Quality of Wines Produced from Grape Varieties Grown on Suranaree University of Technology Farm

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คุณภาพของไวน์ที่ผลิตจากองุ่นสายพันธุ์ต่าง ๆ ที่ปลูกที่ฟาร์มมหาวิทยาลัยเทคโนโลยีสุรนารี

ลำไพร ดิษฐวิบูลย์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
สาขาวิชาเทคโนโลยีชีวภาพ
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QUALITY OF WINES PRODUCED FROM GRAPE VARIETIES GROWN ON SURANAREE UNIVERSITY OF TECHNOLOGY FARM

Suranaree University of Technology Council has approved this submitted in partial fulfillments for the Master's Degree

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การวิจัยเรื่องนี้มีวัตถุประสงค์เพื่อผลิตไวน์คุณภาพดีจากองุ่นสายพันธุ์ต่าง ๆ ที่ปลูกที่ฟาร์มมหาวิทยาลัยเทคโนโลยีสุรนารี โดยผลิตไวน์แดงและไวน์ขาวจากองุ่น 5 สายพันธุ์ ที่เก็บเกี่ยวในฤดูแล้งและฤดูฝน ตรวจสอบคุณภาพเบื้องต้นของวัตถุดิบพบว่าองุ่นที่เก็บเกี่ยวในฤดูแล้งและฤดูฝนมีปริมาณ total soluble solid เฉลี่ย 15.5-18.4°Brix และปริมาณกรด 0.42-0.82% ตามลำดับ จากการศึกษาพบว่าองุ่นเกือบทุกสายพันธุ์ที่เก็บเกี่ยวในฤดูฝนมีคุณภาพโดยรวมต่ำ เนื่องจากมีผนชุกและมีแสงแดดน้อยทำให้องุ่นสังเคราะห์น้ำตาลได้น้อย นำองุ่นมาหมักแอลกอฮอล์โดยใช้ยีสต์ *Saccharomyces cerevisiae* K1-V1116 และแบคทีเรีย *Leuconostoc oenos* (Viniflora) นำไวน์ที่ผ่านการหมักบ่มแล้วมาวิเคราะห์องค์ประกอบทางเคมีที่สำคัญ ๆ เช่น ethanol และกรดอินทรีย์ต่าง ๆ ด้วย HPLC และประเมินคุณภาพด้านประสาทสัมผัสโดยการทดสอบชิมด้วยวิธี Quantitative Descriptive Analysis (QDA) พร้อมทั้งเปรียบเทียบตัวอย่างไวน์จากท้องตลาด จากการทดลองพบว่าองุ่นบางสายพันธุ์ที่คุณภาพไม่ดีจะเกิดการหมักที่ไม่สมบูรณ์ จากการวิเคราะห์ค่าทางเคมีของไวน์จากองุ่นฤดูแล้งพบว่ามีปริมาณ ethanol เฉลี่ย 11.4% v/v และ 9.4% v/v ในไวน์แดงและไวน์ขาวตามลำดับ โดยที่ค่าทางเคมีอื่น ๆ ไม่มีความแตกต่างกันระหว่างไวน์ที่ผลิตได้กับไวน์ตัวอย่าง ในขณะที่เมื่อทำการทดสอบชิมและวิเคราะห์ข้อมูลทางสถิติพบว่า ไวน์จากองุ่นแต่ละสายพันธุ์จะมีลักษณะเฉพาะตัวที่แตกต่างกันไป ไวน์ที่ผลิตได้มีคุณภาพโดยรวมจากการทดสอบชิมยังอยู่ในระดับต่ำ จากองุ่นสายพันธุ์ต่าง ๆ ที่นำมาผลิตไวน์พบว่า องุ่นพันธุ์ Black Pop และ Albany มีคุณภาพโดยรวมจากการทดสอบชิมสูงที่สุดในกลุ่มไวน์แดงและไวน์ขาวตามลำดับ โดยที่คุณภาพโดยรวมไม่มีความแตกต่างกันอย่างมีนัยสำคัญที่ระดับความเชื่อมั่น 95% แต่จะแตกต่างกันอย่างมีนัยสำคัญในคุณสมบัติบางประการในบางสายพันธุ์ แต่อย่างไรก็ตามเนื่องจากไวน์ที่ได้จากองุ่นแต่ละสายพันธุ์จะมีลักษณะเฉพาะตัวที่แตกต่างกัน การนำไวน์จากองุ่นบางสายพันธุ์มาผสมกัน เป็นแนวทางหนึ่งที่จะสามารถเพิ่มหรือปรับปรุงคุณภาพของไวน์ให้ดีขึ้นได้ หรืออาจปรับปรุงขั้นตอนการบ่มซึ่งจะต้องทำการศึกษาต่อไป

สาขาวิชาเทคโนโลยีชีวภาพ
ปีการศึกษา 2543

ลายมือชื่อนักศึกษา .....
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LUMPHRAI DITHAVIBOOL : QUALITY OF WINES PRODUCED FROM GRAPE VARIETIES GROWN ON SURANAREE UNIVERSITY OF TECHNOLOGY FARM THESIS ADVISOR : PROF. NANTAKORN BOONKERD, Ph.D. 82 PP. ISBN 974-533-001-9

The objective of this study was to produce high quality table wine from various varieties of grapes planted on Suranaree University of Technology Farm (SUT Farm). Red and white wines were prepared from 5 grape varieties. Some varieties were harvested in either dry or rainy season whereas some varieties were harvested in both seasons. Physical and chemical properties of grapes were analyzed. Average amount of total soluble solids in dry and rainy season grapes was range from 15.5-18.4^{o}Brix and titratable acidity was 0.42-0.82%. Almost rainy season grapes were low quality due to high moisture and low light intensity rendering low sugar accumulation. Wine fermentation was carried out by using commercial yeast and bacteria; *Saccharomyces cerevisiae* K1-V1116 and *Leuconostoc oenos* (Viniflora), respectively. Matured wines were analyzed for main chemical properties such as ethanol and organic acids by HPLC and sensory evaluation by Quantitative Descriptive Analysis (QDA). Some samples of imported wines were also analyzed in order to compare the attribute profiles. Some varieties of grapes harvested in rainy season performed incomplete fermentation. Matured wines from dry season grapes had average 11.4 and 9.4% v/v of ethanol in red and white wine, respectively. There was no different in main chemical value between SUT wines and imported wines. Sensory evaluation indicated that each varieties had its own characteristic. The grape varieties, Black Pop and Albany showed highest score in overall impression among SUT wines. No significant difference at 95% confidence interval in overall impression was found whereas some varieties had distinct attributes. Nevertheless, due to its own characteristic, to make good quality of wine various techniques such as blending or modifying in maturation step need to be considered. In addition, due to high in both humidity and temperature in rainy season resulting in low quality of grapes, timing of harvesting and vineyard management had to be taken for consideration for producing quality wine.

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Lumphrai Dithavibool

CONTENTS

Page

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

LAB	=	Lactic Acid Bacteria
mm	=	millimeter
M	=	molarity
^{o}C	=	degree Celsius
ml	=	milliliter
min	=	minute
µl	=	microliter
nm	=	nanometer
CFU	=	colony forming unit
g	=	gram
l	=	liter
UV	=	ultraviolet
KHT	=	Potassium bitartrate
kg	=	kilogram
N	=	normality
mg/l	=	milligram per litre
% v/v	=	percent volume by volume
MLF	=	malolactic fermentation
MRS agar	=	Lactobacillus agar acc. to DE MAN, ROGOSA and SHARPE
cm	=	centimetre
∅	=	diameter
rpm	=	revolution per minute
SUT	=	Suranaree University of Technology

CHAPTER 1

INTRODUCTION

1.1 Definitions

Wine in generally is defined as an alcoholic beverage obtained by the fermentation of the fruit juice. The U.S. Bureau of Alcohol, Tobacco and Firearms (BATR or, more commonly ATF) defines wine as "The product of the juice of sound, ripe grapes." Wine, as the word is used in this case, *is the product of fermenting and processing grape juice or must*. Crushed grapes, generally with all or some portion of the stems removed, are known as *must*.

Wine made from any fruits other than grapes is qualified, both by tradition and by ATR commercial regulation, by identifying that particular fruit. By itself the term *wine* implies the beverage is made from grapes. Otherwise it is labeled as "blackberry wine," "peach wine," and so on. By law, in Thailand wine is non-distilled alcoholic beverage made from **wine grapes** with ethanol content less than 15% v/v. Wine made from any fruits other than grapes are called **fruit wines.**

1.2 Historical background

Wine culture may have commenced in the Far East, in Mesopotamia, or in Egypt, where important centers of early civilization and primitive winegrowing. There can be no doubt, however, that the Mesopotamian Persians made wine some 6,000 years in the Trigis-Euprates river region, in where is now Iraq.

Some authorities contend that the first commercial vineyards were located northwest of Mesopotamia, across modern-day Turkey and over the Caucasus mountains into Georgia. (Fig. 1)

Figure 1. The course of winegrowing in the early history of Western civilization

Since Pasteur' s discoveries people were faced with the realization that fermentation was not magical or mystical after all, but a natural product unveiled by science.

In comparison with the 6,000 years of winegrowing history in the Old World, the 400-year span of New World vines and wines seems minuscule. Grapevines grow abundantly in the United States. Australia and New Zealand are British Commonwealth nations, ability to make world-class quality wines. Vines cultivated in New Zealand are also of German origin, along with the typical New World immigration of vines from France, Italy, Portugal, and Spain.

