Heta is a juicy and suitably acidic eating apple. (Kinnanen et al. 2007, 193.)

Raike (Duchess x Lobo) is a variety brought to Finland from Canada. Its fruit is medium-sized or large, roundish, somewhat conical and ribbed. The ground colour is yellowy. A red stripe may cover most of the apple. The flesh is white and green, with a sour, modest flavour. (Kinnanen et al. 2007, 198.)

Samo (Melba x Huvitus). The fruit is medium or large in size, round or conical in shape. A reddish-brown blush covers the yellow ground colour. The taste is fresh and crisp, and the flesh is juicy. (Kinnanen et al. 2007, 189.)

Figure 2. Late season varieties, from left: Heta, Raike and Samo.

4.2.3 Winter Varieties

Antonovka originates in Ukraine and is one of Russia's oldest cultivars. It has long been cultivated in Finland, having been in the standard catalogue of cultivars as early as in the first half of the 1900s. The apples are medium-

sized or large, varying in shape from oblong to roundish, and often asymmetrical and strongly ribbed. Their ground colour is greenish yellow, and yellow when ripe. The flavour is strongly acidic, with a refined aroma when ripe. The trees begin yielding early and are usually generous. The variety is resistant to scab and winter-hardy, which is why it is often used in breeding. Good apple for household use, requiring a few weeks of storage. Keeps in storage for a couple of months.

Juuso (Antonovka x Lobo). The fruit is large, evenly round and impressive. The colour is almost entirely red. The flesh is crisp and juicy. The flavour is aromatic and finely acidic. (Kinnanen et al. 2007, 181, 201.)

Konsta (Lobo x Antonovka). The apples are large or medium-sized. The colouring is almost entirely red, with a white and coarse flesh. The taste is acidic, with a mild aroma. (Kinnanen et al. 2007, 201 – 202.)

Lepaan Liereä (Åkerö x Antonovka). The fruit is medium-sized, roundly conical, with a greenish tinge. When ripe, the colour is almost lemon yellow. The flesh is firm and juicy. The apples are acidic and aromatic. (Kinnanen et al. 2007, 204 – 205.)

Linda is a Canadian winter variety that arrived in Finland in the 1930s. The fruit is large, round and somewhat ribbed. The ground colour is yellow and it is covered by an even or patchy red blush. The flesh is white, crisp, refreshingly acidic and slightly spicy. (Krannila & Paalo 2008, 119.)

Lobo is a Canadian variety with medium-sized or large, round to flat fruit. The skin is thick and often coated in a bluish wax. The ground colour is yellowy green, often completely covered in a red blush. The flesh is soft, juicy, mild and almost acid-free. The aroma is weak but refined. (Kinnanen et al. 2007, 181, 199 – 200.) According to a survey by Statistics Finland (2007), Lobo is Finland's most common cultivar.

Punainen Atlas is a Canadian variety with conical fruit having a green ground colour. A red blush appears in dark stripes. The apples are slightly sour. (Kinnanen et al. 2007, 202.)

Tobias (Lobo x Huvitus). The fruit is medium-sized or large, roundly conical in shape, narrowing towards the eye. The skin is strong, making the fruit resistant to handling. The ground colour is yellowy green, and it is almost entirely covered by dark and bright red stripes. There is also red in the flesh. The flavour is aromatic and sweet.

Åkerö is a Swedish variety. The fruit is medium-sized or small and barrel-shaped. It is characterised by a bulge at the base of the stem. The ground colour is yellow, commonly with a thin brick-red blush. The flesh is coarsely textured and hard, yet succulent. The flavour is mildly acidic, sweet and spicy. Åkerö is a delicacy.

Figure 3. Winter varieties, from left: top row: Antonovka, Juuso, Konsta; middle: Lepaan Liereä, Linda, Lobo; bottom row: Red Atlas, Tobias and Åkerö.

4.2.4 Crab Apple

Ranetka Purpurovaja is a Russian crab apple variety. The fruit is berry-like, with a diameter of 1.5 – 2 cm. It is red and yellow in colour. (Hokka, Laamanen, Lahtonen, Pöyhönen & Uosukainen 2009.)

Figure 4. Ranetka Purpurovaja (crab apple).

4.3 Currant Variety Descriptions

4.3.1 Blackcurrants

Marski (87 034 060) (Hedda x Mortti). Flowers as Mortti or slightly earlier. The bush is fairly vertical in growth. The yield is greater than in Öjebyn, but usually slightly smaller than in Mortti. The berries are larger than in Mortti. Powdery mildew was not found during the growth period. Clean parent plants will be available at the Laukaa research and breeding centre from 2010.

Mikael (79 044 026) (Brödtorp ip x Brödtorp ip (3.p)). Flowering is as in Mortti, although slightly earlier on old bushes. Generous yield. Berries are sized similar to Mortti, but sweeter. Powdery mildew was not found during the growth period. Clean parent plants will be available at the Laukaa research and breeding centre from 2010.

Mortti (67 008 081) (Öjebyn x Wellington XXX). Strong and tall bush with vertical growth. Generous yield. The berries are firm, with a thick skin. Resistant to winter and mildew in Finland. Flowers and ripens slightly later than Öjebyn. (Matala 1993, 174 – 175.)

ARF Strain 15 (79 032 027) (Risager ip). Bush with moderately vertical growth, although lower than Mortti. Exceptionally winter-hardy compared to all others. No powdery mildew has been found on the strain. Very generous yield compared to other varieties, but the berries are very strong and sour. Seedlings are not available.

ARF Strain 36 (87 021 022) (Hedda x Ben Sarek). Lower and less vertical bush than Mortti. Similar to Mortti in yield and quality. Seedlings are not available.

4.3.2 Redcurrants

ARF Strain 103 (90 026 058) (Red Dutch x Rondom). Somewhat earlier variety than Red Dutch. Similar in height to Red Dutch but slightly narrower. Fewer lateral shoots than in Red Dutch, making harvesting easier. Yield similar to Red Dutch or slightly greater. Susceptible to defoliant disease, and will not produce proper yields without spraying. Seedlings are not available.

ARF Strain 110 (90 051 024) (Fortun x Rondom). Flowers at the same time as Red Dutch. Pale red berries. Taller and wider bush than the Red Dutch, with a tendency to creep when young. Matures for harvesting more quickly than other varieties. High-yielding. Some growth on non-crop-bearing bushes was found be affected by powdery mildew. Susceptible to defoliant disease, and will not produce proper yields without spraying. Suitable for mechanical harvesting. Seedlings are not available.

Punahilkka (90 002 033) (White Dutch, Juva x Valkea Jüterbog). Vertically growing bush, larger than Red Dutch. The leaves are usually reddish or very dark; a decorative plant. Earlier to harvest than Red Dutch, with beautiful, dark-red, droplet-shaped berries. Low acidity, excellent for use when fresh. Susceptible to defoliant disease, and will not produce proper yields without spraying. Suitable for mechanical harvesting. Clean parent plants will be available at the Laukaa research and breeding centre from 2010.

Red Dutch. Over 300-year-old variety, of which many different strains exist. Large bush with strong, vertical branches which are easily damaged by mechanical harvesting. The berries are relatively small and fairly acidic, with large seeds. The variety is partly self-sterile, so pollination problems may arise if the flowering period is too cool or too hot. Winter-hardy. Susceptible to defoliant disease, and will not produce proper yields without spraying. Reaches harvesting maturity fairly late. Highly suitable for industrial use. (Matala 1993, 177 – 178.)

Rotes Wunder. German modification of Red Dutch. Similar to the latter in many ways. Has been found in tests to have somewhat higher yields than Red Dutch. (Matala 1993, 178.)

Rovada. Flavourful redcurrant developed in the Netherlands. The leaves are easily damaged by rain and the bush is susceptible to defoliant disease. Quick and strong growth; reaches harvesting maturity early. Bears clusters of large berries that ripen early.

4.3.3 Whitecurrants

Blanka. High-yield Dutch variety, whose shiny champagne-coloured berries ripen late in the season.

Inkilän Annukka. Heirloom strain from the Inkilänhovi estate in Juva. Beautiful, flavourful berries. Smallish bush. Bushes have been found to be healthy in Piikkiö, but powdery mildew was found in small bushes after propagation. Seedlings are not currently available.

ARF Strain 81 (90 007 003) (Ri 200 x White Dutch, Juva). Slightly smaller bush than the White Dutch. Not very vertical. Flowers at the same time as White Dutch. Pink, sweetly acidic berries. Seems to provide a high yield. Fairly susceptible to defoliant disease. Seedlings are not available.

ARF Strain 85 (90 008 006) ('Helmi', from White Dutch, Juva x Ri 308). Slightly smaller but more vertical bush than the White Dutch. Flowers slightly earlier than the White Dutch. Sweet and attractive berries that look like pearls. Fairly susceptible to defoliant disease. Seedlings are not available.

ARF Strain 97 (90 059 055) ('Timantti', from White Dutch, Juva x Red Dutch). Slightly smaller but more vertical bush than the White Dutch. Flowers slightly earlier than the White Dutch. Fairly sweet, beautiful berries. Seems to provide a high yield. Fairly susceptible to defoliant disease. Seedlings are not available.

Valkea Jüterbog is a German variety. Produces a fairly low and wide bush that ramifies at the base. Flowers and ripens at the same time as White Dutch. Optimally a high-yield variety. Produces long berry bunches on the lower parts of the bush, which makes mechanical harvesting difficult. Easily damaged by mechanical harvesting. The berries are fairly tightly attached and acidic in taste. Susceptible to defoliant disease. (Matala 1993, 180.)

Valkea Suomalainen is a strain selected for propagation of White Dutch. Very old variety. Large, vertical bush with stiff branches. Flowers early and harvests a few days before Öjebyn blackcurrants (Matala 1993, 180). Fairly easily damaged by mechanical harvesting. The berries are smallish, usually on long bunches. Milder taste than in redcurrants. Fairly regular yields. Suitable for industrial and household cultivation. Fairly susceptible to defoliant disease.

4.3.4 Greencurrants

Venny (86 015 040). Finnish variety selected from stock descendant from Vertti and green currants. Planted for seedling production in Laukaa in 2006. Stronger but slightly more vertical growth than in Vertti. Forms a fairly wide, moderately tall bush. Taller, wider and higher-yielding than Vertti. The berries do not fall off easily and are yellowy-green when ripe. Brown spots may appear, but fewer than in Vertti. More acidic than Vertti and Vilma. Similar size of berry as in Vertti: 62 g/100 berries in testing. Flavourful berries.

Vertti is a Finnish variety selected from self-pollinated stock of Öjebyn. Launched on the market in 1987. Grows more slowly and more vertically than Öjebyn. Forms a fairly wide, moderately tall bush. Fairly low yield. The berries are yellowy-green when ripe and may have brown spots. Smaller size of berry than in Öjebyn: 62 g/100 berries in testing. Compared to blackcurrants, the berries are mild and aromatic. The variety has attracted some interest from industry. Suitable for the fresh market, e.g. jams and jellies, due to its specialist nature and flavour. Also suitable for home growing. Commercial cultivation is stopping due to the berries' susceptibility to falling off the branch. (Matala 1993, 172.)

Vilma (86 007 185). Finnish variety selected from stock descendant from Vertti and green currants. Transferred to Laukaa for seedling propagation in 2006. Stronger but slightly more vertical growth than in Vertti. Forms a fairly wide, moderately tall bush. Taller, wider and higher-yielding than Vertti. The berries do not fall off easily. The berries are yellowy-green when ripe and may have more brown spots than Vertti. Slightly sweeter than Venny and smaller than Vertti: 59 g/100 berries in testing. Sweet and flavourful berries.

4.4 Pressing

The frozen and thawed currants were crushed by hand by squeezing them with a steel container. The purpose of crushing was to break both the skin and the structure of the berries. This manual crushing was comparable to the usual method of passing the berries between rubber rollers.

The crushed berry mass was heated to approx. +35 – 40 °C, after which pectinase enzyme was added at 0.35 ml/kg (Senson Oy, Biopectinase CCM). The enzyming time was approx. 2 hours. The effect of the enzyming was checked with pectin testing.

The apples were processed fresh (ripe for eating). They were crushed using a centrifugal crusher (EPL 23 Mixer, Enotecnica Pillan) (Fig. 5). Pectinase enzyme (0.15 ml/l) was added to the juice.

Figure 5. Apple crusher (EPL 23 Mixer, Enotecnica Pillan).

Juicing was done either by hand in a 4.5-litre juice press (Palumbo) (Fig. 6) or in a 40-litre hydraulic pressure juicer (EPL 740, max. 4 bar) (Fig. 6), depending on the quantity of raw materials.

Figure 6. 4.5 l juice press (Palumbo) used for pressing currants (left) and 40 l hydraulic pressure juicer (EPL 740) used for apples.

4.5 Mixing of the Must

In the study, the juice content of the must was standardised to 25 % for currants and 50 % for apples.

The target alcohol content for the wines was 12 % by volume (target sugar content of must 203 g/l), except for the blackcurrant wines from 2007, where the alcohol content was 11 % by volume. The sugar used was granulated sugar (sucrose). Then 30 g/hl of yeast nourishment (SIHA-Gärsalz, E. Begerow GmbH) and wine yeast (Lalvin 1116, Lallemand) were added.

4.6 Fermentation

The fermentation vessels were 10-litre steel pressure vessels (Das Finn-Keg) (Fig. 7). Stainless steel as a material corresponds to fermentation in a tank. It is hygienic and does not affect the flavour of the product. The vessel was closed with an ascending tube and a coupling clip (MicroMatic) that was used to create a fermentation lock. Sampling during fermentation was done by passing carbon dioxide gas into the vessel from the gas side of the coupler. This extracted the sample from the vessel without inserting air.

Figure 7. Ten-litre steel vessels (Das Finn-Keg) used for the fermentation and aging of apple and currant wines.

The temperature of the fermentation room was maintained at approx. 20 °C. The progress of fermentation was monitored by measuring the sugar content of samples once a week. Fermentation was stopped by transferring the fermentation vessel to a temperature of 12 °C once the sugar content fell below 10 g/l.

Approximately two weeks after fermentation, the yeast was removed from the wine by siphoning. Sulphur dioxide (100 mg/l) (SIHA potassium pyrosulphite, E. Begerow GmbH) and potassium sorbate (220 mg/l) (SIHA potassium sorbate, E. Begerow GmbH) were added to protect the wine from harmful bacteria and oxygen. Sulphur dioxide also helps in developing the wine's aromatic elements.