In South America, vines were planted in Peru in 1563, Chile was the next to grow wine, modeling its industry on that in France. Commercial winegrowing was undertaken by Italian immigrants in Argentina. Brazillian viticulture emerged in the early twentieth century under Portuguese influence. Uruguay was settled by people who emigrated from all of four of these European nations. Today there is more wine produced and consumed in South America than in North America.

Modern-day wines from South Africa rank with any in the world. Then South Africa winegrowing widely expanded, but, for the concentrated an increasing quantity, rather than improving quality, nevertheless, success continued until 1861.

1.3 Uses of Wine

It has been used to complement meals, and in countries where wine is cheap it is served as the normal beverage at mealtime. Wine has been also used to improve the flavor of food in cooking. Throughout history it has played an important role in religious ceremonies, and is used to minister to the ill. Wine is also commonly used for the celebration of important occassions, as well as to welcome guests.

1.4 Classification

Wines can be classified in several items based upon the criteria of interests. One method is based on characteristics that are easily recognized such as color, presence of herps or flavoring material, amount of carbondioxide and sugar present, and detection of varietal aromas. Altogether geographical origin, or the use to which the wine is to be put are other classification criteria.

Wine experts generally classify wine into five categories, with the distinctions among the classes based primarily on major differences in their manner of vinification.

1.4.1 Table Wines

The majority of the wine produced in the world falls into the table wine category. Table wines are designed for use at the table as a complement to good food, table wines are sometimes referred to as “dinner wines”. There are white, blush (pink), and red table wines. These are the base wine needed in order to make every other wine type.

1.4.2 Sparkling Wines

These are wines, which “effervesce” or bubble. Nowadays, many people use the terms “Champagne” and “ sparkling wines” interchangeably. However, Champagne is a sparkling wine producing region in France and the term is thus generic. All Champagne are sparkling wines, but not all sparkling- wines are Champagne.

1.4.3 Dessert Wines

Dessert wines are usually made by the addition of grape brandy to a fermenting juice or must, less often to a completely fermented table wine. The brandy addition usually increases alcohol content to 19 to 20 percent by volume, not to exceed 24 percent by ATF regulations. Wines having undergone a brandy addition are sometimes referred to as “fortified”.

1.4.4 Aperitif Wines

Aperitif wines are those designed to serve as appetizers to prime the palate before a special meal. Aperitif wines are largely consumed in the United States as cocktail mixers. Aperitif wines are fortified with brandy, generally up to a level of 17 or 18 percent alcohol by volume. ATF approval is required prior to producing each of these "special natural" wines, as they are sometimes referred to. Essences from various barks, herbs, peels, roots, and/or spices, combined in a special, closely guarded, sometimes patented recipe, are added to create a consistently distinctive wine.

1.4.5 Pop Wines

In short, pop wines closely resemble aperitif wines, except that the added essences are more exotic, typically boldly pronounced fruit and/or berry flavors.

1.5 Wine Quality

Quality is a subjective judgment that depends on the degree to which the wine is satisfying and balanced and reflects the character of the grape wine styles differ because of number of variables in grape growing and in winemaking (Fig. 2).

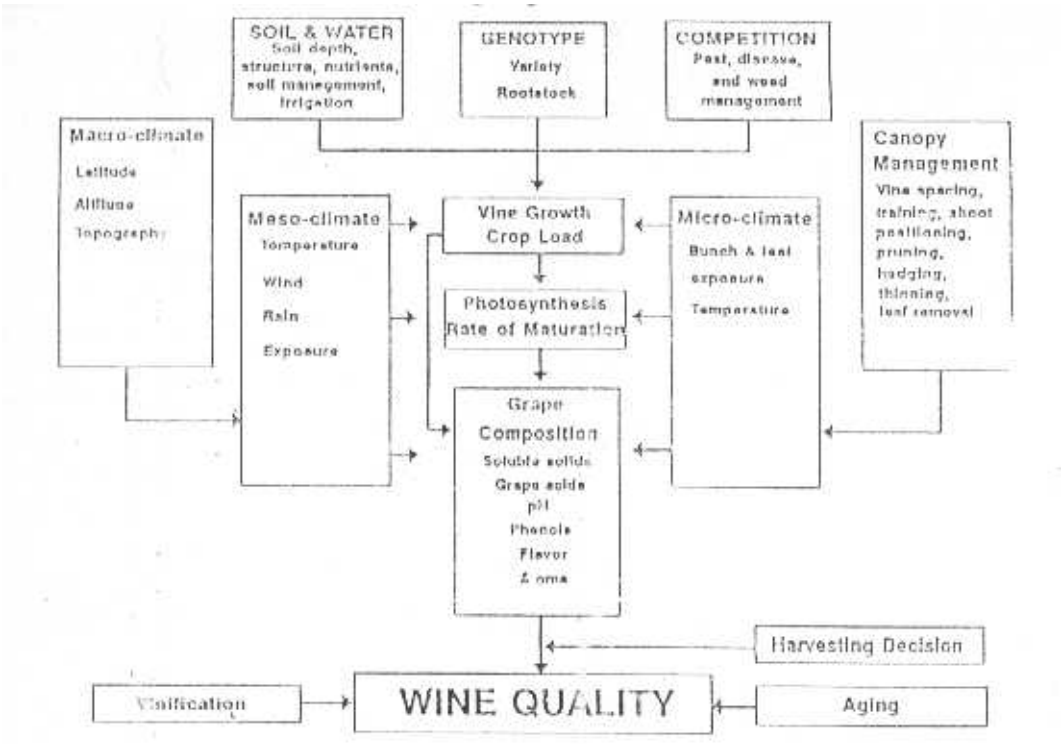


Figure 2. Environmental and viticultural imports into grape composition and wine (adapted from Jackson and Lombard, 1993).

In short, can be divided main factors that effect on wine quality as following:

- Grapes (varieties and quality of grapes)
- Microbial strains used for winemaking
- Wine fermentation

1.5.1 Grapes

The Old World species, *Vitis vinifera* is the grape used for produce table wine and raisin. V. *vinifera* originated in the region between and south of the Caspian and Black seas in Asia Minor has been carried from region to region in all temperate climates, and has been grown more recently in subtropical climates as indicated in Fig. 3.

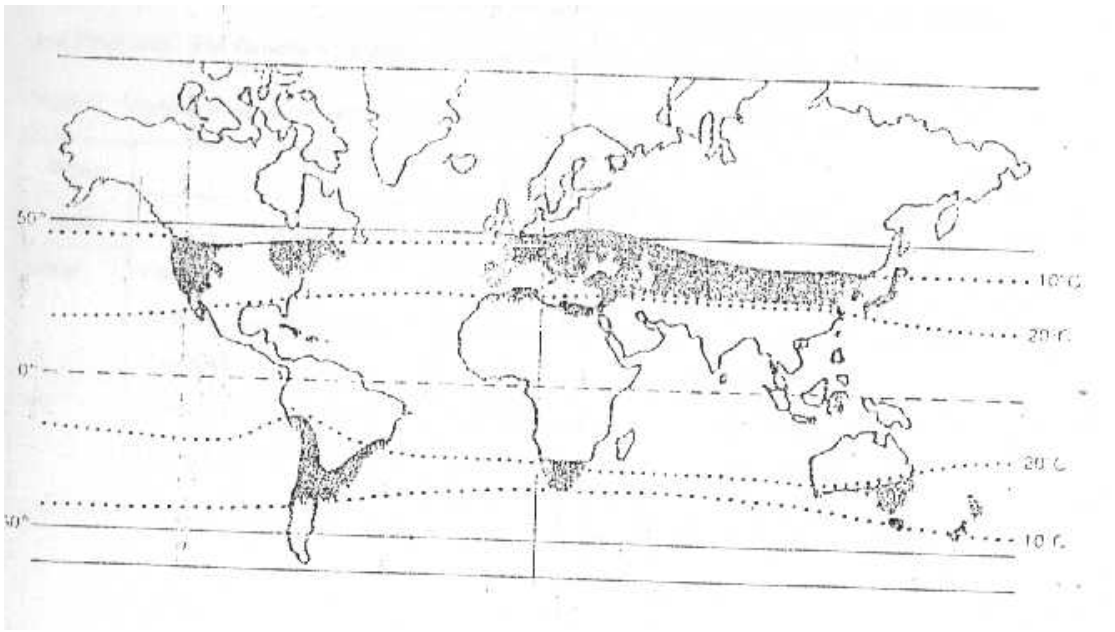


Figure 3. World distribution of viticulture*

*Note that virtually all quality wine is produced in the regions situated in the temperated-zones between the 10°C,and 20°C lines(these are the mean temperatures over the whole year)

Several thousand varieties of grapes have been derived from this species. *Vinifera* is also a parent of many hybrid grapes in eastern America, as breeders in this region desired to introduce some of the qualities of *vinifera* into their grapes.

1.5.1.1 Wine Grapes Varieties and Quality

The majority of grapes grown throughout the world are utilized for winemaking. In all wine producing countries, wine are made from varieties of the *Vitis vinifera* grapes. For dry or table wines, grapes of high acidity and moderate sugar content are desirable, while grapes with high sugar content and moderately low acid are required for sweet or dessert wines.

There are a wide number of grape varieties suitable for producing many wine styles. The famous white wine varieties were Sémillon, Chenin Blanc, Chardonnay, Riesling and Palomino whereas more than 75% for red wine varieties were Cabernet Sauvignon Merlot, Shiraz and Pinot noir. The famous wine grape varieties was shown in Table 1, Fig 4 and Fig 5.

Table 1. Various wine grape varieties planted in France, California and Australia.

Wine type	**Varieties/area**		
	France	**California**	**Australia**
White	Chardonnay, Riesling, Sémillon, Sauvignon Blanc, Muscadelle	Chardonnay, Riesling, Sémillon, Chenin Blanc	Chardonnay, Riesling, Sémillon, Chenin Blanc, Muscadelle
Red	Syrah, Cabernet Sauvignon, Cabernet France, Merlot	Cabernet Sauvignon, Zinfandel, Pinot noir, Merlot	Cabernet Sauvignon, Zinfandel, Pinot noir, Shiraz, Merlot

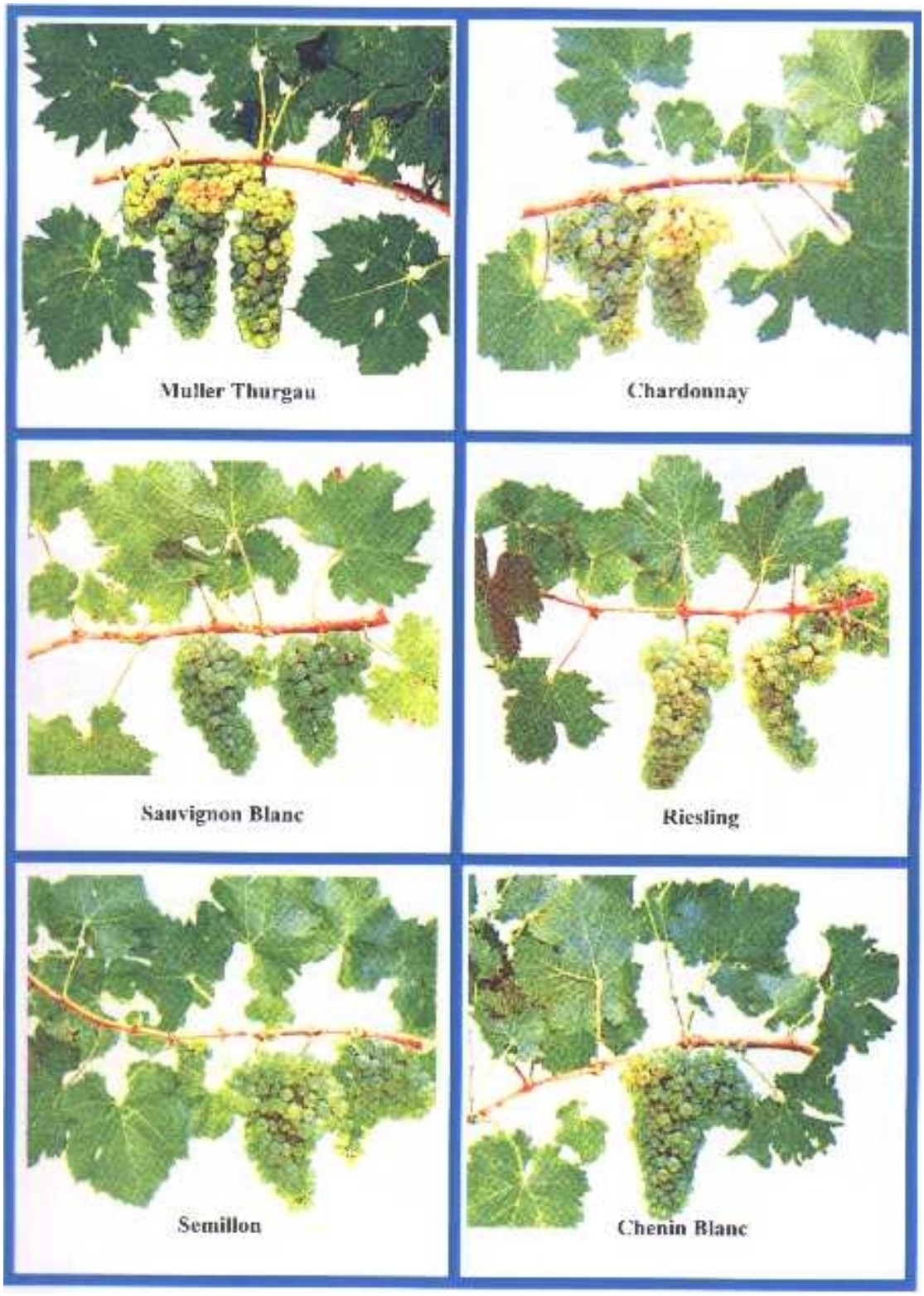


Figure 4. The famous white wine grape varieties.

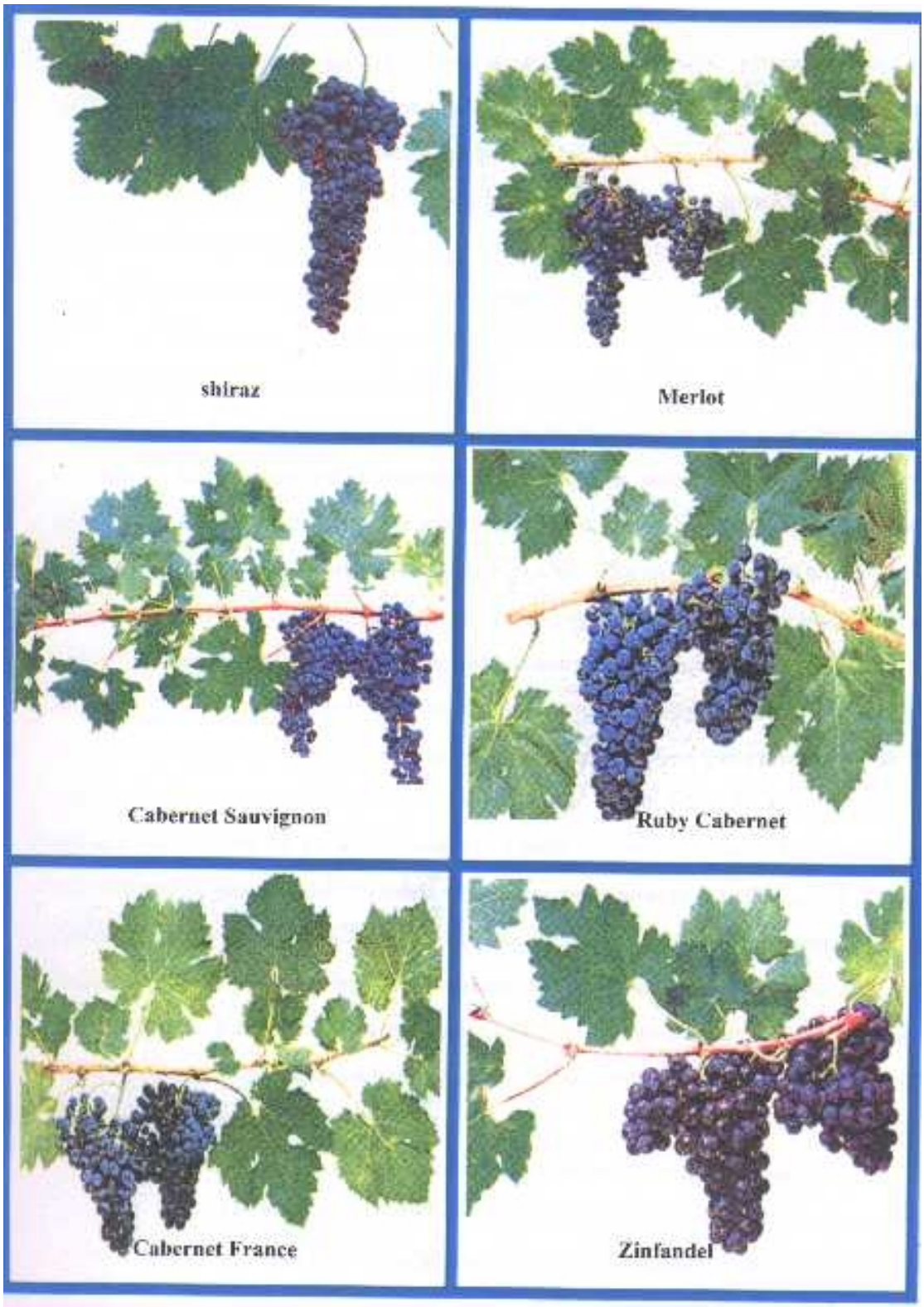


Figure 5. The famous red wine grape varieties.

Each grape varieties will result in differ wine quality (Suttayaporn Tontemsup, 1996) due to their unique characteristics. Moreover, same grape varieties which planted in various areas can also differ in taste, style and unique characteristic due to climate, sunshine, soil mineral, water and viticulture management as indicated in Figure 2. In 1997 Thai government had collected 14 grape varieties and planted at Phureu Station, Loei province (Phureu Agricultural Station; 1997). This research is in process.