4.7 Maturing

In ordinary winemaking, the wine is clarified prior to maturing. The purpose of clarification is to reduce or remove unwanted elements from the wine using clarifiers. Clarification is used to achieve the desired clarity, colour, aroma and stability. The wines produced in this study were not clarified to avoid affecting the properties arising from the raw materials with clarifiers.

The wines were matured in a steel container in a cool environment for 1 – 2 months.

4.8 Analysis, Blending and Bottling of the Products

After maturing, the wine was prepared for bottling. They were subjected to chemical analysis. The wines were sweetened to have the same sugar content per fruit type, to make sensory evaluation easier. The target sugar content for red, white and greencurrant wines was 15 g/l, and for blackcurrant wines 20 g/l. For the apple wines, the sugar content was 9 g/l. The quantity of free sulphur dioxide in the wines was adjusted to approx. 30 – 35 mg/l.

The wines were filtered using a two-stage (coarse + fine) Sartorius cartridge filter (Sartoclean Mini-Cartridge) with pore sizes 3.5 µm and 0.8 µm. After filtration, the wine was bottled and sealed with natural corks. The wines were aged in the bottles for at least two weeks prior to sensory evaluation.

4.9 Analyses

Chemical analyses were mainly made according to the methodological instructions of the International Organisation of Vine and Wine (OIV).

The following analysis methods and equipment were used:

- Soluble solids (Brix) measured with refractometer (Atago N1 [Japan], Brix 0 – 32 %) at 20 °C
- Specific gravity measured with areometer at 20 °C (OIV method MA-E-AS2-01-MASVOL)
- pH measured with pH Meter CG 840 (Schott-Geräte GmbH) (OIV method MA-E-AS313-15-pH)
- Sugar content measured by titration using an alkaline copper salt solution (reduced sugars), Rebelein method (C. Schliessmann Kellerei-Chemie)
- Total acidity (titratable acids expressed as tartaric acid) measured using OIV method MA-E-AS313-01-ACITOT
- Alcohol strength by volume measured from distillate with a hydrometer (OIV method MA-E-AS312-01-TALVOL)
- Total dry extract calculated from the specific gravity of the wine and from the specific gravity of the water-alcohol mixture as measured by hydrometer (OIV method MA-E-AS2-03-EXTSEC)
- Sulphur dioxide content (free and total sulphur) measured by iodometric titration, rapid method (OIV method MA-E-AS323-04-DIOSOU)

4.10 Sensory Analysis of Varietal Wines

Initially, an evaluation method based on the national quality classification system for berry and fruit wines funded by the Ministry of Agriculture and Forestry was tested for the sensory evaluation of wines. The first evaluation of the 2005 and 2006 vintages of white and redcurrant wines was done according to this method. In it, the wines are ranked based on points, but it does not indicate why a certain sample is awarded certain points. The differences achieved were very small. Therefore a new evaluation method, taking into account both the typical characteristics of the fruit and the differences between varieties, was developed. The white and redcurrant wines from 2005 and 2006 were re-evaluated (on 8 October 2008) using the new method.

The criteria selected for sensory evaluation were the properties of the wines that were considered to be most affected by the raw materials. The chosen properties were the depth of colour, the fruitiness of the aroma, the fruitiness of the flavour, the acidity of the flavour, the full-bodiedness of the flavour and the length of the flavour. Grading was done on a scale of 0 – 5, according to strength. The evaluation form is in Appendix 2. The evaluation team involved 7 – 12 trained tasters. The evaluation was done as a blind tasting by type of fruit.

4.11 Statistical Processing of Data

The numerical results of the sensory evaluation and the chemical analysis results of the wines were statistically analysed for each raw material (apple, blackcurrant, greencurrant, redcurrant, whitecurrant). The analysis focused on the effect of the crop year, the effect of the variety and the statistical dependencies between the wines' sensory properties and the chemical properties of the juices and wines. The links between the chemical properties of the juices and the length of fermentation were also analysed. Data processing was done using Microsoft Office Excel 2007 software.

The effect of the crop year on the apple and currant wines' sensory properties was tested using one-way variance analyses and t-tests. In the cases where the crop year had no effect on the wines' sensory properties, the data for all the crop years were combined for testing the effects of the variety. First, one-way variance analysis was used to test whether the variety had any effect at all. Then, for the properties where differences were observed, the differences were localised using paired t-tests. For the properties where the crop year was found to be significant, the results for each crop year were kept separate and two-way variance analysis was used to analyse the effects of the variety.

The statistical interdependence of the sensory properties of the wines produced from the same raw material (different varieties and crop years), the chemical properties of the juices used for the wines, and the properties

of the apples or currants used as raw materials was analysed using Pearson's correlation coefficient (r). The test sample sizes (n), i.e. the number of batches of analysed wines, were as follows: apple wines 41, blackcurrant wines 14, redcurrant wines 16, whitecurrant wines 17 and greencurrant wines 9.

4.12 Water

One batch of whitecurrant wine was used to investigate whether the water used in winemaking has an effect on the sensory properties of the end product. The whitecurrant variety used in this test was White Finn from Nurmijärvi, from crop year 2007.

Three water samples were taken on 12 January 2009: one from Lepaa (Kanta-Häme, Hattula 61.067°N, 24.383°E), one from Veteli (Central Ostrobothnia, 63.467°N, 23.767°E) and one from Anttola (Mikkeli, Etelä-Savo, 61.365°N, 27.385°E). Three parallel whitecurrant wine batches were produced from the water samples on the next day. Processing was identical to that of the other currant wine batches. The juice content was 25 %, as for all the currant wines.

The researchers tested whether the whitecurrant wines produced with the different water types could be differentiated. This was done as a differentiation test, where evaluators were asked to identify one different sample from a set of three wine samples. There were 45 evaluators and three series of samples. The water sample pairs being tested varied. The evaluation form is in Appendix 3.

5 Results and Analysis

5.1 Apples and Apple Wines

5.1.1 Sensory Properties of Apples

The verbal descriptions of the apples' sensory properties are shown in Table 1. The evaluations of crop years 2007 and 2008 are combined. The sensory properties correspond well to the above descriptions of the varieties.

Table 1. Sensory properties of apples ripe for eating from crop years 2007 and 2008, evaluations by 3–4 evaluators.

Variety	Appearance	Smell	Taste
Summer varieties			
Petteri	Yellowish ground colour, dark red blush. Red-tinged flesh.	Strong smell before cutting (Christmas apple, vanilla); milder, acidic scent after cutting.	Cinnamony, slightly acrid, "Christmas apple", floury mouthfeel, slightly watery taste; unacidic, longish taste.
Valkea Kuulas	Even, light-green colour. Darker patches, dents on surface.	Ripe, includes core. Fairly strong scent even before cutting. Sweet, acidic/zesty, grassy.	Surprisingly acidic, short taste, some tannins, floury.
Vuokko	Mainly light-green, some red.	Cinnamony, fresh, lemony, fairly sweet vs. slightly zesty.	Very good eating apple, pleasant mouthfeel, somewhat floury structure. Firm flesh.

Late season varieties			
Heta	Green, half with red blush, rough brown patches.	Heavy scent, mushroomy, "basic apple".	Fresh, rich, Christmassy, like 'Jonagold'. Delicacy, good for applesauce?
Raike	Waxy, light-green ground colour, red blush on approx. 1/3, cork spots.	Very mild, almost non-existent.	Bitterness in the skin, mild taste, sharp acid, fresh, short, some tannin.
Samo	Green ground colour, some orange-red blush, some cork spots.	Very mild, almost non-existent.	Mild, slightly acrid, sweet, malic acid overpowering, "green" .
Winter varieties			
Antonovka	Light-green, rough surface.	Green, acidic scent.	Crisp mouthfeel, thin skin, harsh flesh.
Juuso	Waxy surface, green ground colour, red blush, large size.	"Clean laundry smell", sweet	Bitter, good as delicacy, crisp.
Konsta	Waxy skin. Light green with Christmas red blush.	Traditional apple smell.	Watery taste, somewhat floury flesh.
Lepaan Liereä	Cylindrical, light green.	Sweet, somewhat musty smell.	
Linda	Red-green, large. Some cork spots at stem.	Sweet, peachy.	Brittle texture. Somewhat acrid aftertaste. Tannins.
Lobo	Waxy skin, Christmassy red, blotchy blush.	Strongly smelling skin, aromatic.	Quite harsh structure.
Red Atlas	Cylindrical, size varies, yellow ground colour, half with red striped blush.	Strongly smelling skin, mild, off-putting right after cutting.	Acrid taste, firm flesh.
Tobias	Large size, Christmassy red blush, red-tinged flesh.	Jammy, scent of fresh apple.	Mild, floury.
Åkerö	Slightly oval, yellow ground colour with some red, dark patches below the surface.	Zesty.	

Crab apple			
Ranetka Purpurovaja	Cherry red, slightly blotchy. Rock hard.	Mild, no smell before cutting. Very acidic.	Strong tannins, acrid, rowan berry taste, brittle.

In the numerical data, the differences between varieties were only statistically significant ($p<0.01$) in the apples' sweetness and acidity. The most acidic variety, which stood out sharply from the others, was the crab apple Ranetka Purpurovaja. Also acidic were Antonovka, Linda and Raike, while the sweetest were Åkerö, Tobias and Lobo.

Based on the data it cannot be said that the smell of the apples, the toughness of the skin or the juiciness of the fruit differ in a statistically significant way between the apple varieties.

5.1.2 Apple Juice Analysis Results

The juice yields from the apples varied between 33 and 78 %. Slightly overripe apples, such as Petteri 2008, Heta 2007 and Lepaan Liereä 2007, produced lower juice yields than ready-to-eat fruit of the same varieties in other years. Raike had the highest juice yields at 68 – 78 %. The juice yields of summer, late season and winter varieties were on average 54, 62 and 57 %, respectively.

The integrity of the apples' surface and the toughness of the skin had a statistically significant effect on pressing. The more intact the surface of the apple had been perceived to be, the greater pressure could be used in pressing. The tougher the apples' skin, the higher the juice yield. The juice yield was also better when the apples had been perceived to be juicy.

The highest juice sugar content of the summer varieties was in Vuokko (99 – 103 g/l), of the late season varieties in Heta (98 – 103 g/l) and of the winter varieties in Linda (121 g/l), Åkerö (109 g/l) and Juuso (96 – 109 g/l).

The highest total acidity levels of the juice were found in Linda (15.5 g/l) and Red Atlas (13 – 14 g/l). The crab apple variety Ranetka Purpurovaja clearly differed from the apple varieties with its high juice sugar content of 148 g/l and its high juice acidity of 28 g/l.

The apple varieties' juice analysis results are presented in Table 2.

Table 2. Apple juice analysis results, by variety, for crop years 2007 – 2008.

	Pressing pressure bar	Juice yield %	Soluble solids Brix	Specific-gravity of juice	Sugar content g/l	pH	Total acid-content g/l (tar-taric acid)
Summer varieties							
Petteri 2007	3,5	56,2	8	1,0332	78,2	3,30	6,02
Petteri 2008	3,2	50,0	11,4	1,0479	81,3	3,50	6,00
Valkea Kuulas 2007	4	64,2	8,8	1,0362	85,7	3,22	8,02
Valkea Kuulas 2008	4	54,1	9,8	1,0424	91,6	3,09	8,48
Vuokko 2007	2,2	49,2	10,6	1,0436	103,0	3,50	4,58
Vuokko 2008	3	51,2	10,2	1,0444	99,3	3,39	6,05
Late season varieties							
Heta 2007	3	48,2	11	1,0449	103,1	3,59	7,30
Heta 2008	2	62,5	10,5	1,0424	98,4	3,43	6,15
Raike 2007	4	68,4	8,4	1,0359	77,4	3,17	13,05
Raike 2008	2	77,5	10	1,0409	94,2	3,23	9,00
Samo 2007	4	62,6	9	1,0374	82,3	3,32	12,45
Samo 2008	2	51,5	10,7	1,0439	98,7	3,32	8,25
Winter varieties							
Antonovka 2008	4	64,6	8,2	1,0339	70,8	3,42	9,73
Juuso 2007	3,5	50,7	12	1,0506	109,4	3,36	11,35
Juuso 2008	4	61,5	10,4	1,0449	95,6	3,36	7,39
Konsta 2007	3,5	48,5	10	1,0419	92,4	3,20	11,30
Konsta 2008	2	53,5	9,8	1,0399	86,0	3,27	8,20
Lepaan Liereä 2007	2,4	32,7	9	1,0369	82,2	3,62	9,00
Linda 2007	4	59,9	12,4	1,0519	121,5	3,32	15,50
Lobo 2007	4	59,7	9,6	1,0399	93,1	3,68	6,20
Lobo 2008	4	79,4	11,2	1,0459	96,0	3,40	6,40
Red Atlas 2007	3,5	52,2	9,4	1,0404	90,0	3,22	13,65
Red Atlas 2008	3,5	64,0	10,8	1,0459	57,4	3,10	13,05
Topias 2008	3,5	61,5	11,1	1,0469	54,1	3,40	7,05
Åkerö 2008	4	55,1	12,2	1,0489	109,4	3,58	6,30
Marjaomena							
Ranetka Purpurovaja 2007	4	68,1	16,7	1,0689	148,4	3,08	28,28

Brix (a measurement of soluble solids) is often used in estimating ripeness. The soluble solids are mainly sugars. This was also evident in the analysed data. Figure 8 shows the sugar content and corresponding Brix value of the juices extracted from the different apple varieties.

An analysis of the sensory evaluation results of the apples and the Brix values of the juices from the corresponding apple varieties showed that the sweeter an apple seemed in the evaluation, the higher the Brix value was. Other statistically significant correlations included the fact that the sweeter an apple had been perceived as in the evaluation, the higher the specific gravity and pH of the juice. These results were predictable.