1.5.2 Microbial strains used for winemaking

Wine quality is closely related to microbial ecology of fermentation (Fleet et al., 1984). Normally at the grapes berries had natural yeast or wild yeast in the genus *Kloeckera*, *Hanseniaspora*, *Metschniknowia* and *Candida* whereas disappear of wine yeast *Saccharomyces cerevisiae*. At the beginning of alcoholic fermentation the process was done by wild yeast especially by *Kloeckera apiculata* then substituted by high ethanol tolerant strain of *S. cerevisiae* which is true wine yeasts, it can produce up to 18% v/v of ethanol. Spontaneous fermentation by wild yeast was slower and resulted in lower ethanol content than that produced with true wine yeasts. In addition, *Kloeckera apiculata*, *Metschnikowia pulcherrima* also produced greater amount of 2-aminoacetophenone which is off-flavor than *S. cerevisiae*. Different strains of *S. cerevisiae* also produce different balances of aromatic esters. Nowaday, killer yeasts has been used in almost wineries. Killer yeast is the yeast that has killing action due to toxins which are produced and secreted by the killer strain which lethal to sensitive yeasts. Killer yeasts were classified into 10 groups (K1-K10) based on cross reactions between the killer strains of various genera and species (Young and Yagiu 1978). Five kinds of toxins have been distinguished in *S. cerevisiae* strains. The killer type K2 is common in winery ecosystem (Naumov, et al, 1973). The K2 killer toxin was secreted by *S. cerevisiae* K1. It tolerated in wide pH range between 2.8 and 4.8 and complete fermentation betweeen 15^0C and 30^0C with maximum toxic activity at 25^0C (Ramon-Portugal et al., 1997).

Killer wine yeasts offer three advantages over conventional wine yeasts due to:

a) They could be selected to kill certain wild yeasts which cause problem such as delay of fermentation, stuck fermentation and production of off-flavors.

b) They have immunity against any killing action of wild yeasts, therefore have dominate the fermentation.

c) They could produce stable killer toxins that would protect the wine from in fection by spoilage yeasts.

Killer strains of *S. cerevisiae* has suitable properties in wine fermentaton due to good fermentation kinetics, production of good quality wine and has killing activity under the extreme environment of wine.

After alcoholic fermentation, it always has spontaneous malolactic fermentation by wild malolactic bacteria in the genus of *Leuconostoc*, *Pediococcus* and *Lactobacillus*. *Leuconostoc oenos* is the species most frequently responsible for malolactic fermentation due to their tolerate to pH, ethanol, SO_2 and low temperature while the others cannot. If pH exceed 3.5 it always found *Pediococci*, and the strong growth of this genus can lead to off-flavors and to an oily consistence (Fleet and Heard 1993). In some cases malolactic fermentation are disadvantages because it can lead to spoilage of wine which conducted by spoilage bacteria. Spontaneous malolactic fermentation is difficult to control due to a poor growth of maloctic bacteria in extreme wine condition. To overcome this problem, in recent years the introduction of commercial freeze-dried bacterial cultures of *Leu. oenos* for direct inoculation into wine has improved the control of malolactic fermentation.

1.5.3 Wine Fermentation

1.5.3.1 Alcoholic fermentation

The main reaction of alcoholic fermentation in wine is mainly caused by yeast. *Saccharomyces* is generally the ethanol producing genus widely used in wine production. It metabolizes glucose and fructose to pyruvate via glycolytic pathway. In a model fermentation starting with about 22 to 24% sugar (22 to 24^{o}Brix), 95% of sugar is converted into ethanol and carbondioxide, 1% is converted into cellular material, and the remaining 4% is converted to other end products. Fermentation in terms of end products formed is insufficient as a significant amount of energy is lost as heat. In general, there is 1.3^{o}C rise in temperature for each Brix consumed per liter if heat is not removed by loss or cooling. A typical plot of consumption of sugar, production of ethanol and biomass versus time is presented in Fig. 6.

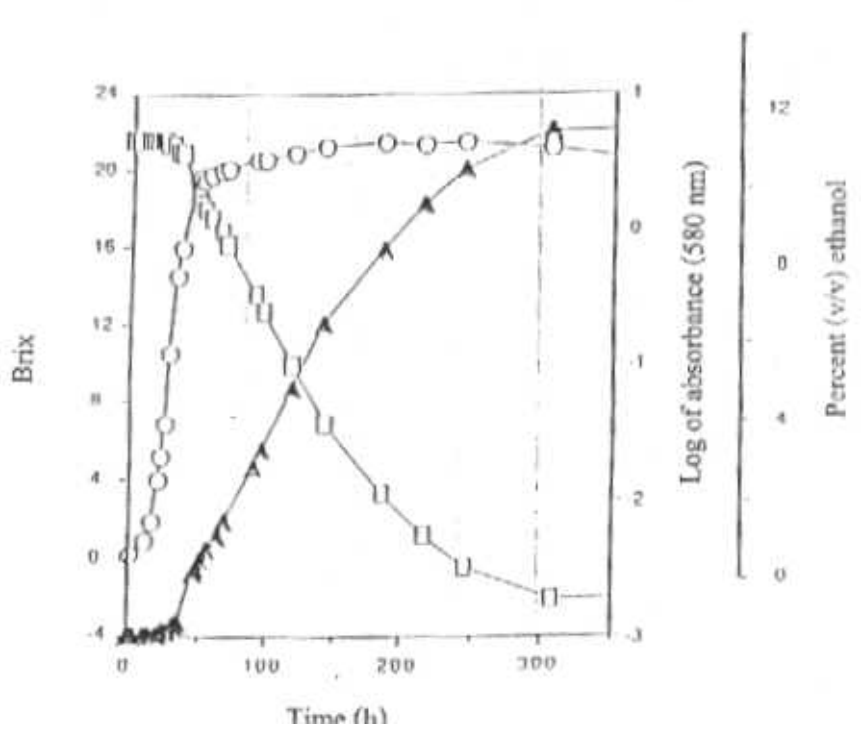


Figure 6. Fermentation profile of Chenin blanc juice fermented by an industrial strain of *Saccharomyces cerevisiae*, Prise de Mousse. Ethanol, % v/v ▲ ; yeast growth (absorbance) O; sugar concentration; (BRIX)

1.5.3.2 Condition for alcoholic fermentation

a) Temperature

The rate of fermentation increases with increasing temperature up to about 30 to 33°C. Increase temperature above 35°C will ultimately kill yeast cells, particulary at higher ethanol concentrations, and lead to "stuck fermentation". The usual temperature for white wine is 15 to 22°C and red wine is 25 to 30°C. Temperature increasing above 30°C, cooling system must be applied. The temperature of the fermentation effects on ethanol yields, by products of the fermentaion, aroma of wine, rate of yeast growth, time course of ethanol formation and the extraction of phenolic compounds. The aroma of white wines ferment at low temperature is preferred. Fermentation

temperature of 30°C effect on all strains of *S. cerevisiae* causing increase in acetaldehyde production (Romano, 1994).

b) pH

The pH of grape juice at maturity normally varies between 3.1 to 3.9 which wine yeast can growth. The rate of fermentation is greater at the higher pH values but this condition is favorable for spoilage microorganisms.

1.5.3.3 Malolactic Fermentation (MLF)

During growth in wine, lactic acid bacteria (LAB) metabolize malic acid, which contain 1-8 g/l in grape juice (Zoecklein et al., 1990) forming lactic acid and carbondioxide (Henick-Kling, 1988) without free intermediates (Lonvaud and Strasser de Saad, 1982; Caspritz and Radler, 1983; Spettoli et al., 1984; Naouri et al., 1990). This reaction generally called malolactic fermentation (MLF). The reaction is catalyzed by malate carboxylase, which called malolactic enzyme, and requires the coenzyme NAD^+ as well as Mn^{2+}, as shown in Fig. 7 and 8.

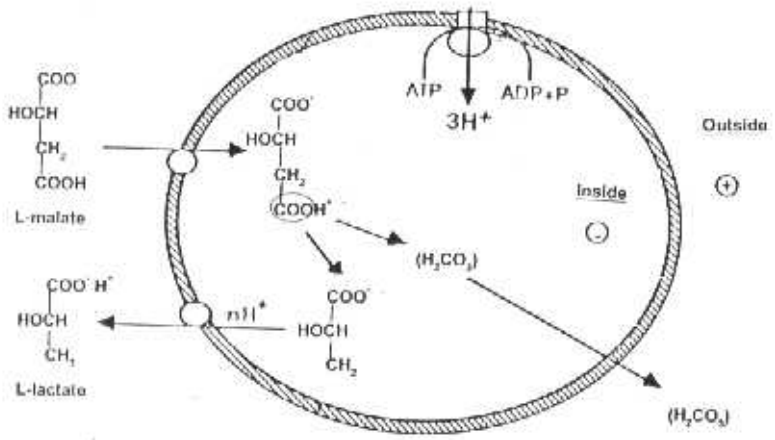


Figure 7. Mechamism of malolactic conversion in the cells.

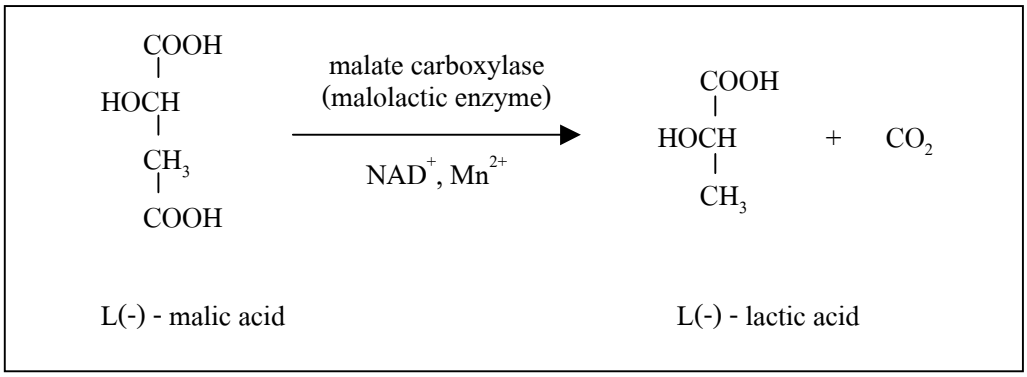


Figure 8. The conversion of malic acid into lactic acid in MLF

MLF is justified as an important process in winemaking for three reasons:

a) For deacidification

The conversion of dicarboxylic acid (malic) to the monocarboxylic acid (lactic) and the loss of carbondioxide, decrease the acidity and increase pH of the wine. This function is important in wines which often have a high acid (tartaric plus malic) content and low pH.

b) For flavor modification

MLF not only affects the taste of wine through deacidification but also can contribute other flavor characteristics. These malolactic flavors have been generally described as 'malolactic', 'buttery', 'lactic', 'nutty', 'yeasty', 'oaky' and 'sweaty'. Furthermore, it is believed that MLF can enhance the fruity and mouthful character of a wine.

c) For microbial stability

Completed MLF gives the wine some microbial stability by removing malic acid which can be used as substrate for some microorganisms and some sugars, and by producing antimicrobial agents such as lactic acid and most likely bacteriocins.