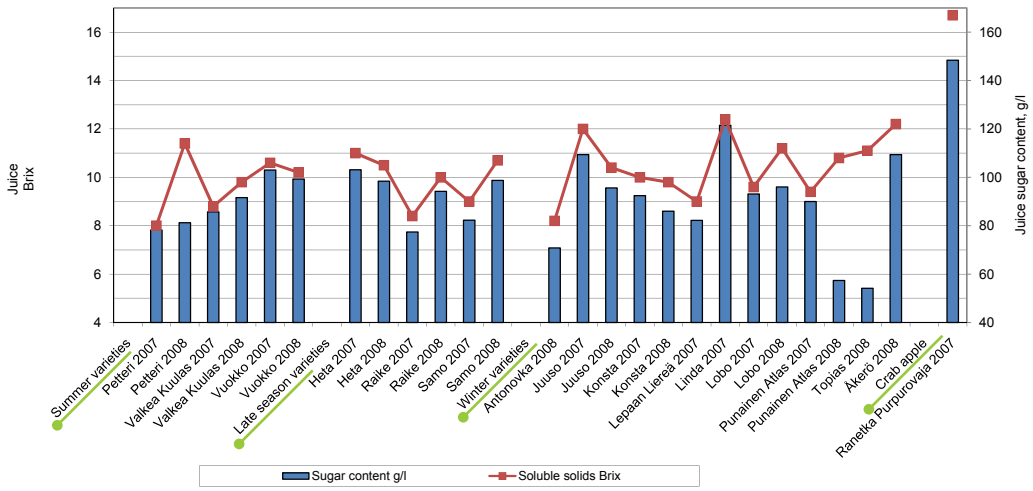


Figure 8. Effect of crop year on the sugar content (A) and total acid content (B) of apple juice, by variety, for crop years 2007 and 2008.

A summary was made of the Finnish Meteorological Institute's weather data for Piikkiö (Appendix 4). The June rainfall was significantly higher in 2008 than in 2007. According to the Horticultural Statistics of Statistics Finland, the apple harvest from 2008 was 20 % higher (by weight) than that from 2007.

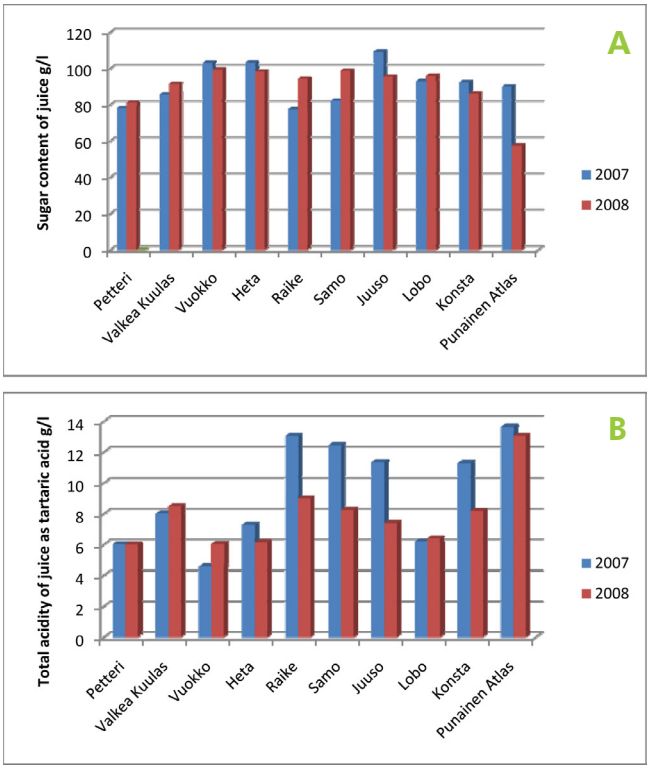


Figure 9. Effect of crop year on the sugar content (A) and total acid content (B) of apple juice, by variety, for crop years 2007 and 2008.

A summary was made of the Finnish Meteorological Institute's weather data for Piikkiö (Appendix 4). The June rainfall was significantly higher in 2008 than in 2007. According to the Horticultural Statistics of Statistics Finland, the apple harvest from 2008 was 20 % higher (by weight) than that from 2007.

5.1.3 Processability of Apple Wines

No differences were discerned in processability for the raw materials from the different varieties and crop years. There were no problems in juice pressing or wine production for any of the raw materials.

The progress of fermentation was monitored weekly by analysing the sugar content. Because determining the quantity of soluble solids (Brix) is very quick and easy compared to measuring the sugar content, the reduction in the sugar content of must was also monitored in the form of the change in

the Brix value. Figure 10 shows the linear graphs drawn from the data obtained during fermentation for two apple varieties from both crop years. These models may be useful in estimating sugar contents during apple wine fermentation, but they cannot be generally applied to all situations.

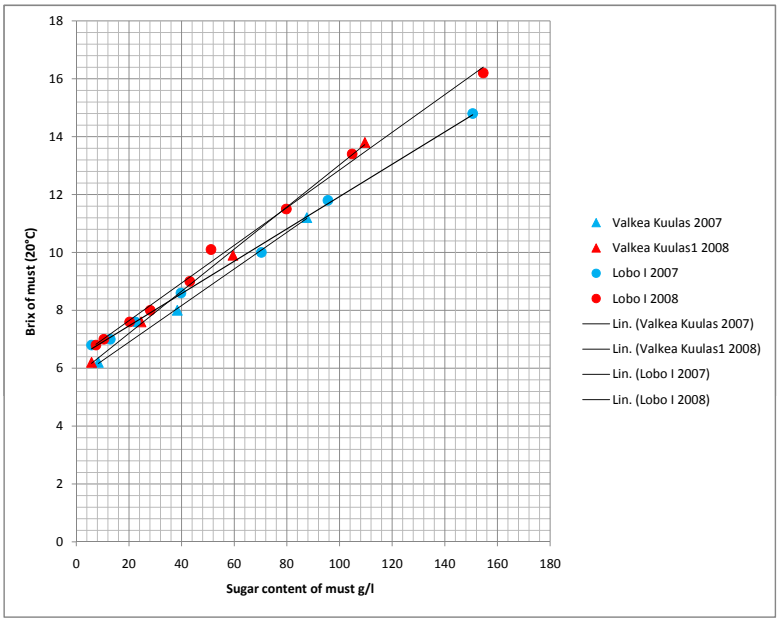


Figure 10. Soluble solids in apple must, Brix (20°C), and sugar content measured weekly during fermentation for produce from crop years 2007 and 2008. Apple wine juice content 50 %. Measurement times: Valkea Kuulas 2007: weeks 1, 2 and 3 and 2008: weeks 1, 2, 3 and 4; Lobo 2007: weeks 1 – 7 and 2008: weeks 1 – 9. Fermentation temperature approx. 15 – 19 °C. Fermentation was stopped when the sugar content of must fell below 10 g/l.

Fermentation continued until the sugar content fell below 10 g/l. This took 3 – 12 weeks, depending on the variety. For Samo apples from 2007 and 2008, the fermentation period was 3 weeks. For Raike, Lobo, Konsta and Red Atlas, the fermentation period was 6 weeks or more in both crop years. The long fermentation time was partly due to the high acid content and low sugar content of the juice. The lower the original sugar content of the juice, the more granulated sugar (sucrose) had to be added, meaning that it took a longer time to attain the target alcohol content (these correlations were statistically almost significant). Yeast consumes sucrose more slowly than glucose.

The correlation analyses also found that the longer the fermentation time, the more acidic the wine's flavour was perceived to be in sensory evaluations (a statistically very significant correlation).

The apple wines' fermentation times and chemical analysis results are shown in Table 3. For the winter varieties, the sugar content of the must fell more slowly, i.e. fermentation took longer than it did for the summer and late season varieties. The target alcohol content of 12 % by volume was exceeded for all the apple wines.

Table 3 . Chemical analyses after 1 – 2 months' maturing in steel vessels and fermentation times (until sugar content fell below 10 g/l, monitored by weekly measurements of the sugar content) of apple wines from produce from years 2007 and 2008. Juice content 50 % and target alcohol content 12 % by volume.

	Crop year	Alcohol content, % by volume	Specific gravity of wine	Total extract content g/l (computational)	Sugar content g/l	Sugar-free extract g/l	Total acid content, tartaric acid g/l	pH	Fermentation time, weeks
Summer varieties									
Petteri	2007	13,2	0,9893	18,0	2,1	15,9	5,30	3,40	5
Petteri	2008	13,8	0,9878	15,4	5,1	10,3	6,20	3,42	8
Valkea Kuulas	2007	12,8	0,9888	14,2	2,3	11,9	5,82	3,43	3
Valkea Kuulas 1	2008	12,8	0,9888	18,0	3,7	14,3	5,55	3,46	4
Valkea Kuulas 2	2008	12,9	0,9888	18,0	3,7	14,3	5,48	3,47	4
Vuokko	2007	13,0	0,9890	15,9	3,4	12,5	5,22	3,43	5
Vuokko 1	2008	12,8	0,9883	16,7	3,6	13,2	5,10	3,56	4
Vuokko 2	2008	12,9	0,9888	18,0	3,8	14,2	5,05	3,56	4
Late season varieties									
Heta	2007	12,6	0,9868	11,1	3,3	7,8	4,55	3,64	4
Heta 1	2008	13,0	0,9868	12,9	2,7	10,3	5,10	3,47	4
Heta 2	2008	13,0	0,9868	12,9	2,2	10,8	5,05	3,47	5
Raike	2007	15,2	0,9878	22,4	7,4	15,0	6,00	3,66	11
Raike 1	2008	12,9	0,9878	15,4	2,8	12,6	6,15	3,38	6
Raike 2	2008	12,9	0,9873	14,2	2,6	11,6	6,00	3,41	6
Samo	2007	13,3	0,9888	17,2	1,6	15,6	5,05	3,50	3
Samo 1	2008	12,8	0,9885	17,4	2,6	14,7	5,63	3,47	3
Samo 2	2008	12,8	0,9883	16,7	2,8	13,9	5,48	3,46	3
Winter varieties									
Antonovka 1	2008	13,2	0,9878	13,6	3,7	9,8	5,40	3,39	4
Antonovka 2	2008	13,3	0,9873	12,9	3,6	9,4	5,44	3,44	4
Juuso	2007	12,5	0,9903	21,1	7,9	13,2	6,50		8
Juuso 1	2008	13,6	0,9873	16,7	2,6	14,1	4,95		4
Juuso 2	2008	13,3	0,9873	15,4	2,4	13,0	5,00		4
Konsta 1	2007	13,4	0,9883	18,5	4,1	14,4	6,94	3,48	7

Konsta 2	2007	12,9	0,9883	16,7	4,2	12,5	6,55	3,43	7
Konsta 1	2008	13,1	0,9878	14,2	2,3	11,9	5,70	3,46	6
Konsta 2	2008	13,0	0,9878	12,9	2,1	10,8	5,75	3,44	6
Lepaan Liereä	2007	13,2	0,9878	15,9	3,0	12,9	4,95	3,68	4
Linda	2007	13,1	0,9898	20,6	3,4	17,2	6,60	3,59	6
Lobo 1	2007	13,0	0,9873	14,2	4,1	10,1	5,50	3,61	7
Lobo 2	2007	13,1	0,9878	16,7	3,5	13,2	5,30		7
Lobo 1	2008	13,6	0,9888	18,0	4,1	13,9	5,58	3,44	9
Lobo 2	2008	13,7	0,9888	18,0	4,4	13,6	5,50	3,41	8
Red Atlas 1	2007	13,0	0,9896	20,1	5,4	14,7	7,13	3,45	8
Red Atlas 2	2007	12,0	0,9898	18,0	5,0	13,0	7,10	3,37	8
Red Atlas 1	2008	14,5	0,9898	23,2	7,2	16,1	6,65	3,50	11
Red Atlas 2	2008	14,8	0,9893	21,9	7,6	14,3	6,60	3,52	12
Ranetka Purpurovaja	2007	12,5	0,9968	35,4	5,7	29,7	11,55	3,37	5
Tobias 1	2008	15,5	0,9858	18,0	3,7	14,3	4,40		7
Tobias 2	2008	15,4	0,9868	20,6	5,5	15,1	4,60		8
Åkerö 1	2008	12,0	0,9883	12,9	3,1	9,8	5,20	3,69	6
Åkerö 2	2008	13,6	0,9873	13,6	3,1	10,5	5,20	3,62	6

5.1.4 Sensory Properties of Apple Wines

The finished varietal apple wines, matured for 1 – 2 months in steel vessels and sweetened to have the same sugar content (9 g/l), were subjected to a sensory evaluation of the depth of the colour, the fruitiness of the aroma, the fruitiness of the flavour, the full-bodiedness of the flavour, the acidity of the flavour and the length of the flavour. The apple wines from 2007 were aged in bottles for seven months prior to evaluation, and the wines from 2008 for 1 – 3 months. Evaluation was done on a scale of 0 – 5, with higher points indicating greater strength of the property under evaluation. Trained tasters evaluated the samplers in random order. The evaluators were also asked for verbal descriptions of each evaluated wine. The verbal evaluations were turned into a sensory profile for each varietal wine, describing its appearance, aroma and flavour.

The sensory quality profiles for the apple wines are shown by variety in Table 4. The apple wines from crop year 2007 were evaluated by 7 – 11 evaluators, and those from 2008 by 12 evaluators.

Table 4. Sensory quality profiles of varietal apple wines. Verbal evaluations by 7 – 12 evaluators of the apple wines from crop years 2007 and 2008. Juice content 50 %, target alcohol content 12 % by vol., sweetened to 9 g/l sugar.

Varietal apple wines	Appearance	Aroma	Flavour
Summer varieties			
Petteri	Clear and green-tinged.	Pleasantly fruity, crisp, fresh, green.	Refined, mineral, harshly apple-like. Wide and smooth acidity. Medium-bodied. Average length.
Valkea Kuulas	Olive-green, greeny-yellow, golden. Clear.	Floral, aromatic, sweetish, perfumed.	Soft/medium/harsh acidity. Fairly thin, medium-bodied. Aromatic, not fruity, core flavour. Short to average length.
Vuokko	Clear, greeny-yellow, light yellow.	Sweet, juicy, caramelly.	Mild, mellow acidity. Hollow, thin, harshly apple-like. Medium-bodied. Short/fairly short.
Late season varieties			
Heta	Clear, pale green.	Fresh, fruity, mineral, floral, pleasant.	Mild, pleasant, balanced acidity. Pleasantly fruity. Medium- to full-bodied. Average length.
Raike	Clear, greeny-yellow, yellowy.	Crisp, fresh, juicy.	Firm, punchy and long acidity. Lacking fruitiness. Medium-bodied, balanced, no berry accents. Average to long length.
Samo	Clear, translucent, greenish.	Floral, fruity, perfumed.	Feeble, round, strong acidity, increases with time. Floral, simple, smooth. Light- to medium-bodied. Short to average length.
Winter varieties			
Antonovka	Clear, greeny-yellow.	Soft, succulent, cinnamony.	Firm and pleasant acidity. Fruity, delicious. Medium-bodied. Long.
Juuso	Clear, golden tone, green tinge.	Ripe green apple, pleasant, excellent.	Crisp, fresh, sweet. Pleasant and balanced acidity. Medium-bodied, pleasant, mellow. Average to long length.

Konsta	Clear. From greenish to yellowish.	Fresh, apple-like, ripe.	Pleasant acidity. Medium- to full-bodied. Crisp, fresh, fruity, delicious. Long aftertaste.
Lepaan Liereä	Pale, lightly green-tinged.	Floral, mushroomy, sweet.	Acidic. Core and seed taste overpowers fruitiness.
Linda	Watery, almost transparent.	Mild. Scent of pale apple skin.	Sharpish, zesty acidity. Wine-like, thinly apple-like. Hollow. Fairly short.
Lobo	Clear, ranging from pale green to greenish straw colour.	Ranging from fresh fruity apple to sweetly aromatic.	Fairly harsh or harsh acidity. Fruity, aromatic. Medium- to full-bodied. Average to long length.
Red Atlas	Clear, greeny-yellow, yellowy.	Ripe apple, fruity, aromatic.	Harsh, sharp, strong acidity. Tartly apple-like, branchy, harshly fruity. Light- to medium-bodied. Average to long length.
Tobias	Clear, translucent, greeny-yellow. High viscosity.	Light, fresh, mild.	Waxy, apple skin-like, light. Strong acidity. Slim. Short to average length.
Åkerö	Clear, greenish, yellowy-green, yellow.	Fruity.	Fruity, berry-like. Strong acidity, too acidic. Full-bodied. Average length.
Crab apple			
Ranetka Purpurovaja	Golden yellow, slightly red-tinged.	Fruity, vanilla.	Acid and tannins overpower any fruitiness. Raw, sharp acidity. Fairly short.

The variety was found to have an effect on the sensory properties of colour depth, acidity of flavour, full-bodiedness of flavour and fruitiness of aroma. Colour depth varied in a statistically very significant way ($p<0.001$) between the varieties (Figure 11). The deepest colour came from Ranetka Purpurovaja, then from Åkerö and thirdly from Valkea Kuulas. The least depth of colour was in the variety Linda.

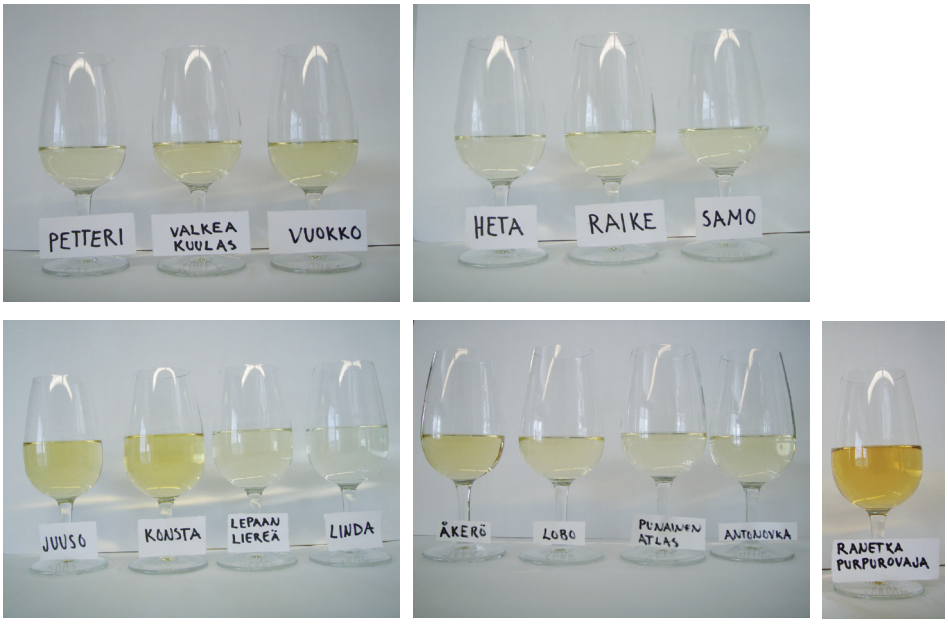


Figure 11. Colour palette of apple wines. Juice content 50 %..

The wine made from the crab apple variety (Ranetka Purpurovaja) was perceived to have significantly higher acidity of flavour than the others (very significant difference). The next most acidic apple wines were Antonovka, Petteri, Red Atlas and Tobias. The least acidic were Vuokko, Samo and Lepaan Liereä. The most full-bodied in flavour were Petteri, Åkerö and Konsta. The fruitiest aroma came from Ranetka Purpurovaja, Åkerö, Heta, Lobo and Konsta. The apple varieties were not perceived to differ significantly in the fruitiness of flavour or the length of flavour.

Wine was produced in both crop years from ten varieties (Lobo, Konsta, Red Atlas, Valkea Kuulas, Petteri, Vuokko, Heta, Samo, Raike and Juuso). This data was subjected to t-testing to see whether the crop year had an effect on the sensory qualities.

The main effect of the crop years 2007 and 2008 seemed to be on the depth of colour of the apple wines (significant difference). In Konsta and Red Atlas, the colour of the wines from 2007 was deeper than that of 2008. The high rainfall of June 2008 may have affected the water content of the apples and thereby the colour.

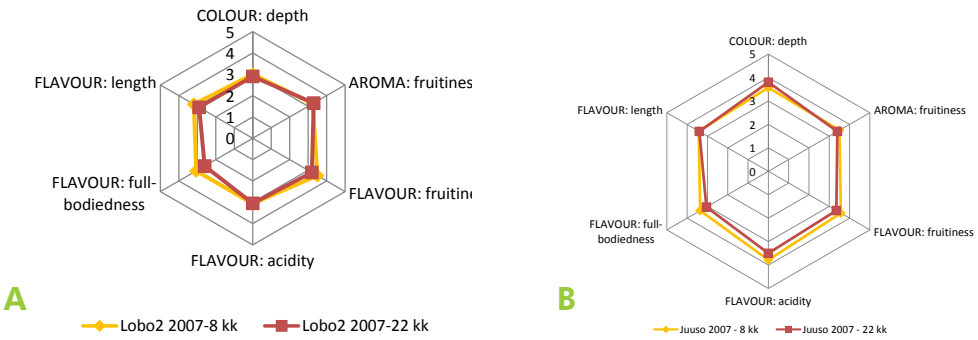
For individual apple varieties, the crop years were found to have small differences in the acidity of flavour, the length of flavour, the fruitiness of the aroma and the fruitiness of the flavour. The crop year (2007 vs. 2008) had no effect on the full-bodiedness of flavour for any of the apple wines (statistically significant result).

No statistically significant correlation was found between the apple raw materials and the sensory properties of the wines produced from them with the properties analysed in this study. Apparently a 50 % juice content was not sufficient to transfer the sensory properties of the apples into the wines.

Small correlations were found between the chemical properties of the apple juice and the sensory properties of the apple wines. There was an almost significant correlation between the juice sugar content and the fruitiness of the aroma and acidity of flavour of the wines: the fruitier the wine's aroma, the higher the juice's sugar content. Also, the more acidic the wine's flavour, the lower the juice's sugar content.

5.1.5 Effect of Aging on Sensory Properties of Apple Wines

The effect of bottle aging on the sensory properties of wine was investigated for the varieties Lobo and Juuso (crop year 2007). The analysis showed that 14 months of bottle aging (12 °C) had very little effect on the evaluated properties of these varietal wines (Figure 12). The full-bodiedness and fruitiness of flavour declined slightly during bottle aging.



Kuva 12. Change in sensory properties of varietal apple wines Lobo (A) and Juuso (B) during bottle aging. The wines were evaluated after eight and 22 months of bottle aging.

5.2 Currants and Currant Wines

5.2.1 Sensory Properties of Currants

All currants were evaluated in their thawed state prior to pressing. Freezing affected the integrity of the berries' surface structure and its evaluation. Marski and ARF Strains 15 and 36 were perceived to be more acidic and less sweet than the other blackcurrant varieties. Mikael was described

as a ready-to-eat berry thanks to its pleasant and soft taste. Its smell is not typical of a blackcurrant, but sweeter. The verbal descriptions of the blackcurrants' sensory properties are shown in Table 5.

Table 5. Sensory properties of frozen and thawed blackcurrants (3–4 evaluators).

Variety	Appearance	Smell	Taste
BLACKCURRANTS			
Marski	Reddish-black, black, fairly large.	Smell of foliage and earth, sweet.	Not for eating, tart, acidic, watery, greencurrant-like, zesty, bitter aftertaste.
Mikael	Reddish-black, evenly sized.	Unpleasant, earthy, sweet, strawberry, blueberry.	Suitable for eating, pleasant, mellow, thickish skin.
Mortti	Very black, red-tinged.	Blend of sweet and tart, perfumed, earthy, steamed cordial.	Suitable for eating, slightly musty (due to freezing?), tart, thick-skinned.
ARF Strain 15	Varying shades of black (red/grey), varying sizes	Zesty, floral or fruity.	Taste of stem and branches, sharply acidic, tart, slightly redcurrant-like.
ARF Strain 36	Reddish-black, quite large.	Blackcurrant-like, some strawberry.	Not for eating, acidic, tart, bland taste, candy-like aroma, some redcurrant.

Punahilkka stood out from the other redcurrants with its atypical flavour. Its aroma and taste were described as woody, stem-like. Punahilkka and Rovada were darker in colour than the other redcurrants. Rovada was very acrid in taste and perceived to be the least sweet. Strain 110 was pale red in colour (Table 6).

Table 6. Sensory properties of frozen and thawed redcurrants (3–4 evaluators).

Variety	Appearance	Smell	Taste
REDCURRANTS			
ARF Strain 103	Fairly light red, pale berries, long green stems.	Hollow, lingonberry-like.	Mild, juicy, fairly acidic, whitecurrant-like, bitterness from large seeds.
ARF Strain 110	Pale, pinkish colour, large green stems.	Stem or leaf compost. Fresh hay, grass.	Slightly watery, zesty and acidic, bitter, whitecurrant-like.
Punahilkka	Dark red.	Sweet, earthy, stem-like, woody, leaf compost, birch log.	Fairly mild, slightly acidic, pleasant, woody. Smallish seeds.
Red Dutch	Varying size, (light) red.	Slightly sweet, strawberry-like, stem-like.	Juicy, watery, acidic, slightly musty. Large seeds.
Rotes Wunder	Evenly sized.	Typical redcurrant.	Large seeds.
Rovada	Dark red.	Grassy, stem-like.	Insipid, zesty, very acrid.

In the redcurrant varieties, the berries' colour gave an indication of the future wine's colour. The dark red varieties, such as Punahilkka and Rovada, were perceived to produce wines deeper in colour. Strain 110 was light-red in colour and its wines were perceived to have the least depth of colour.

The whitecurrant varieties varied quite a lot in their sensory properties. There were also differences between crop years. The berries from ARF Strains 81, 85 and 97 were fairly small. The berries were perceived to contain lots of seeds, which made their flavour acrid and tannin-like. Strain 85 was perceived to have low acidity, where as White Jüterbog, White Finn and Blanka were acidic. Inkilän Annukka was perceived to be the sweetest. All whitecurrants had in common the bitterness caused by seeds, which varied depending on the variety and crop year (Table 7.).

Table 7. Sensory properties of frozen and thawed whitecurrants (3–4 evaluators).

Variety	Appearance	Smell	Taste
WHITECURRANTS			
Blanka	Evenly sized, large, yellowy.	Mild, fresh, rhubarb, cut grass.	Very bitter, pleasant, lots of tannins in seeds, lots of seeds.
Inkilän Annukka	Pale, greyish colour, smallish size.	Sharp, woody, forest-like, mossy.	Some bitterness. Clear, fresh flavour. Large seeds.
ARF Strain 81	Yellowy colour, no colour variation.	Earth, hay, dry shoots.	Tannins and bitterness from lots of seeds.
ARF Strain 85	Smallish berries, varying colours. Yellow stems.	Freshly cut grass, shoots, lemony, fresh, sweet.	Lemony, grassy, short taste. Large seeds, tannins.
ARF Strain 97	Smallish, translucent, grey.	Sharp, unpleasant, woody/stemmy, mild, rhubarb-like, succulent, foresty.	Bitterness, strong tannins, large seeds, fairly mild.
White Jüterbog	Very light, pearly berry, very decorative.	Slight rhubarb tones. Cut grass.	Fairly bitter, good for eating. Seeds are prone to release tannins.
White Finn	Pale, greyish light yellow, green stems.	Sweetish, mild, zesty, slightly musty, rhubarb tones, cut grass.	Acidic, woody, juicy. Large seeds for berry size (bitterness, tannins).

Out of the greencurrants, Vilma was perceived to be the sweetest and least acidic. Its sweetness was also in the smell. Venny was the most acidic, while Vertti was blackcurrant-like in smell and taste, though softer. The sensory properties of the greencurrants are shown in Table 8.

Table 8. properties of frozen and thawed greencurrants (3–4 evaluators).

Variety	Appearance	Smell	Taste
GREENCURRANTS			
Vertti	Pale green, some red tinges.	Similar to blackcurrant earthy, off-putting.	Blackcurrant-like. Surprisingly mild and soft,.
Venny	Fairly intact, greyish green.	Woody, earth, soil, nettle, currant leaves.	Sweetness and acidity, zestily acidic, white- and blackcurrant-like.
Vilma	Green, fairly dark, red-tinged, quite large.	Sweet, musty, stem-like, blackcurrant-like.	Juicy, fresh, acidic, light, soft, insipid, strawberry-like.

5.2.2 Results of Currant Analyses

The juice analysis results for blackcurrants are shown in Table 9. The juice yields for blackcurrants ranged from 51 to 62 %.

ARF Blackcurrant Strains 15 and 36 stood out from the rest with an acidity level that was higher by approx. 10 g/l, with the average acid content being 49 g/l. Blackcurrant sugar contents varied greatly depending on the crop year; the values were highest in 2008, except for Mortti, and lowest in 2009 (93 – 151 g/l).

Table 9. Blackcurrant juice analysis results for crop years 2007 – 2009.