1.5.3.4 Microorganism that responsible for MLF

The most selective conditions determining growth of LAB in wines are pH and ethanol content (Davis et al., 1985; Britz and Tracey, 1990), interaction with yeast (Beelman et al., 1982; King and Beelman, 1986; Lemaresquier, 1987; Wibowo et al., 1988 Lonvaud-Funel et al., 1988); the presence of bacteriophage (Davis et al., 1985; Henick-Kling et al., 1986)

temperature (Asmundson and Kelly, 1990); and nutrient availability and growth inhibitors (Lonvaud-Funel et al., 1987). Moreover, fungicide residues and sulfur dioxide (Gallander, 1983; Wibowo et al., 1988) also have selective influences. Figure 9 showed the native LAB in alcoholic fermentation.

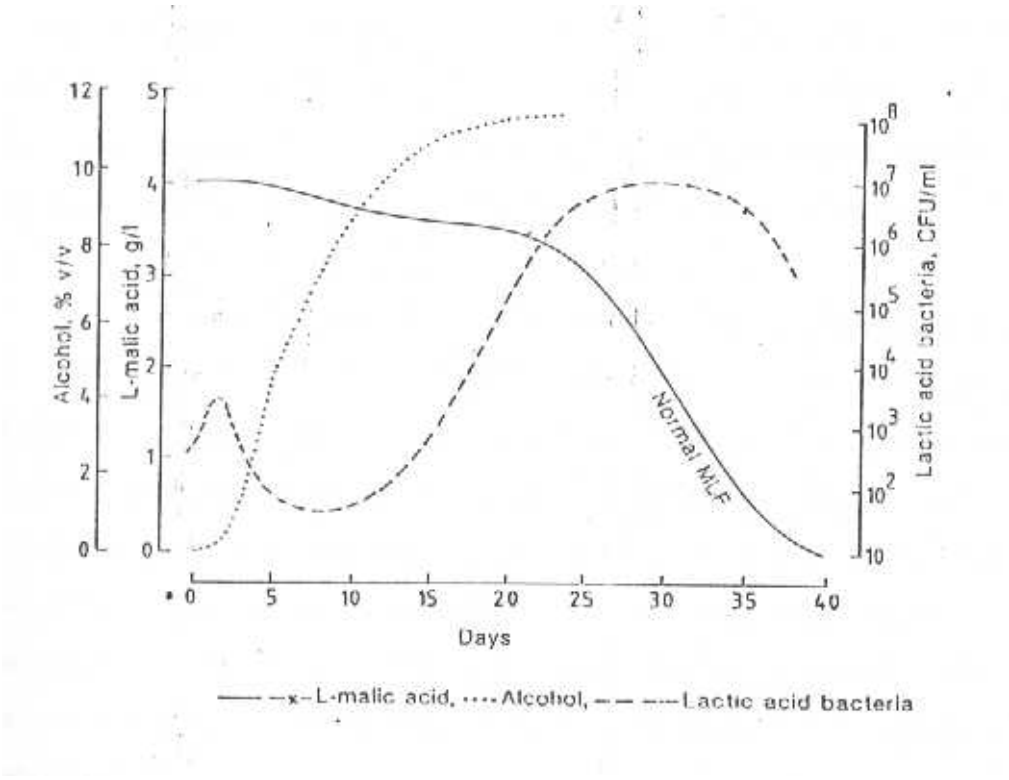


Figure 9. Development of native LAB during alcoholic fermentation of must and wine [modified from Prahl and Nielsen (1995).]

The LAB of wine sometimes call malolactic bacteria belong to three genera, *Leuconostoc, Lactobacillus,* and *Pediococcus*. Only one species of *Leuconostoc*, *Leuc. oenos*, can grow in wine due to their tolerance to pH, ethanol, sulfur dioxide (SO_2), and low temperature. In addition, they produced flavors and mouthfeel characteristic in wines, so this strain are most preferred. *Leuc. oenos* generally predominates in wines with pH below 3.5 as well as tolerate up to 14% (v/v) of ethanol concentration, while growth of the others was eliminated at ethanol concentrations of 5-6% (v/v). In addition, *Schizosaccharomyces pombe* which yeast is able to completely degrade L-malate but have not given satifactory wine quality due to absence of lactic acid and also produce off-flavours (Gallander, 1997.)

15.3.5 Malolactic activity

The rate of MLF in wine is directly linked to cell density and malolactic activity of the cell. Inoculation with a cell density of 10^6-10^7 cell/ml is suitable. The pH strongly affects the malolactic activity of the cell. The rate of malic acid degradation is highest at pH 3.2-3.4. Temperature above 25^{o}C should be avoided because it can completely inhibit growth. Ethanol concentrations of 5-12% (v/v) are not inhibitory of malolactic activity. The malolactic activity of the cells is sensitive to SO_2; 20 mg/l bound SO_2 reduces malolactic activity by 13%, 50 mg/l reduces it by 50%, and 100 mg/l inhibits it completely (Lafon-Lafourcade, 1970)

1.5.3.6 Time of inoculation

Generally, spontaneous MLF occurs after completion of alcoholic fermentation. Simultaneous malolactic and alcoholic fermentations have the advantages that all fermentation is completed early, but this situation does not frequently occured because *Leuc. oenos* are not present at sufficiently high numbers in the juice at the start of alcholic fermentation to effect MLF (Costello et al., 1983; Lafon-Lafourcade et al., 1983; Fleet et al., 1984; Davis et al., 1986). However, simultaneously fermentation is a danger that strong bacterial growth can inhibit yeast growth, leading to a stuck alcoholic fermentation and subsequent bacterial spoilage of the wine with excessive acetate and other off-flavors. Stuck alcoholic fermentation during simultaneous MLF cannot be stimulated usual aeration since this cause increased production of acetate and possibly polysaccharides by the malolactic bacteria. Moreover, bacteria will produce excessive amounts of acetate from the sugars in the juice. For best to control of MLF, the appropriate time for inoculation of malolactic bacteria is just at completion of alcoholic fermentation and SO_2 should not be added until after completion of MLF.

MLF, not only malic acid but also citric acid in the wine which present at levels < 0.5 g/l (Zoecklein et al., 1995) metabolized by *Leuc. oenos* as shown in Fig. 10. This may be of secondary importance compared with malic acid conversion, but this degradation was delayed for several days compared to the degradation of the malic acid.

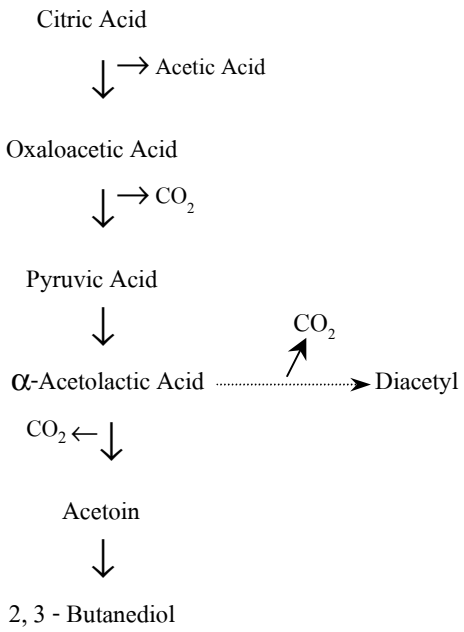


Figure 10. Main pathways for citric acid metabolism by *Leuc. oenos* CHEM. OX., chemical oxidation

The catabolism of malic and citric acid in the wine by *Leuc. oenos* was not concomitant but sequential (Nielsen and Richelieu, 1999). One of the intermediary compounds in the metabolism of citric acid is diacetyl, which is considered as one of the most important flavors produced during MLF (Laurent et al., 1994, Rankine et al., 1969). When present at a concentration above the sensory threshold, diacetyl gives the wine an aroma which can be characterized as buttery or nutty. It has been reported that threshold value in different wines vary from 0.2 mg/l in Chardonnay wine to 0.9 mg/l in Pinot noir and 2.8 mg/l in Cabernet Sauvignon wine (Martineau et al, 1995). The source of diacetyl is α–acetolactic acid (ALA), an unstable compound that besides the enzymatic decarboxylation by the bacteria also may spontaneous decarboxylate to acetoin and in oxidized conditions, also to diacetyl. Diacetyl is further reduced by *Leuc. oenos* to acetoin and 2, 3-butanediol, which in normal concentrations has no influence on the wine aroma. MLF with semiaerobic fermentation and anaerobic fermentation had no influence on the degradation of malic and citric acid by *Leuc. oenos* and the growth during the degradation was almost the same in both fermentation conditions. However, large differences were observed for the diacetyl and acetoin concentration . Under semiaerobic conditions, the diacetyl concentration was higher than obtained under anaerobic conditions due to chemical oxidation, but acetoin

concentration obtained under anaerobic condition was higher than obtained from semiaerobic conditions (Nielsen and Richelieu, 1999). Moreover, the final diacetyl concentration in wine is also affected by the concentration of SO_2. The main source of SO_2 in wine are from the addition to the grape juice before the alcoholic fermentation, from SO_2 produced by the yeast during the alcoholic fermentation and from the addition after completion of the MLF which is normally stops all further microbiological activity. SO_2, which exists predominantly as the bisulfite ion at the pH observed in wine, has the ability to react with many different compounds in the wine, including carbonyl compounds like diacetyl, acetaldehyde, α–ketoglutaric acid, and pyruvic acid. Generally, the reaction of SO_2 with carbonyl compounds can be demonstrated in Fig. 11.