Black-currant variety	Crop year	Juice yield, %	Soluble solids (Brix)	Specific gravity of juice	Sugar content g/l	pH	Total acid content g/l (tartaric acid)	Date of picking
Marski	2007	55,5	15,2	1,0689	114,8	3,25	37,54	6.8.2007
Marski	2008	60,2	17,6	1,0794	139,6	3,27	34,00	19.8.2008
Marski	2009	60,0	15,2	1,0647	107,7	3,20	36,81	20.8.2009
Mikael	2007	52,5	15,6	1,0704	122,0	3,33	36,53	7.8.2007
Mikael	2008	59,6	18,4	1,0824	151,0	3,19	32,60	14.8.2008
Mikael	2009	61,1	15,2	1,0641	107,2	3,20	39,35	20.8.2009
Mortti	2007	51,6	19,4	1,0865	149,6	3,38	42,98	9.8.2007
Mortti	2008	56,3	17,2	1,0769	136,0	3,24	31,65	19.8.2008
Mortti	2009	52,8	15,6	1,0709	117,6	3,06	39,12	24.8.2009
Strain 15	2007	51,7	16,4	1,0769	120,4	3,17	51,25	8.8.2007
Strain 15	2008	56,0	18,2	1,0804	137,6	3,04	43,13	14.8.2008
Strain 15	2009	54,8	16,8	1,0759	118,6	3,25	51,53	21.8.2009
Strain 36	2007	51,0	16,2	1,0742	117,4	3,04	50,85	7.8.2007
Strain 36	2009	62,0	14,0	1,0609	93,0	3,04	47,38	21.8.2009
average		56,1	16,5	1,0738	123,7	3,19	41,05	

The juice analysis results for redcurrants varied quite a lot depending on the variety. The juice yields, based on the average for each variety and crop year, ranged from 54 to 84 %. Acid contents were 23 – 40 g/l and sugar contents 65 – 156 g/l. The sugar content for Punahilkka from crop year 2008 was exceptionally high at 156 g/l.

Table 10. Redcurrant juice analysis results for crop years 2005 – 2009.

Redcurrant variety	Crop year	Juice yield, %	Soluble solids (Brix)	Specific gravity of juice	Sugar content g/l	pH	Total acid content g/l (tartaric acid)	Date of picking
Punahilkka	2006	42,7	11,7	1,0531	99,6	3,04	25,43	1.8.2006
Punahilkka	2007	57,3	14,0	1,0626	120,4	3,13	29,05	30.7.2007
Punahilkka	2008	50,7	17,8	1,0794	156,0	3,17	31,40	5.8.2008
Punahilkka	2009	64,5	14,6	1,0637	111,3	3,17	30,28	18.8.2009
Red Dutch	2005	50,7	12,1	1,0539	101,7	3,00	26,30	29.7.2005
Red Dutch	2006	60,5	11,9	1,0532	100,5	3,00	30,04	1.8.2006
Red Dutch	2008	45,5	15,0	1,0674	116,8	3,15	37,71	30.7.2008
Red Dutch	2009	70,7	10,0	1,0459	64,8	3,18	34,65	18.8.2009
Rotes Wunder	2005	84,1	11,9	1,0529	96,4	2,92	27,70	9.8.2005
Rovada	2008	57,8	17,1	1,0769	142,4	3,04	39,90	12.8.2008
Rovada	2009	64,4	13,8	1,0604	112,5	2,93	33,10	19.8.2009
Strain 103	2005	60,1		1,0576	99,1	3,04	24,20	28.7.2005
Strain 103	2006	52,3	10,9	1,0500	95,0	3,09	23,46	1.8.2006
Strain 103	2009	64,0	11,2	1,0485	76,2	3,21	32,01	18.8.2009
Strain 110	2008	58,9	14,9	1,0649	115,4	3,21	32,88	31.7.2008
Strain 110	2009	65,1	11,8	1,0519	92,4	3,25	29,10	18.8.2009
average		59,3	13,2	1,0589	106,3	3,10	30,45	

The juice yield from whitecurrants ranged from 49 to 69 %. The total acid contents were 17 – 35 g/l. The sugar content ranged from 85 to 173 g/l. The whitecurrant juices had their highest sugar contents in crop year 2008 (Table 11).

Table 11. Whitecurrant juice analysis results for crop years 2005 – 2009.

Whitecurrant variety	Crop year	Juice yield, %	Soluble solids (Brix)	Specific gravity of juice	Sugar content g/l	pH	Total acid content g/l (tartaric acid)	Date of picking
Blanka	2008	57,5	14,4	1,0629	113,0	3,22	34,30	21.8.2008
Blanka	2009	57,6	13,0	1,0569	98,0	3,07	34,28	19.8.2009
Inkilän Annukka	2008	58,3	17,2	1,0769	160,8	3,38	22,15	30.7.2008
Strain 81	2005	61,5	11,4	1,0502	94,0	3,25	31,60	29.7.2005
Strain 81	2006	49,1	10,9	1,0482	85,9	3,25	28,73	25.7.2006
Strain 85	2005	65,9	11,8	1,0517	101,6	3,57	22,65	26.7.2005
Strain 85	2006	59,3	12,0	1,0539	110,6	3,57	18,25	25.7.2006
Strain 85	2008	52,0	19,0	1,0849	172,6	3,50	27,03	30.7.2008
Strain 97	2005	59,0	10,2	1,0439	84,7	3,42	17,22	26.7.2005
Strain 97	2006	68,7	11,6	1,0509	103,1	3,30	24,15	24.7.2006
Strain 97	2008	50,0	20,1	1,0880	173,0	3,30	34,50	24.7.2008
White Jüterbog	2008	49,3	17,2	1,0749	144,0	3,19	31,03	30.7.2008
White Finn	2005	59,1	12,2	1,0537	103,4	3,25	26,74	29.7.2005
White Finn	2006	59,2	12,0	1,0524	99,8	3,15	27,50	24.7.2006
White Finn	2007	49,5*	13,9	1,0609	113,4	3,20	32,70	fall 2007
White Finn	2008	60,5	16,4	1,0739	146,0	3,12	34,73	30.7.2008
White Finn	2009	72,4	14,6	1,0634	121,4	3,01	33,94	20.8.2009
* sample size 63 kg								
average		58,7	14,0	1,0616	119,1	3,28	28,32	

The juice yields from greencurrants ranged from 37 to 54 %. The greencurrants were the sweetest of all the currants, measured in terms of the sugar content of the juice, which ranged from 104 to 185 g/l. Their acidity was similar to that of the blackcurrants from 34 to 47 g/l of total acid content.

The juice analysis results for greencurrants are shown in Table 12.

Table 12. Greencurrant juice analysis results for crop years 2007 – 2009.

Greencurrant variety	Crop year	Juice yield, %	Soluble solids (Brix)	Specific gravity of juice	Sugar content g/l	pH	Total acid content g/l (tartaric acid)	Date of picking
Venny	2007	46,9	19,8	1,0880	148,0	3,22	42,61	13.8.2007
Venny	2008	46,1	20,6	1,0909	170,2	3,07	41,97	7.8.2008
Venny	2009	45,1	17,3	1,0769	133,2	3,11	46,82	19.8.2009
Vertti	2007	54,2	17,3	1,0759	138,0	3,19	38,63	6.8.2007
Vertti	2008	49,1	18,0	1,0791	154,8	3,13	34,2	7.8.2008
Vertti	2009	54,4	14,0	1,0619	104,4	3,09	37,92	5.8.2009
Vilma	2007	48,1	18,0	1,0794	146,5	3,30	34,05	13.8.2007
Vilma	2008	37,0	21,8	1,0966	185,0	3,19	37,95	12.8.2008
Vilma	2009	52,9	16,0	1,0712	127,0	3,26	38,95	19.8.2009
average		48,2	18,1	1,0800	145,2	3,17	39,23	

According to data from the Finnish Meteorological Institute for Piikkiö (Appendix 4), 2006 had the highest effective temperature of the period 2005 – 2009. This did not have an enhancing effect on the currants' sugar content. The high sugar content of the currant juices from 2008 may be due to a long growing season. In 2008, the thermal beginning of spring was slightly earlier than average (on 4 February) with a maximum of 17 cm of ground frost. In winter 2008, there was no permanent snow covering in Piikkiö, and the depth of the snow was an average of 0 – 1 cm all winter. The temperature remained at around zero degrees throughout the season, with exceptionally few days below zero.

Certain statistically significant concurrencies were observed between the sensory evaluations of the currants and the juice analysis results. The sweeter the black- and greencurrants were perceived to be, the lower the acid content of the juice turned out to be. Similarly, the more acidic the black- and greencurrants were perceived to be, the higher their total acid content. In red- and whitecurrants, the berries' perceived acidity or sweetness was not found to be related to the total acidity of the juice. In red- and whitecurrants, perceived sweetness correlated in a statistically significant way with a high sugar content, a high Brix value and a high specific gravity of the juice.

In red- and whitecurrants, the toughness of the skin correlated significantly with the acidity of the juice. The perceived smell of the whitecurrants correlated with the juice's sugar content; the stronger the smell, the higher the sugar content, Brix and specific gravity of the juice.

5.2.3 Processability of Currant Wines

All the currant varieties were suitable for winemaking. Monitoring of the fermentation of the currant wines was done similarly to that of the apple wines. As with the apples, there was a clear linear correlation between the sugar content of the must and the Brix value. Figure 13 indicates the points and lines for the musts drawn in 2009 from four varieties (Mortti, Red Dutch, White Finn and Vertti [also 2008]) . The crop year had no effect on the development of the proportion of Brix to sugar content during fermentation, which is shown for Vertti in Figure 13.

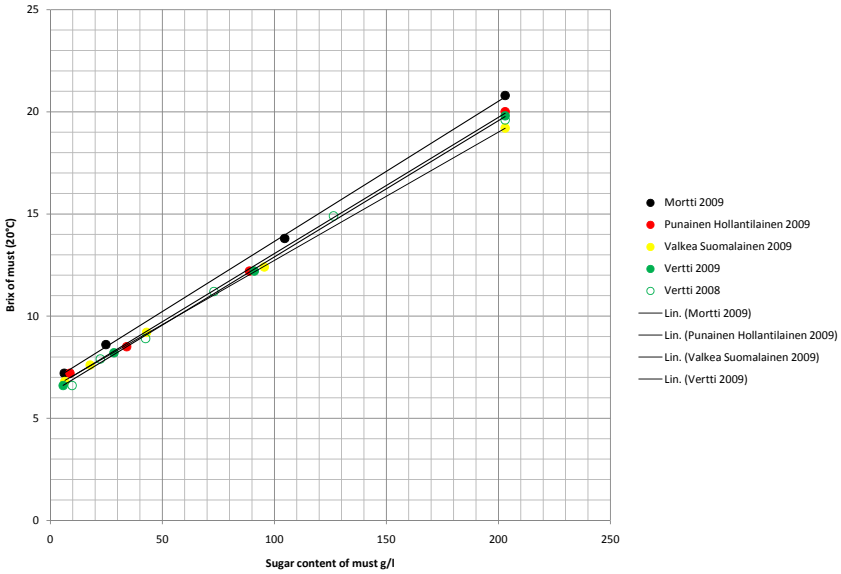


Figure 13. Soluble solids, i.e. Brix (20°C), and sugar content of currant musts from 2009 during fermentation. Currant wine juice content 25 %, fermentation temperature approx. 18 – 21 °C and fermentation time 3 – 5 weeks. Fermentation was stopped when the sugar content fell below 10 g/l.

The chemical analysis results and fermentation times of the currant wines are shown in Appendices 5 and 6. For the currant wines, attaining the desired target alcohol content took 2 – 9 weeks. Fermentation progressed similarly for black- and greencurrant wines from the same crop year. For blackcurrant wines, fermentation took longer for produce from 2007 than for 2008 and 2009. The greencurrant wines behaved similarly; in 2007 fermentation took 6 – 9 weeks, whereas in 2009 it was the shortest at 3 weeks.

Correlation analyses only showed links between fermentation and the chemical properties of the juice for red- and whitecurrant wines. The lower the pH of redcurrant juice, the longer it took to attain the target alcohol

content, i.e. the longer the fermentation period (statistically significant result). For whitecurrants, a (statistically almost significant) correlation was found between fermentation time and pH and total acidity; the lower the juice's pH and the higher the total acid content, the longer the fermentation period.

5.2.4 Sensory Properties of Currant Wines

The finished (fermented and filtered) currant wines were subjected to a sensory evaluation of the depth of the colour, the fruitiness of the aroma, the fruitiness of the flavour, the full-bodiedness of the flavour, the acidity of the flavour and the length of the flavour, as for the apple wines. The evaluation was done by 9 – 11 trained evaluators. One batch of wine was produced for each variety (5 blackcurrants, 5 redcurrants, 5 whitecurrants and 3 greencurrants), in each year when raw material was available (1 – 4 crop years per variety). The sensory quality profiles drawn from the verbal evaluations of the varietal currant wines are shown in Tables 13 and 14 (combining all the crop years for each variety).

Table 13. Sensory quality profiles of varietal black- and redcurrant wines. Verbal evaluations by 7 – 12 evaluators of varietal wines from crop years 2005 – 2009. Juice content 25 %, target alcohol content 12 % by vol., sweetened with sugar to 15 g/l for redcurrant wines and 20 g/l for blackcurrant wine.

Blackcurrant wines	Appearance	Aroma	Flavour
Strain 15	Brilliant red.	Powerful, balanced.	Elegant, fresh, strong. Light acidity; delicious. Light- to medium-bodied. Short to average length.
Strain 36	Brownish red.	Fresh, curranty, pleasant.	Sharp acids, tannins. Fresh, full-bodied, shortish.
Marski	Deep red.	Fruity, spicy, blackcurrant-leafy, caramelly, blackcurrant-like.	Delicious acidity. Corresponds to aroma. Nice dark tones. Full-bodied. Average to long length.
Mikael	Strong colour, browny-red.	Ripe and fruity, clean, pleasant.	Representative, typical, peppery. Delicious acidity. Medium- to full-bodied. Fairly short.
Mortti	Deep red, inky.	Delicious, caramelly. blackcurrant-like. Shoots.	Somewhat overpowering acidity. Ripe. Full-bodied. Fairly short.

Redcurrant wines	Appearance	Aroma	Flavour
Strain 103	Beautifully red, medium depth.	Typical of the fruit, tart.	Delicious acidity. Typical, medium- to full-bodied, average length.
Strain 110	Pink.	Light, wine-like.	Delicious acidity. Typical, currant-like. Medium-bodied. Average length.
Punahilkka	Clear, attractive, warm red.	Slight cherry tones, red wine-like, fruity.	Sweet, slightly hollow. Soft acidity, delicious, slightly harsh. Medium- to full-bodied. Average to long length.
Red Dutch	Clear, deep pink.	Sweetly fruity, fairly light.	Sharp, strong acidity. Tannins cover fruitiness. Medium-bodied.
Rotes Wunder	Ruby rosé.	Candy-like, strawberry tones, buttery.	Delicious acidity. Typical, pleasant, medium-bodied, short to average length.
Rovada	Ruby red, deep	Cleanly fruity, floral, balanced.	Sharp acidity, even acrid, aggressive. Acidity hides fruitiness. Medium- to full-bodied. Long.

Whitecurrant wines	Appearance	Aroma	Flavour
Blanka	Clear, translucent, light-yellow to yellow.	Some raw berries, fruity, apple-like.	Sharpish acidity and tannins. Medium-bodied. Short to fairly long.
Inkilän Annukka	Clear, even brilliant. Pale yellow.	Fruity, mineral, high-quality.	Delicious acidity, firm. Medium- to full-bodied. Fairly long to long.
Strain 81	Golden to yellow.	Pleasant, perfumed, sweetly ripe.	Strong, shoot-like, woody. Suffers from acidity.
Strain 85	Clear, straw-coloured, slightly watery.	Overripe, herbal, floral.	Fruity, herbal, elderflower-like. Delicious, pleasant acidity. Medium- to full-bodied. Fairly short.
Strain 97	Clear, deep yellow, golden tones.	Overripe berries, maturely fruity.	Fairly harsh acidity. Medium-bodied, stalky, branch-like. Average length.
White Jüterbog	Clear, pale, yellowy.	Clean, fruity, perfumed.	Delicious acidity. Alcoholic. Long.
White Finn	Clear, pale yellow, mild.	Spicy, crisp slightly musty.	Stinging, sharp acidity. Medium-bodied, delicious. Pleasant. Fairly long.

Greencurrant wines	Appearance	Aroma	Flavour
Venny	Greeny yellow, golden tones.	Pleasant, fruity, jammy, perfumed, strong.	Soft, pleasant, rich acidity. Zesty, fruity. Medium- to full-bodied.
Vertti	Clear, clean greeny-yellow.	Sweet, fruity, perfumed, tones of cooked rhubarb.	Fairly harsh, aggressive, metallic acidity. Zesty, fruity, thick. Medium-bodied. Long.
Vilma	Clear, yellowy green, golden tones.	Strong, almost unpleasantly powerful, waxy, fruity.	Delicious to harsh acidity. Fruit flesh taste, jammy. Medium- to full-bodied. Average length.

The variety had a clear effect on the colour of the currant wines and the acidity of their flavour. In red- and whitecurrant wines, the variety had a very significant effect on colour. The deepest colour was in the Rovada and Punahilkka wines. The biggest quantity of data was available for the varieties Punahilkka and Red Dutch (four crop years). The results clearly indicated that the colour of wine made from Punahilkka was significantly deeper than that of Red Dutch. Of the whitecurrant wines, the deepest colour came from ARF Strain 81. Also in black- and greencurrant wines, the variety had a significant effect on the wine's colour. In blackcurrants, the deepest colour came from Mortti, while in greencurrants it came from Venny and Vilma.

In whitecurrant wines, the variety was found to affect the acidity of flavour, and the wine from Strain 85 was clearly the least acidic. Of the redcurrant wines, Rovada wines were significantly more acidic than the others, but there were no significant differences apart from that.

In none of the currant types (black, red, white or green) was the variety found to have any effect on the following sensory properties of the wine: fruitiness of aroma, fruitiness of flavour, full-bodiedness of flavour or length of flavour.

The crop year had a limited or no effect on most of the sensory properties of the wines. The most significant effect was on the depth of colour. The crop year was found to affect the perceived depth of colour of blackcurrant wines in a statistically significant way ($p<0.01$) for the varieties Mikael and Marski, and an almost significant way ($p<0.05$) for Strain 36, such that the wines from 2007 and 2008 had a deeper colour than those from 2009. For redcurrant wines, the crop year was found to have a significant effect on the colour in the varieties Red Dutch and Strain 103, such that the colour of the wine from 2009 was less deep than that of the others. For whitecurrant wines, the crop year's effect on colour was almost significant for Strain 85, Strain 97 and White Finn.

For the sensory properties of the wine other than the colour, the crop year was only found to have effects on a few varieties, and despite their statistical significance these results should not be considered as strong proof of the significance of the crop year for those properties in general. The crop year was found to have a significant effect on the fruitiness of the flavour and aroma for the greencurrant variety Venny, such that the aroma and flavour of the wine from 2007 were less fruity than those from 2008 and 2009. The crop year only had an effect on the acidity of flavour for the greencurrant variety Vertti; there, the wine from 2009 was less acidic than those from 2007 and 2008.

The sensory properties of the varietal currant wines, measured on a scale of 0-5, are shown in Figures 14 – 17.

The strong smell of blackcurrant berries correlated significantly with a deep wine colour and a strongly fruity wine aroma. It also correlated very significantly with the fruitiness of the wine's flavour. A high juice sugar content also correlated significantly with a deep wine colour in blackcurrant wines.

Only limited or no statistical correlations were found between the other sensory properties of the currants or the chemical properties of the juices and the sensory properties of the corresponding wines. In redcurrants, the juiciness of the berry seemed to increase the fruitiness of the wine's aroma. The fruitier the wine's aroma, the higher the acid content of the juice. The higher the juice's acid content, the more acidic the wine's flavour.

In whitecurrants, the juicier the berry in the sensory evaluation, the less deep the colour of the wine but the fruitier the flavour.

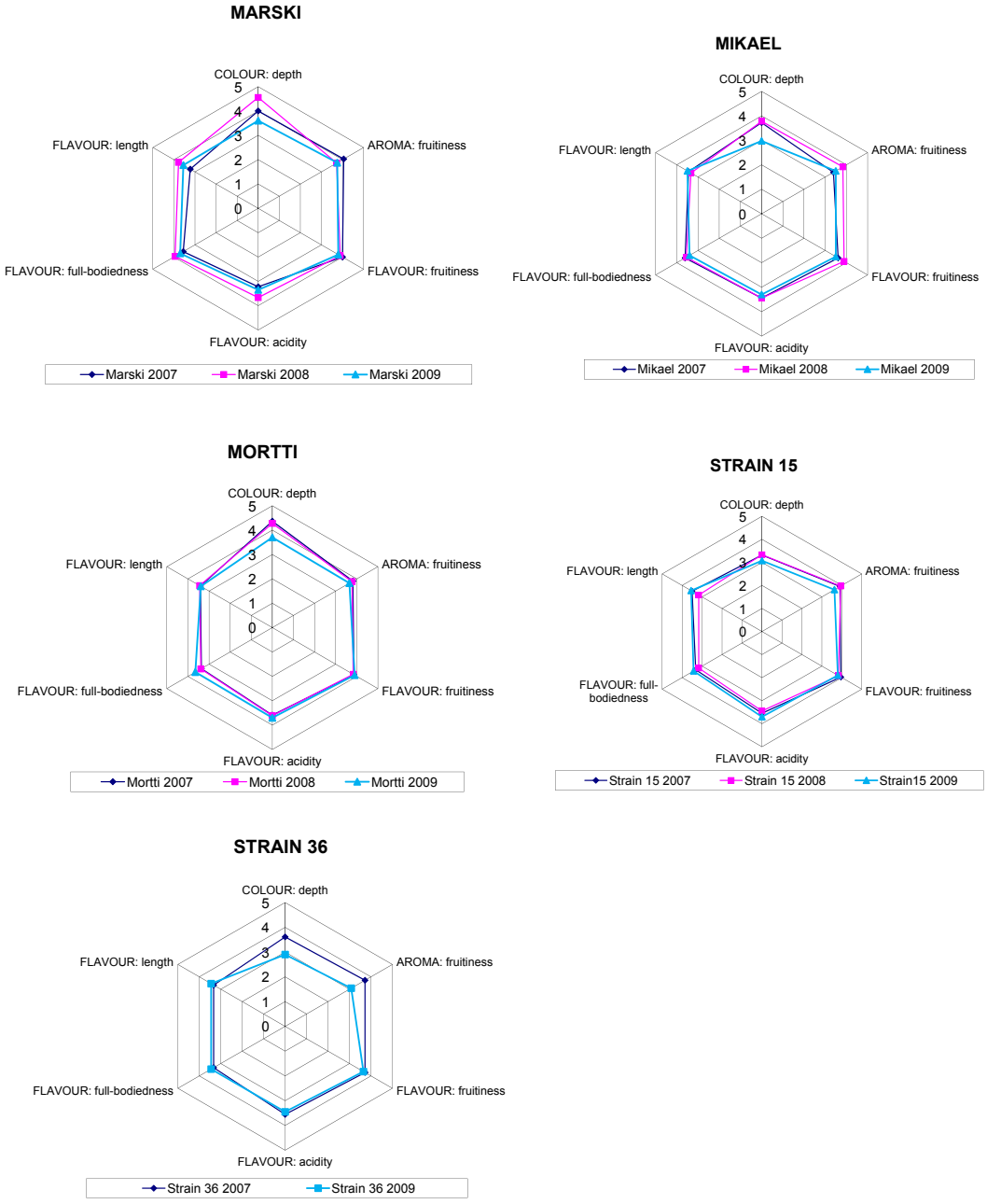


Figure 14. Sensory quality profiles of varietal white- and greencurrant wines. Verbal evaluations by 7–12 evaluators of varietal wines from crop years 2005–2009. Juice content 25%, target alcohol content 12% by vol., sweetened to 15 g/l sugar.

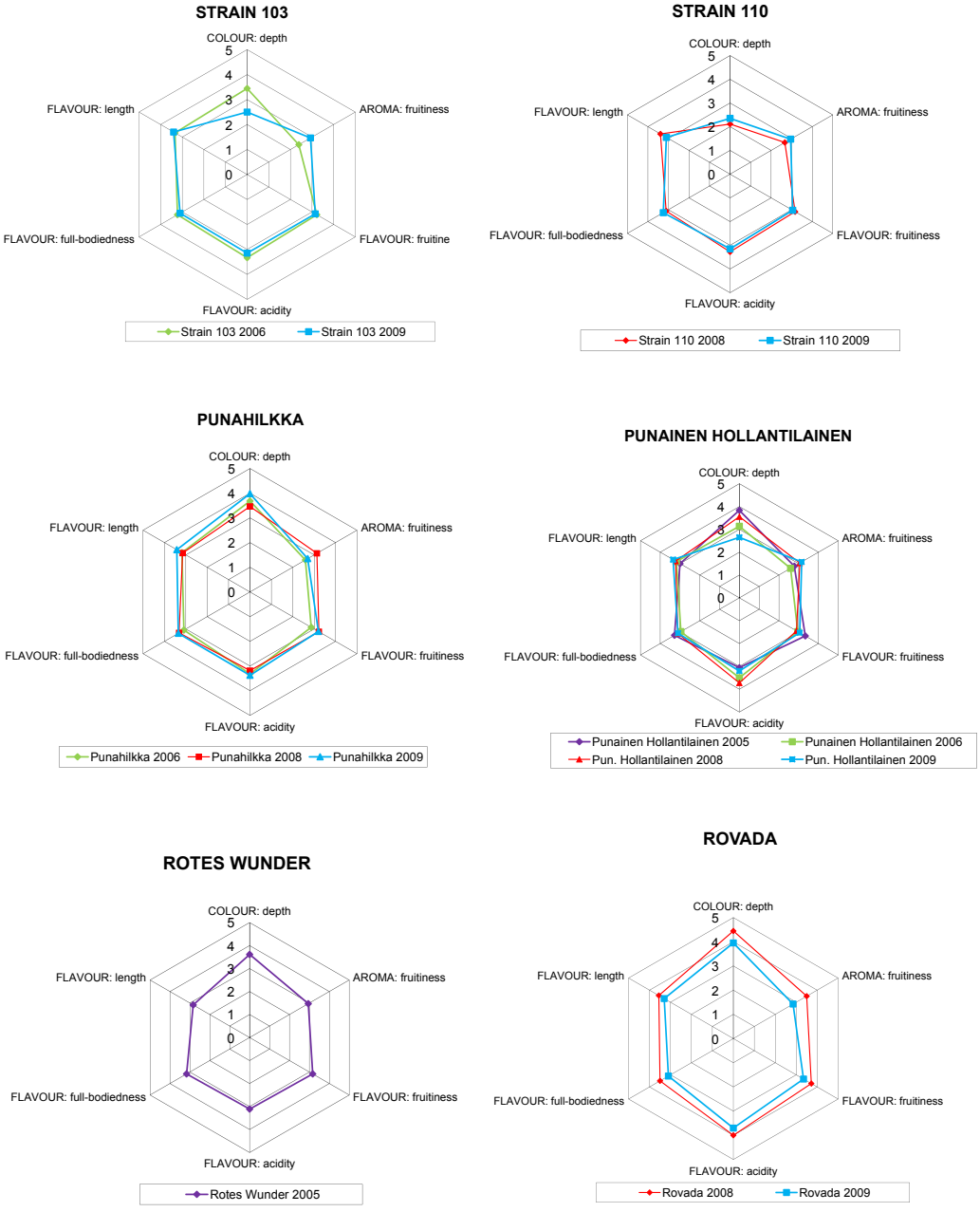


Figure 15. Sensory properties of varietal redcurrant wines, measured on a scale of 0–5 according to strength (7–12 evaluators). Juice content 25%, target alcohol content 12% by vol., sweetened to 20 g/l sugar.