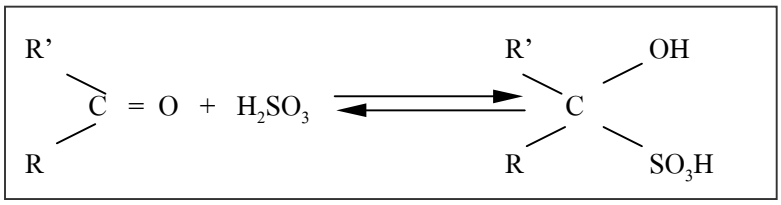


Figure 11. Reaction of SO_2 with a carbonyl compound.

Sulfite added to wine reacts fast and rather stronger with diacetyl and thereby reduced the buttery flavor. However, this reaction is reversilble. If some of the SO_2 evaporates or combines with other compounds in the wine, the concentration of the flavor may later increase in the wine again (Nielsen and Richelieu, 1999). This should be important for when the time of sulfitation after the MLF is decided and when the wine is stored in tanks or barrels and later bottled. Nielsen and Richelieu 1999 also found that in the pH range of 2.6 to 4.0, which generally occurred in most wines has only a weak influence on the reaction between diacetyl and SO_2.

After sulfitation, most wines are stored in tanks, barrels, or bottles for several months or several years. During this stage, some of the SO_2 will evaporate and some will react, reversibly or irreversibly, with different compounds in the wine, including oxygen diffusion into wine from the environment.

1.6 Viticulture, Wine production and Consumption in Thailand

Grapes has been first planted in Thailand in the period of King Rama VII. Then more than 100 rootstock varieties has been imported from various countries. Growth and yield were in satisfactory level. The previous study of suitability for viticulture in Thailand showed that there were no highly suitable areas for grape wine growing due to limitation in climate factor but there were the most moderately suitable climate areas about 120, 290 square-kilometers (Boonyanuch Sukkato, 1999). These area were in Loei, Udon Thani, Sakhon Nakhon, Kamphaeng Phet, Nakhon Sawan, Chaing Mai, Lamphun, Nakhonpathom, Kanchanaburi, Ratchaburi, Tak, Sakhothai and Nakhonratchasima provinces. Moreover, in the north part was also suggested that 4 varieties, Portugieser (No.12), Chenin Blanc-4 (No.13), 316/58 GM (No.2) and Excelsior (No.16) could perform high productivity. For winemaking, Portugieser (No.12), Chenin Blanc-4 (No.13) and Excelsior (No.16) were suitable for winemaking and high quality wine can be obtained (Kawich Wanichakul, 1994). However, Thailand has many advantages due to there is not dormancy stage of vine which is differ from temperate area. So only 1 crop per year can be harvested whereas about 2-3 crops per year can be harvested in Thailand (Pradit Karuwanna, 1994) depending on pruning technique and vineyard management.

About winemaking, in 1986 Pradit Karuwanna studied on quality of wine produced from various varieties of grapes grown on Kasetsart University, Kamphaengsan campus Nakhonpathom, the results showed that Chenin Blanc-4 and Trebbiono were suitable for white wine whereas Portugieser and Siebel were recommended for red wine production. However these wines should be improved in flavor and color by blending other varieties such as Italia and Early Muscat for white wine and Black Muscat and Barbera for red wine. Wines are blended in order to enhanc complexity, balancing sensory components and correct their defects. Wines can be blended in several steps such as in the vineyard which interplanted, in fermentation step which all varieties had fermented together, after clarification, stabilization and aging which could be combined prior to bottling. Winemaker must carry out a careful sensory evaluation of each wine to be mixed and compare many trial blends before the final blend is determined. Cabernet Sauvignon has been blended for centuries to soften its tannins. The vineyard of Bordeaux are made up of mixtures of Cabernet Sauvignon, Cabernet Franc, Mertlot and Malbec. Generally winery follow certain conventions based on flavour and structural compatibility when making

varietal blends. The laws that govern the labelling of blended wines in must to consist of at least 75% of the labelled variety while at least 95% of the grapes are harvested in the year named on the label, so only 5% may be blended from another vintage (Baldy, 1997). In 1989, The Faculty of Agro-Industry, Kasetsart University studied on winemaking from 17 wine grape varieties grown in Chaing Mai, Sukothai, Lamphang and Nakhonpathom, the data suggested that there were 5 varieties, Chenin Blanc-4, Excelsior, Portugieser, 316/58 GM and Siebel could be promoted in commercial. For the wine consumption in Thailand, the data of wine importation during 1988-1997 was shown in Figure 12 (Thai Custom Department).

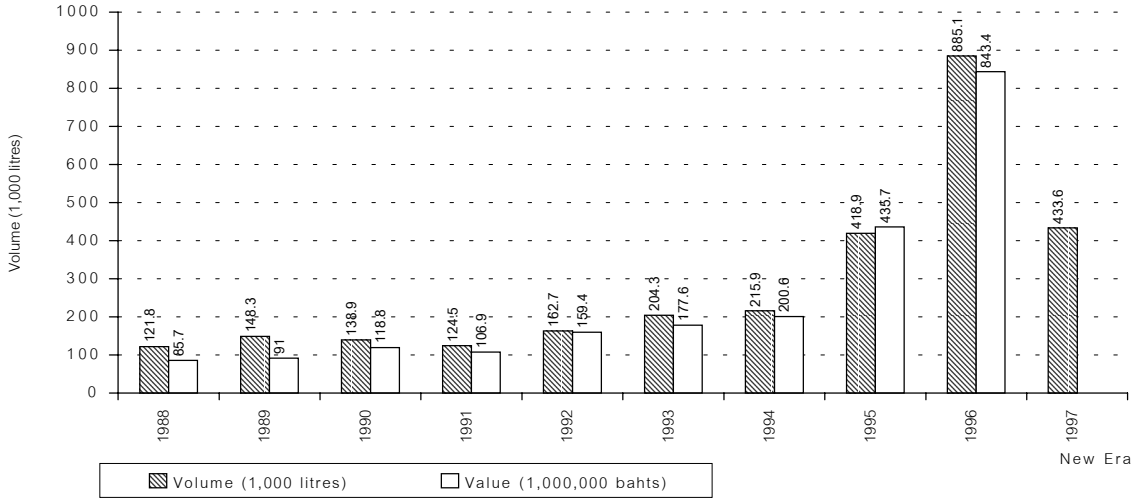


Figure 12. Volume and Value of imported wine during 1988-1997.

The data indicated the continuous increment was highest in 1996, then decreased in 1997 due to economic crisis, make the government increase 50 and 55% tax in 1997 and 1998 respectively as luxurious products.

Industrial scale of winemaking in Thailand has been established in 1974. However, in the present situation almost wines produced in Thailand are cooler wines whereas small amount of table wines are produced. In 1994 there were 9 small wineries in Thailand as listed in Table 2 (Boonyanuch Sukkato, 1999).

Table 2. List of wineries in Thailand

Company name	Location	Capacity (litre)	Capital (million bahts)	Products Type
Pramuanpol Co., Ltd.	Nakhonpathom	-	39	Wine Cooller, Whisky
T.C. Winery Co., Ltd.	Samutsakorn	-	41	Spy Wine Cooller
Suraphiset suwannaphum Co., Ltd.	Nakhonpathom	-	-	In process
S.T. Beverage Products Co., Ltd.	Pratumthani	2,100	43	Segram Wine Cooller
United wineries and Distilleries Co., Ltd.	Nakhonpathom	-	-	Thai Red Wine, Thai White Wine, Cooller Club, Masala Vin Blanc, Masala Vin Rose
C.P.K. International Co., Ltd.	Loei	1,200,000	61	Red and White Wine, Brandy
B.B. Development Co., Ltd.	Nakhonratchasima	-	100	Red, Rosé and White Wine, Brandy
Toonchai N.T. Co., Ltd.	Rattchaburi	-	-	Table Wine
Klong Phai Vineyard Co., Ltd.	Nakhonratchasima	-	-	Table Wine

There were 3 wineries among these, C.P.K International Company, B.B. Development, and Toonchai N.T. company can produced and distributed table wines by using Chenin Blanc for white wine and Syrah or Shiraz for red winemaking. Total capacity is not less than 2,000,000 liters per year. However, wineries in Thailand have to be further researched and developed in grape quality by selection the suitable varieties, winemaking process and quality control system in order to keep consistency of high quality wine.

1.7 Objectives

a) To evaluate the best quality of wine produced from various varieties of grapes planted in Suranaree University of Technology.

b) To determine the quality control technique for mintaining consistent high quality wine.