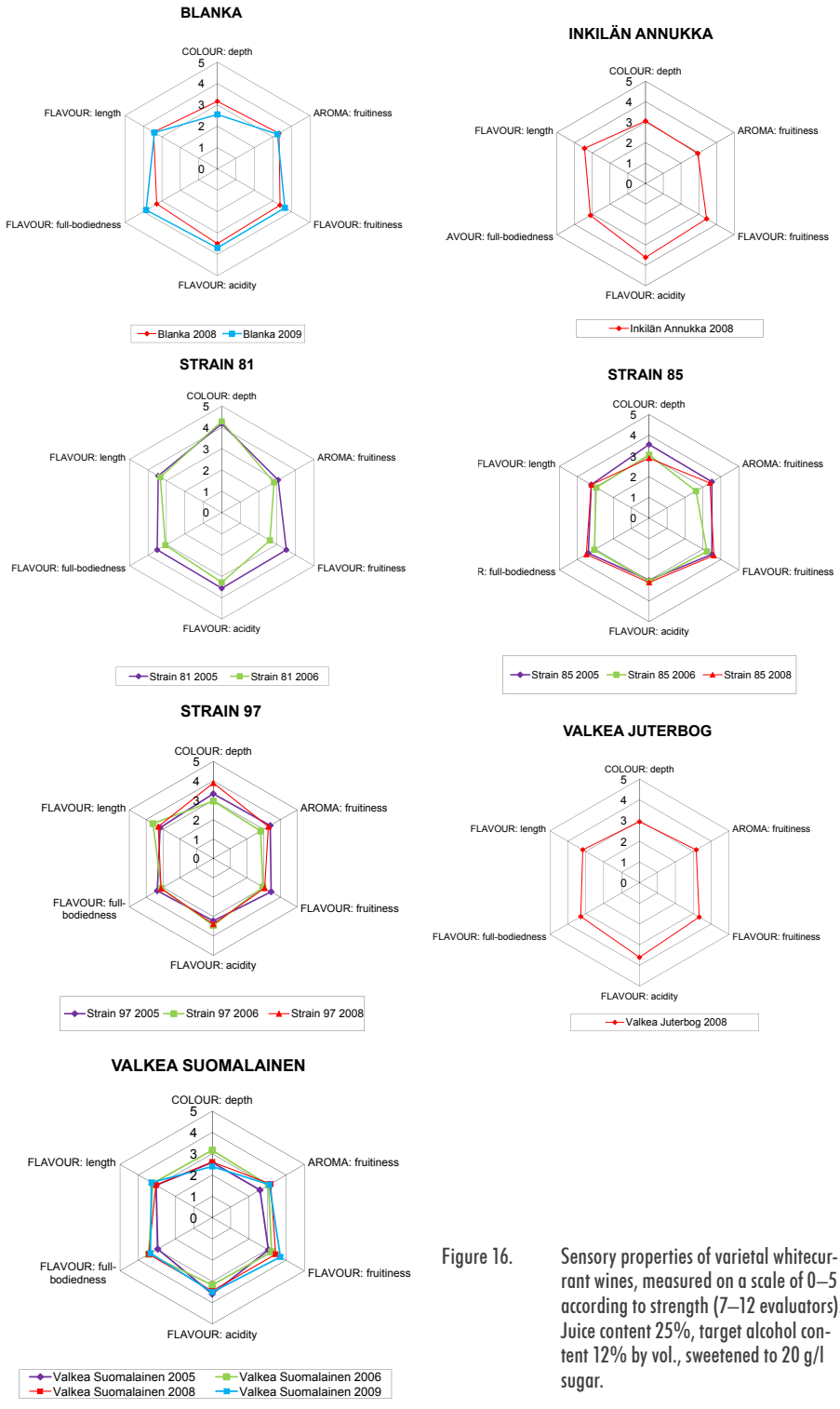


Figure 16. Sensory properties of varietal whitecurrant wines, measured on a scale of 0–5 according to strength (7–12 evaluators). Juice content 25%, target alcohol content 12% by vol., sweetened to 20 g/l sugar.

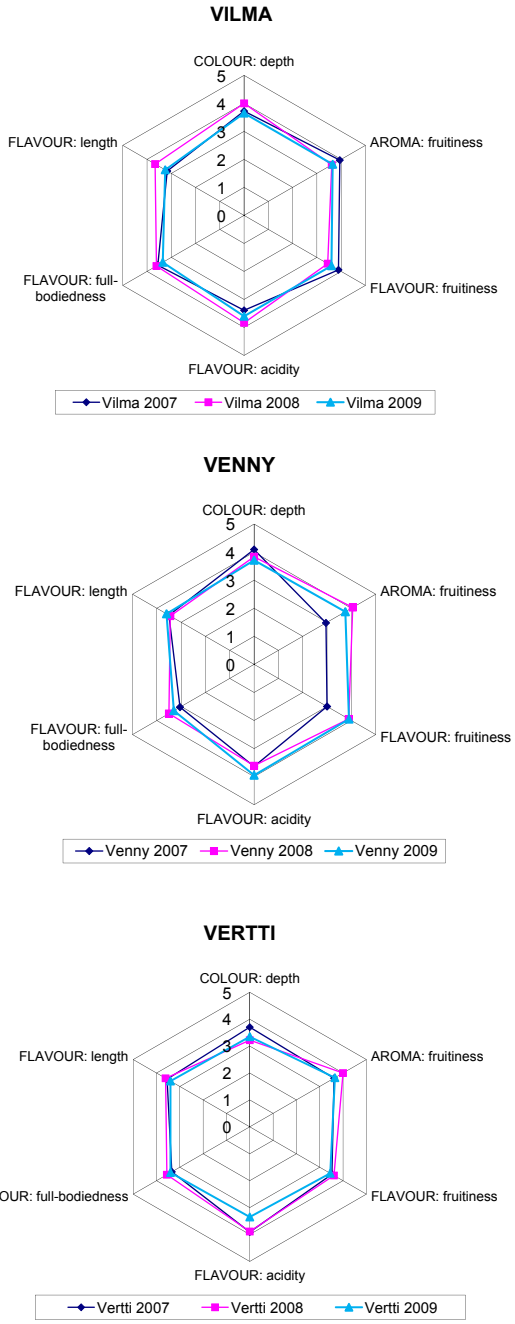


Figure 17. Sensory properties of varietal greencurrant wines, measured on a scale of 0–5 according to strength (7–12 evaluators). Juice content 25%, target alcohol content 12% by vol., sweetened to 20 g/l sugar.

5.2.5 Effect of Aging on Sensory Properties of Currant Wines

According to this study, 14 months of bottle aging of varietal blackcurrant wine made from Mortti berries slightly increased the depth of the wine's colour, the fruitiness of the aroma and the full-bodiedness and length of the wine's flavour. The same was noted in terms of the colour of the Marski varietal blackcurrant wine. Similarly, the fruitiness of the aroma and the flavour increased during 14 months of bottle aging (Fig. 18).

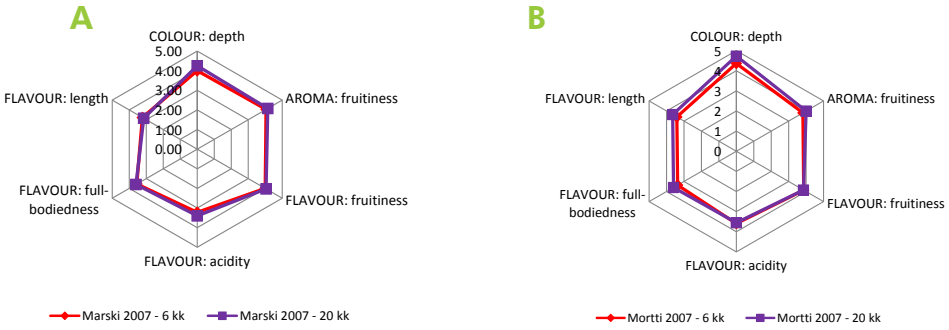


Figure 18. Change in sensory properties of varietal blackcurrant wines Mortti (A) and Marski (B) during bottle aging. Juice content 25 %, target alcohol content 11 % by vol., sweetened to 20 g/l sugar. The wines were evaluated after eight and 22 months of bottle aging.

5.3 Effect of Water Used in Winemaking on the Sensory Properties of Whitecurrant Wine

The effect of water was first tested using differentiation testing to see whether differences in water could be perceived in the wine. Wine batches were produced of the same whitecurrant variety (White Finn, crop year 2007) in the same way as the other wines for this study. The fermentation period was five weeks for most batches, except for two batches (made with the same water sample), where it was six weeks.

The wine made from Anttola water was distinguished 11 times out of 46 sample series (24 %), the wine from Lepaa water was distinguished 18 times out of 44 series (41 %) and the wine from Veteli water, 17 times out of 45 series (38 %). The conclusion was that the different waters used as raw materials in winemaking did not have an effect on the wines.

According to the results, the different waters used in winemaking could not be distinguished in the finished whitecurrant wines. For this reason, no further research was conducted on the water in the wine.

6 Conclusions

All of the apple and currant varieties selected for the research were found to be suitable for the country fruit wine production process. The processability of each of the raw materials was good and all of the produced apple and currant wines were technically good in terms of their sensory properties.

When comparing wines of the same type (apple, blackcurrant, greencurrant, redcurrant and whitecurrant), greater differences between varieties were found in the currant wines than in the apple wines.

The following conclusions were drawn on the apple wines and their processing:

- The differences between apple varieties (3 – 4 evaluators' evaluations of two crop years) were only statistically significant in the apples' sweetness and acidity. Other sensory properties that were measured were the integrity of the fruit's surface, strength of the aroma, the typicality of the taste, the toughness of the skin and the juiciness of the fruit.

- All of the apple varieties were suitable for pressing. The integrity of the apple's surface and the toughness of the skin had a statistically significant effect on pressing. The more intact the surface, the higher the pressure that could be used. The tougher the apple's skin, the higher the juice yield.

- There was fairly little variation between the apple varieties and chemical properties of the juices drawn from them. There were no great or regularly appearing differences between the summer, late season and winter varieties. Neither did the crop year have a regular effect on any chemical property of the juice.

- With regard to the chemical properties of the juices made from the apple varieties in the study, the sugar content had an almost statistically significant effect on the duration of the fermentation of the must. The lower the sugar content of the fresh apple juice, i.e. the more sucrose had to be added to the must in order to reach the desired alcohol content, the longer the fermentation time. A high acidity level in the juice also increased the fermentation time.

- According to the results, the apple varieties with the higher sugar content were suitable for quick fermentation, which may reduce the risk of microbial contamination as compared to slow fermentation. On the other hand, the resulting apple wine may be simpler in its sensory properties than a wine whose must develops metabolic products others than those of the wine yeast Saccharomyces cerevisiae. Quick fermentation may also have a financial significance in the process.

  The longer the fermentation period, the more acidic the wine's perceived flavour in the study.

- The variety was found to have an effect on the sensory properties of colour depth, acidity of flavour, full-bodiedness of flavour and fruitiness of aroma.

- The juice content of the analysed apple wines was 50 %. There was an almost significant correlation between the sensory properties of juice and of the resulting in relation to the sugar content of the juice and the fruitiness of the aroma and the flavour of the wine. A high sugar content added fruitiness to the aroma of the wine. On the other hand, the lower the sugar content, the more acidic the wine's flavour.

- All of the summer apple wines were perceived to have little fruitiness of flavour. Of the late season varieties, Heta produced a wine with a freshly fruity and mineral aroma, and a balanced flavour. Of the winter apple varieties, none stood out from the others in terms of sensory properties; all were good.

- Bottle aging slightly weakened the sensory properties of the wine made from both of the varieties under investigation (Lobo and Juuso). Fourteen months of aging weakened the full-bodiedness and fruitiness of the flavour.

The following conclusions were drawn on the currant wines and their processing:

- Differences were found to exist in the sensory properties of the different currant varieties. The greatest differences were

found in acidity and sweetness. From a winemaker's point of view, high acidity of the raw material is significant in that water must be added to the wine to reduce it. The juice content of the currant wines included in the study was standardised at 25 %.

- The juice analysis results for greencurrants were similar to those of blackcurrants, but the greencurrants had the highest sugar content of all currants. The differences between crop years were fairly large in juice analysis results. After a long growing season, the currants' sugar content was higher than after a short season.

- In black- and greencurrants, the perceived sweetness was highest when the acidity of the juice was low. Similarly, perceived acidity was high when the acidity of the juice was high. In red- and whitecurrants, the perceived sweetness correlated with the sugar-related properties (Brix, specific gravity, sugar content). In red- and whitecurrants, the toughness of the skin also correlated with the acidity of the juice.

- Attainment of the target alcohol content (12 % by vol.) took 2 – 9 weeks for the currant wines. No such correlation between sugar content and fermentation time as in the apple wines was found for the currant varieties. On the other hand, for red- and whitecurrants, the lower the pH of the juice, the longer fermentation took. For whitecurrants, fermentation also appeared to be slower for juices with higher total acidity.

- The colour of the currant wines was affected both by the variety and by the crop year. The darkest redcurrant varieties, such as Punahilkka and Rovada, also produced the darkest wines. Of the other currants Agrifood Research Finland's whitecurrant Strain 81, blackcurrant Mortti, and greencurrants Venny and Vilma stood out due to the depth of their wines' colours. ARF whitecurrant Strain 85 stood out from the other whitecurrants due to the low acidity of its flavour. Of the redcurrant wines, Rovada produced the most acidic flavour.

  The strength of the smell of the berries correlated with the depth of the wine's colour, the strength of the aroma, and the fruitiness of the flavour, especially in the case of blackcurrants.

- Of the whitecurrant varietal wines, Inkilän Annukka stood out in the sensory descriptions due to the mineral nature of its aroma and the delicious firmness of its acidity of flavour. ARF whitecurrant Strain 85 was distinguished by the floral and herbal tones of its aroma and flavour.

- Of the varietal redcurrant wines, Punahilkka stood out thanks to its attractive, warm-red colour.
- Of the varietal greencurrant wines, Venny was described as pleasantly soft in acidity and fruitily perfume-like in aroma.
- Of the varietal blackcurrant wines, the wine from ARF Strain 15 was perceived as a balanced and high-quality blackcurrant wine. Marski and Mikael also produced wines with positive sensory properties.
- Aging had a positive effect on the sensory properties of blackcurrant wines for both of the analysed varieties (Mortti and Marski). Fourteen months of bottle aging added depth to the wines' colour, fruitiness to the aroma and full-bodiedness and length to the flavour.
- The effect of water quality on the sensory properties of fruit wine was tested using whitecurrant wine made from the variety White Finn. The proportion of water used as a raw material in these wines was 75 %. Differentiation testing showed that the differences between the water types used in winemaking could not be perceived. The variation of the water in the winemaking had no effect on the perceived taste.