CHAPTER 2

MATERIALS AND METHODS

2.1 Grapes

All varieties of grapes used in this study were obtained from Suranaree University of Technology (SUT Farm). There were 8 varieties harvested in dry season and 7 varieties harvested in rainy season. Dry season varieties harvested during 17 February – 11 March 1999 were Black Pop, Cabernet Sauvignon, Carignane noir, Delaware, Niagara, Macabeu Blanc, Riesling and Albany. Rainy season varieties harvested during 9 July – 12 July 1999 were Black Pop, Cabernet Sauvignon, Big Black, Muscat HambUrg, Delaware, White Gogo and Macabeu Blanc.

2.2 Microbial strains

Commercial microbial strains used in this study were *Saccharomyces cerevisiae* K1-V1116 (LALVIN, CANADA) in dried powder form which used for alcoholic fermentation, *Leuconostoc oenos* DSM 7008 (Viniflora, CHR HANSEN, DENMARK) was used in MLF.

2.3 Culture media

Composition per litre of each medium used was as follow;

Malt Yeast Extract Broth

Glucose	10	g
Yeast extract	3	g
Peptone	5	g
Malt extract	3	g

Malt Yeast Extract Agar

Glucose	10	g
Yeast extract	3	g
Peptone	5	g
Malt extract	3	g
Agar	15	g

Peptone Water Diluent 0.1%

Peptone	1	g

***Leuconostoc oenos* medium**

Glucose	10	g
Peptone	10	g
Yeast extract	5	g
$MnSO_4.4H_2O$	0.1	g
Tomato Juice	250	ml
Cysteine. HCl solution	10	ml

pH 4.8 ± 0.2 at 25^0C

Cysteine. HCl soultion

Composition per 10 ml

Cysteine. HCl	0.5	mg

Cysteine. HCl was added to distilled/deionized water and bring volume to 10 ml. Mixed thoroughly and followed with filter sterilization.

Lactobacilli MRS agar

MRS agar	70	g

2.4 Chemicals

2.4.1 HPLC grade for HPLC analysis

- Glucose
- Ethanol
- Malic acid
- Lactic acid
- Tartaric acid
- Acetic acid
- Conc. sulfuric acid

2.4.2 Laboratory grade

- Sodium hydroxide pellet
- Potassium hydrogenpthalate

- Potassium metabisulfite
- Phenopthalein
- 95% Ethanol
- Filter aid (Diatomaceous earth, Celite Filter cell, 545 Fluka)
- Calcium carbonate
- Tartaric acid
- n-Butylacetate
- Formic acid
- Sodium formate
- Bromophenol blue indicator

2.4.3 Food grade

- Refined sugar

2.5 Equipment and other materials

- High Performance Liquid Chromatography (HPLC), Hewlette Packard, Model HP1100
- Hot air oven
- Incubator
- Autoclave
- Vortex mixer
- Cold storage room (4-6^{0}C)
- Microfiltration set
- Suction pump
- Analytical balance
- pH meter
- Microscope
- Colony counter
- Slide and cover slip
- Hot plate
- Hand Refractometer (ATAGO, N1, 0-32^{0}Brix)
- Petri dish and petri dish box

- Graduated pipette and pipette box
- Test tube and test tube rack
- Membrane filter pore size 0.45 μm
- Buchner Funnel
- Filter paper Whatman No. 4
- Plastic bag
- Forcep
- Suction flask
- Chees cloth
- Fermentation lock with adaptor
- Loop
- Syring
- Color chart (The Royal Horticultural Society, RHS Color Chart)
- Vernier Calipper
- Silicone tubing
- Rubber ball
- Erlenmeyer flask
- Burette and strand
- Magnetic bar
- Whatman No. 1 paper size 25x25 cm.
- Capillary tubes

2.6 Microbial preparation

Saccharomyces cerevisiae K1-V1116 in dried form was cultured in Malt Yeast Extract Broth (MY Broth) by shaking for 18-24 hours at 25^{o}C, 200 rpm. Then streak on Malt Yeast Extract Agar plate, incubated at 25^{o}C for 2-3 days. Single colony was then transferred to agar slant, kept in refrigerator until used and subcultured every 3 months.

Starter The grape juice was adjusted to 15-17^{o}Brix, pH 3.2-3.5 before autoclaved at 121^{o}C, 15 minutes, then cooled to room temperature followed by inoculated 1 loop of *S.*

cerevisiae K1-V1116 from slant. Aeration was done by shaking at 200 rpm for 18-24 hours, actively starter was ready to use.

Leuconostoc oenos DSM 7008 in freeze-dried form was determined viable cells by serial dilution in water containing 0.1% peptone and 0.9% NaCl, followed by pour plate seeding in MRS agar with pH 5.0. Viable counts were obtained as the number of CFU after incubation at 30^{o}C for 7 days (Nielsen and Richelieu, 1999).

Inoculation of *Leuc. oenos* *Leuc. oenos* was inoculated in freeze-dried form after 5 days of alcoholic fermentation. Inoculum size in fermented broth was not less than 10^{6} cells/ml. Inoculum size will be varied from batch to batch depend on initial viable cell number.

2.7 Characterization of grapes

Each varieties of grape was analyzed both in physical and chemical properties. Physical properties was determined in term of fruit size by measured the fruit size diameter and color by Color Chart. Chemical properties was determined in basic properties as pH, titratable acidity and total soluble solid by "Methods for Analysis of Musts and Wines" (Ough and Amerine 1988). The other chemical components were determined by HPLC, using condition as following: mobile phase 0.05 M H_2SO_4, Aminex BDH C-18 column, 25^{o}C, flow rate 0.6 ml/min with 5 μl injection volume using UV detector at 200 nm.

2.8 Winemaking

After each varieties was evaluated in physical and chemical properties, then 3 kg of each varieties was used for winemaking as following step;

a) Selection

Infected grape was separated, good quality grape was then destemmed by hand.

b) Crushing

Destemmed grape was then crushed by put in plastic bag and pressed by hand to prevent seed cracking.

c) Sulphitation

After crushing, for white grape, SO_2 solution was added to 100 ppm as soon as possible, then separated pomace. Crushed red grape was also added SO_2 solution at same level without pomace separation. After sulphitation crushed grapes were kept in cold storage room at 4-6^{o}C for overnight.

d) Chemical analysis

Grape juice was determined for pH, total soluble solid and titratable acidity.

e) Amelioration or chemical adjustment

Grape juice was adjusted in total soluble solid by adding sugar, titratable acidity by tartaric acid or calciumcarbonate and pH until following specification was achieved Table 3.

Table 3. Criteria for chemical adjustment in must.

Wine type	Suitable analyses		
	Total soluble solid (^{o}Brix)	Ttitratable acidity (%)	pH
Red	23-24	0.7-0.9	3.2-3.5
White/Rosé	22	0.8-0.9	3.2-3.5

f) Alcoholic fermentation

After chemical adjustment, then each varieties was separated in equal two parts, transferred in 2 litre fermentation flask, inoculated with active fermenting starter culture with 2% inoculum size prior closed with fermentation lock with adaptor. The fermentation broth was incubated at room temperature (25-27^{o}C) for 5 days, in the mean time it was stirred or shaked twice a day in order to punching the cap. Then separated grape pomace by stainless sieve for red wine. White wine stand until alcoholic fermentation stop (14 days).

g) Malolactic fermentation (MLF)

For red wine, fermented broth was then conducted to malolactic fermentation by inoculated with *Leuc. oenos*. Paper chromatography or HPLC was used for MLF monitoring.

h) Racking and stabilization

When malolactic fermentation was stopped in case of red wine or finished alcholic fermentation for white wine, then fermented broth was separated lees and supernatant by siphoning to clean erlenmeyer flask before SO_2 was added to 50 ppm for red and 60 ppm for white

wines. Cold stabilization was conducted by keeping in cold storage room at 4-6^{o}C for 1 month in order to precipitate potassium bitartrate (cream of tartar). Racking again for potassium bitartrate separation.

i) Maturation or Aging

Young wine was then aging in controlled incubator at 22-23^{o}C for 6 months followed by steriled filtration using 0.45 μm membrane filter.

j) Quality evaluation

After fermentation and aging, chemical properties of wine samples were analysed by "Methods for Analysis of Musts and Wine" and HPLC. Quantitative Descriptive Analysis (QDA) by scoring method using 5 panelists was used for sensory of single variety wines and wines blended with another varieties. All data of sensory evaluation was analyzed by Analysis of Variance (ANOVA).

2.9 Analytical methods

2.9.1 Total soluble solids

The hand held refractometer was used for determined the total soluble solids levels in grape juice or must.

2.9.2 pH

The pH was measured in 10 ml of sample using a JENWAY pH meter 3305.

2.9.3 Titratable acidity

Titratable acidity was analyzed by titration method with standard 0.1 N NaOH, which standardized by using potassium hydrogenpthalate prior to use. Phenolphthalein was used as indicator.

Five ml of sample was added into 100 ml of boiled distilled water then titrated with 0.1 N NaOH until end-point persists for 15-20 seconds until pink color was developed or pH about 8.2 (AOAC 1984).

If the titratable acidity is expressed as tartaric acid, calculate as follows:

$$\text{Tartaric acid (g/100ml)} = \frac{(V)(N)(75)(100)}{(1000)(v)}$$

where V = volume of 0.1 N NaOH used for titration (ml)

N = normality of NaOH solution

v = sample volume (ml)

Note: Red wine or red must sample should be de-colourised by shaking with approximately 0.5 g activated charcoal and filtering through a Whatman No. 1 filter paper before titration.