Cultivation technology, management of the fermentation process and competence in winemaking are crucial issues in country fruit wine production. The results of this study show that in comparison with those factors, the effects of the choice of fruit variety on the sensory properties of wines are very limited. Differences between varieties are more significant when apples and currants are used fresh or made into juice. It is to be expected that the differences between the varieties will be greater in fruit wines that have a larger proportion of juice than that used in this study (>50 % apple juice or >25 % currant juice).

7 Project Evaluation

This was the first study to investigate the raw materials suitable for Finnish country fruit wine production, as well as their processing and quality. The project progressed as planned. Three years was a sufficiently long period for this kind of study, in order that differences between crop years could be accounted for.

The main emphasis of the research was on the properties of raw materials and their transference to finished wines. In this study, the varietal wines were not modified in any way, and the processing and conditions were standardised to the greatest possible extent.

Contrary to expectations and advance requests, no sufficient justification was found for limiting the number of varieties under review, so test batches were produced of a fairly large number of varieties. In some years, insufficient crops were obtained of some varieties, which reduced the research data and complicated data processing and its statistical reliability. It may be that certain differences between varieties or correlations went unnoticed due to this fact. Specifically, the interaction effect of the crop year and the variety could not be proven using statistical methods in this study, although indications of it could be observed in the data. The small sample sizes also restricted analysis; for example, sensory evaluation of the juices could not be done because there was not enough juice to spare.

The practical implementation of the study was very successful. Careful winemaking and process monitoring ensured that all wine batches were successful.

Sensory evaluations turned out to be surprisingly difficult to carry out in a way that would bring out the properties of the raw materials. No ready-made model existed for what should be measured and how.

As a further study, it would be good to examine the suitability of different varieties for different products – for example various processed products,

jams, juices, ciders, wines and liqueurs. A closer look at the chemical compositions of the raw materials in comparison with the end products could also contribute new perspectives.

References

Blomqvist, L. 2005. Pohjoisen omenat. pp. 76, 127.

Decision of the Finnish Ministry of Social Affairs and Health 7.6.1995/852

Finnish Alcohol Decree 22.12.1994/1344

Finnish National Supervisory Authority for Welfare and Health (Valvira). "Alkoholijuomien jakeluverkosto vuonna 2009". Accessed on 24/2/2010. http://www.valvira.fi/ohjaus_ja_valvonta/alkoholi/tilastot/vuosi_2009

Hokka, H., Laamanen, J., Lahtonen, V., Pöyhönen, P. & Uosukainen, M. 2009. "Varmennetun taimituotannon emokasvihinnasto vuonna 2009". Accessed on 22/1/2009. https://portal.mtt.fi/portal/page/portal/www/Palvelut/Valiotaimituotanto/Varmennetun_taimituotannon_emokasvihinnasto2009.pdf

International Organisation of Vine and Wine (OIV). Compendium of International Methods of Wine and Must Analysis. Edition 2007. Volumes 1 ja 2. Available at : http://www.oiv.org/ → Publications → Standardising

Kinnanen, H., Tahvonen, R. & Ylämäki, A. 2007. Lajikkeisto. Teoksessa Tahvonen, R. (Eds.) Omenan viljely. Helsinki: Puutarhaliitto. pp. 181, 184 – 187, 189, 193, 198 – 202, 205 – 206.

Krannila, A. & Paalo, A. 2008. Omenapuu. Helsinki: Multikustannus Oy. p. 119.

Matala, V. 1993. Herukan viljely. Helsinki: Puutarhaliitto.

Statistics Finland. "Suomalaisen omenan tuotanto vahvassa kasvussa". Accessed on 2/5/2009. http://www.mmmtike.fi/fi/index/tiedotteet/e_tiketti/jutut/omenapuutilasto.html

Appendix 1. Raw Material Evaluation Form

Evaluation of Properties of Apples Ripe for Eating

Name: _____ Date: _____ Sample: _____

Appearance

Surface integrity
damaged — intact

Comments:

Smell

Strength
none — strong

Typical of species yes/no

Comments:

Taste

Typical of species
atypical — typical

Sweetness
none — sweet

Acidity
none — acidic

Comments

Other observations

Skin toughness
soft — tough

Juiciness
dry — juicy

Appendix 2. Evaluation Form for Sensory Properties of Varietal Wines

VIINIPRO Project EVALUATION FORM FOR VARIETAL WINES

EVALUATOR: _____

SAMPLE: _____

EVALUATE ON A SCALE OF 0–5

EVALUATION CATEGORY:	VALUE:	VERBAL DESCRIPTION:
COLOUR: depth		
AROMA: fruitiness		
FLAVOUR: fruitiness		
FLAVOUR: acidity		
FLAVOUR: full-bodiedness		
FLAVOUR: length		

SCALE	VALUE
none	0
only just perceptible	1
weak	2
average/clear	3
strong	4
very strong	5

Appendix 3. Evaluation Form for Differentiation Test. Effect on Wine Flavour of Different Waters Used in Winemaking.

VIINIPRO Project

Test form 3/2010

Name:

You have been provided with three wine samples to evaluate.
In each series there are two identical samples and one different sample.

The raw materials are identical in all samples, with the type of water used in the sample as the only variable.
Please circle the differing sample. If you are unsure, please guess.

Series 1	443	320	187
Series 2	854	731	498
Series 3	265	142	909

Appendix 4. Piikkiö Weather Data for 2005 – 2009 (Finnish Meteorological Institute)

Winter (snow depth, temperature, ground frost depth)

The early winters were fairly mild and with little snow. On average, the permanent snow fell in late January and disappeared in March.

January 2005 was slightly warmer than average, with permanent snow from late January to late March. Ground frost depth max. 40 cm (not until mid-March).

In winter 2006, thicker snow only arrived in late March (approx. 15 cm) and stayed until mid-April, at which time the ground frost was at its deepest, i.e. 60 cm.

In winter 2007, the snow covering was permanent from late January to early March. After mid-March there was no snow. There was ground frost from mid-January to mid-March (max. 50 cm). There were fewer days of sub-zero temperatures than average.

In winter 2008 there was no permanent snow covering; the average depth of snow throughout the season was 0 – 1 cm. The temperature remained around zero all winter, with very few days below zero. Maximum ground frost depth 17 cm. The thermal beginning of spring was slightly earlier than average (on 4 February).

Winter 2009 was fairly average, with a permanent snow covering from January to the end of March (average 20 cm). There was ground frost from late December to late March (max. 50 cm).

Total effective temperature during growth season, summer temperatures and rains

In summer 2005 there were 14 days of rain per month on average, with greater rainfall in July/August than usual. The total effective temperature was also slightly higher than usual.

In summer 2006 there were 10 days of rain per month on average. The rainfall was lower than average. In October, however, the rainfall was more than 50 % higher than average (1971 – 2000). In June – August it was slightly warmer than average, with 24 days above 25 °C. Even in September it was approx. 4 °C warmer than average. The total effective temperature was significantly higher than average.

In summer 2007 there were 14 days of rain per month, with 21 rainy days in July. In March/April, the temperature was slightly above average, but in the summer months the temperatures were average (as compared to 1971 – 2000). The total effective temperature was slightly higher than usual.

In summer 2008 there were 15 days of rain per month, with 20 rainy days in August. May had less rainfall than average, at only one-tenth of the usual amount (in mm), whereas in June it rained 50 % more than usual. Temperatures were fairly average, although there were only five days above 25 °C.

In summer 2009 there were 12 days of rain per month. Rainfall was normal in comparison with the average (1971 – 2000). The average monthly temperature and total effective temperature were normal.

Appendix 5. Chemical analyses after 1-2 months' maturing in steel vessels and fermentation times (until sugar content fell below 10 g/l, monitored by weekly measurements of the sugar content) of black- and redcurrant wines. Juice content 25 % and target alcohol content 12 % by vol. (11 % by vol. in 2007 for blackcurrants).

Blackcurrant variety	Crop year	Alcohol content, % by volume	Specific gravity of wine	Total extract content g/l (computational)	Sugar content g/l	Sugar-free extract g/l	Total acid content g/l (tartaric acid)	pH	Fermentation time, weeks
Marski	2007	11,4	0,9938		5,4		11,95	3,17	6
Marski	2008	13,1	0,9933	29,7	6,3	23,5	10,84	3,22	4
Marski	2009	13,2	0,9928	27,8	5,4	22,4	11,59	3,32	3
Mikael	2007	11,85	0,9928	23,2	4,4	18,8	11,50	3,22	7
Mikael	2008	13,1	0,9925	25,8	5,2	21,0	11,29	3,23	5
Mikael	2009	13,0	0,9928	27,2	5,5	21,8	11,93	3,34	3
Mortti	2007	11,8	0,9948	28,4	5,4	23,0	12,95	3,35	6
Mortti	2008	13,1	0,9935	29,7	5,9	23,8	11,33	3,25	6
Mortti	2009	13,3	0,9933	28,4	5,2	23,2	12,35	3,39	3
ARF Strain 15	2007	12,1	0,9938	23,2	4,9	18,3	16,09	3,06	6
ARF Strain 15	2008	13,2	0,9938	31,0	5,2	25,9	13,50	3,12	4
ARF Strain 15	2009	13,1	0,9948	31,0	5,3	25,7	15,77	3,22	3
ARF Strain 36	2007	11,7	0,9948	28,4	5,7	22,7	14,80	3,04	5
ARF Strain 36	2009	13,3	0,9919	25,8	3,8	22,0	13,73	3,20	3

Redcurrant variety	Crop year	Alcohol content, % by volume	Specific gravity of wine	Total extract content g/l (computational)	Sugar content g/l	Sugar-free extract g/l	Total acid content g/l (tartaric acid)	pH	Fermentation time, weeks
ARF Strain 103	2005	13,1	0,9888	21,4	5,2	16,2	10,35	3,60	4
ARF Strain 103	2006	12,8	0,9899	18,0	5,4	12,6	11,15	3,47	5
ARF Strain 103	2009	13,1	0,9903	20,6	3,7	16,9	9,15	3,35	3
ARF Strain 110	2008	13,2	0,9910	22,9	3,5	19,4	9,90	3,18	2
ARF Strain 110	2009	13,5	0,9898	19,3	3,7	15,6	8,93	3,35	3
Punahilkka	2006	13,1	0,9900	20,6	5,1	15,5	11,55	3,41	4
Punahilkka	2007	12,5	0,9933	27,1	4,8	22,4	14,27	3,12	5
Punahilkka	2008	12,9	0,9911	22,7	4,1	18,6	9,58	3,14	4
Punahilkka	2009	13,2	0,9903	19,3	4,8	14,6	9,00	3,32	3
Red Dutch	2005	13,4	0,9878	20,9	4,2	16,7	10,90	3,53	4
Red Dutch	2006	13,0	0,9906	21,1	5,7	15,4	13,60	3,49	6
Red Dutch	2008	12,8	0,9931	25,3	4,7	20,6	10,94	3,18	5
Red Dutch	2009	13,2	0,9908	22,6	5,2	17,4	9,91	3,32	3
Rotes Wunder	2005	13,3	0,9900	20,6	4,3	16,3	11,40	3,57	5
Rovada	2008	12,8	0,9927	26,7	6,2	20,6	12,62	3,02	6
Rovada	2009	13,5	0,9908	22,6	4,7	17,9	10,99	3,11	6

Appendix 6. Chemical analyses after 1-2 months' maturing in steel vessels and fermentation times (until sugar content fell below 10 g/l, monitored by weekly measurements of the sugar content) of white- and greencurrant wines. Juice content 25 % and target alcohol content 12 % by volume.

Whitecurrant variety	Crop year	Alcohol content, % by volume	Specific gravity of wine	Total extract content g/l (computational)	Sugar content g/l	Sugar-free extract g/l	Total acid content g/l (tartaric acid)	pH	Fermentation time, weeks
Blanka	2008	13,7	0,9905	21,9	4,1	17,8	11,14	3,30	5
Blanka	2009	12,9	0,9910	21,3	4,7	16,6	10,88	3,27	4
Inkilän Annukka	2008	13,2	0,9908	21,9	3,7	18,2	8,97	3,26	4
ARF Strain 81	2005	13,6	0,9890	19,6	4,8	14,8	12,40	3,34	6
ARF Strain 81	2006	12,5	0,9910	15,4	5,4	10,0	13,85	3,36	5
ARF Strain 85	2005	13,0	0,9887	17,7	5,3	12,5	9,03	3,53	3
ARF Strain 85	2006	12,4	0,9898	18,3	4,0	14,3	10,40	3,61	4
ARF Strain 85	2008	12,5	0,9923	24,5	3,1	21,4	10,39	3,34	4
ARF Strain 97	2005	13,2	0,9888	18,8	4,4	14,4	7,30	3,47	4
ARF Strain 97	2006	13,4	0,9887	18,0	4,5	13,5	10,85	3,40	5
ARF Strain 97	2008	13,5	0,9920	25,2	3,8	21,4	11,67	3,36	5
Valkea Jüterbog	2008	13,2	0,9915	23,2	3,3	20,0	10,95	3,20	5
White Finn	2005	12,8	0,9898	19,0	4,0	15,0	12,65	3,40	4
White Finn	2006	12,7	0,9903	14,2	4,2	10,0	12,80	3,44	5
White Finn	2007	13,3	0,9909	23,5	4,5	19,0	10,50	3,29	5
White Finn	2008	13,1	0,9910	22,6	2,7	19,9	11,97	3,07	6
White Finn	2009	12,8	0,9913	21,3	3,9	17,4	11,59	3,14	4

Greencurrant variety	Crop year	Alcohol content, % by volume	Specific gravity of wine	Total extract content g/l (computational)	Sugar content g/l	Sugar-free extract g/l	Total acid content g/l (tartaric acid)	pH	Fermentation time, weeks
Venny	2007	13,1	0,9928	27,1	5,6	21,5	12,75	3,24	9
Venny	2008	13,0	0,9948	31,0	6,0	25,0	12,64	3,15	6
Venny	2009	12,9	0,9940	29,1	5,0	24,1	13,95	3,36	3
Vertti	2007	13,1	0,9918	23,2	3,9	19,3	12,42	3,16	6
Vertti	2008	13,1	0,9935	29,7	5,9	23,8	11,33	3,25	5
Vertti	2009	12,3	0,9918	21,9	4,1	17,9	11,74	3,15	3
Vilma	2007	12,9	0,9918	21,9	5,0	16,9	10,88	3,29	8
Vilma	2008	13,2	0,9935	29,1	5,6	23,5	11,82	3,24	6
Vilma	2009	12,6	0,9940	29,1	6,1	23,0	12,45	3,35	3