2.9.4 HPLC Analysis

2.9.4.1 Sample preparation

The solution for mobile phase and each sample was filtered through the 0.45 μ m steriled membrane filter before detection.

2.9.4.2 HPLC analysis

Before the sample analysis, the system was flushed with mobile phase solution and baseline was adjusted until stable, then making standard curve. Each sample was then injected to the system with autosampler before evaluated quantity of each component.

2.9.5 Malolactic fermentation

A paper chromatography method was carried out to determined the presence of malic acid and to detect whether malolactic fermentation has occurred or finished (Schuster and Jackson, 1994).

Detection of MLF by paper chromatography was done by using 100 ml of n-butyl acetate, 40 ml of formic acid and 0.075 g sodiumformate as eluting solvent and 0.03 g of bromophenol blue was used as indicator. Sheets of 25 cm Whatman No. 1 paper was used as chromatograph paper.

2.9.6 Sensory evaluation

Using Quantitative Descriptive Analysis (QDA) which is the most common analytical methods for sensory evaluation used in the wine industry (Zoecklein, 1995). This sensory evaluation method was achieved by asking trained panelists to identify or describe the different characteristics among the products and quantify characteristics using scorecard as shown in the Appendix A.

There were 5 trained panelists used to answer different sensory questions at individual booths in sensory evaluaion room. Sample preparation and data analysis was done according to Meilgaard (1992) and Hoofman (1992) respectively.

CHAPTER 3

RESULTS AND DISCUSSION

3.1 Grape Characterization

There were 16 grape wine varieties which 10 red varieties and 6 white varieties planted on SUT Farm. Winemaking was done by using 6 red varieties and 5 white varieties. Due to pruning technique resulting in 2 crop harvesting, dry season (17 February – 11 March 1999) and rainy season (9-12 July 1999) were abtained.

3.1.1 Dry season grape (Crop I)

All varieties were characterized in chemical and physical properties, data ware summerized in Table 4.

Table 4. Chemical and physical properties of grapes harvested in dry season.

Grape varieties	Chemical properties			Physical properties		Remark
	Total soluble solid (^{o}Brix)	Titratable acidity* (%)	pH	Fruit diameter (mm)	Fruit color	^{o}Brix x (pH)^2
Red						
Black Pop	17.2	0.64	3.82	20.52	202A	250.99
Cabernet Sauvignon	15.6	0.40	4.05	13.91	202A	255.88
Carignane noir	15.8	0.32	3.70	12.49	187A	216.30
Delaware	22.6	0. 73	3.35	11.44	59B	253.63
White						
Niagara	18.2	0.54	3.47	14.97	152A	219.14
Macabeu Blanc	19.0	0.33	4.10	15.18	152A	319.39
Riesling	19.8	0.44	3.58	12.24	152B	253.76
Albany	19.0	0.33	4.10	12.90	152B	319.39

* Expressed as g tartaric acid/100 ml.

From Table 4, among four red grape varieties, total soluble solid varied from 15.6-22.6°Brix. Delaware variety showed the highest amount and most promising among group. Titratable acidity varied from 0.32-0.73 g tartaric acid/100 ml and Delaware was also in the level of satisfaction contained highest amount. Black Pop was also high in acidity but low in sugar content. For the white grape varieties, total soluble solid varied from 18.2-19.8°Brix which only Riesling variety was in acceptable level and contained the highest amount, whereas the other varieties were lower than the recommendation level. All varieties were low in titratable acidity which varied in the range of 0.33-0.54 g tartaric acid/100 ml. In general, the recommend composition for must at harvesting for red table wines are 20.5-23.5°Brix, 0.65-0.75 g tartaric acid/100 ml and pH 3.2-3.4, and for white table wines are 19.5-23.0°Brix, 0.70-0.80 g tartaric acid/100 ml and pH 3.0-3.3 (Singleton et al., 1996).

Total soluble solid, titratable acidity and pH can be used as one maturity gauge. In addition, Cooke and Berg (1983) have been suggested that °Brix/Acid ratio and °Brix x $(pH)^2$ can also be used as maturity gauge. For dry table wines, the value of °Brix x $(pH)^2$ was better as a quality predictor at harvesting than °Brix/Acid, °Brix x Acid, and °Brix x pH (Coombe et al., 1980). The optimal range of °Brix x $(pH)^2$ of SUT grapes varied from 216.30-319.39 whereas the recommendation level was roughly 200-270. Thus according to this suggestion, almost varieties harvested in dry season were mature enough to make table wine by adjusting acidity to the desired level before conducting alcoholic fermentation.

3.1.2 Rainy season grapes (Crop II)

Chemical and physical properties of grapes harvested in rainy season was showing in Table 5.

Table 5. Chemical and physical properties of grapes harvested in rainy season.

Grape varieties	Chemical properties			Physical properties		Remark
	Total soluble solid (^{o}Brix)	Titratable acidity (%)	pH	Fruit diameter (mm)	Fruit color	^{o}Brix x $(pH)^2$
Red						
Black Pop	16.0	0.74	3.86	17.50	187A	238.39
Cabernet Sauvignon	14.0	1.31	3.30	11.40	187A	152.46
Big Black	14.0	0.77	3.60	19.00	166A	181.44
Muscat Hamburg	18.4	0.47	3.87	16.80	187A	275.57
Delaware	17.8	0.65	3.64	11.40	183B	235.84
White						
White Gogo	13.2	1.24	3.57	16.40	152B	168.23
Macabeu Blanc	14.8	0.54	3.70	12.50	152B	202.61

The data showed that almost varieties were low in sugar content. Some varieties, Cabernet Sauvignon and White Gogo, were unripen while the others were damaged by fungi, bacteria and dispersion of insects, due to high humidity and high temperature at that time. Since heavy raining for several days followed by warm weather could promote fungal growth and resulting in necrotic before ripening of grape (Zoecklein et al., 1990). High rainfall increased the humidity and make the grapes more susceptible to fungal disease consequently by bacteria which resulted in low sugar content and bunch rot appear. Photosynthetic rate was also low resulted in low sugar content in grape berries. Moreover, low amount of sugar content might be due to dilution of sugar in grapes berries through water absorption. By using ^{o}Brix x $(pH)^2$ as maturity gauge, a few varieties as Black Pop, Macabeu Blanc and Delaware could be justified used to produce table wines.

Among grape varieties harvested in both seasons there were 4 varieties; Black Pop, Cabernet Sauvignon, Macabeu Blanc and Delaware could be harvested for testing in both seasons. Comparison of basic quality between two seasons was demonstratedin Table 6, Figure 13 and 14. The data showed that grapes harvested in dry season was higher in total soluble solid than those harvested in rainy season. For all varieties had a tendency to contain lower in titratable acidity content except Delaware variety. In addition, fruit color of berries in dry season grape was better than rainy season (except for Macabeu Blanc which was the same). The lower of berry color in rainy season due to red color was oxidized by the mold's enzyme laccase (Boulton, et al., 1996). When compared within the same varieties the results indicated that Black Pop and Delaware were slightly differred for rainy season it was possible that will be same chemical properties as in dry season if harvested at full maturity.

Table 6. Comparison of chemical and physical properties of grapes harvested between dry and rainy season.

Grape varieties	**Season**	**Total soluble solid (^{o}Brix)**	**Titratable acidity (%)**	**pH**	**Fruit diameter (mm)**	**Fruit color**
Red						
Black Pop	dry	17.2	0.64	3.82	20.52	202A
	rainy	16.0	0.74	3.86	17.50	187A
Cabernet Sauvignon	dry	15.6	0.40	4.05	13.91	202A
	rainy	14.0	1.31	3.30	11.40	187A
White						
Macabeu Blanc	dry	19.0	0.33	4.10	15.18	152A
	rainy	14.8	0.54	3.70	12.50	152B
Delaware	dry	22.6	0.73	3.35	11.44	59B
	rainy	17.8	0.65	3.64	11.40	183B

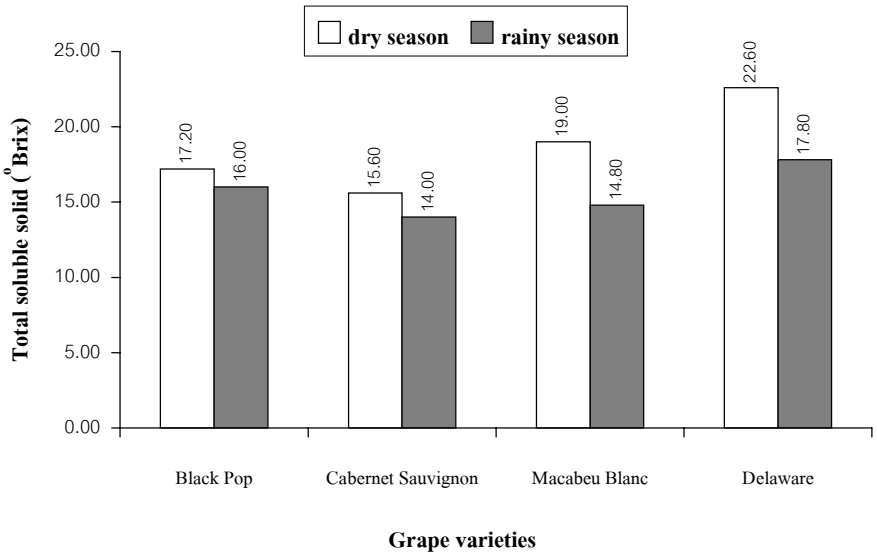


Figure 13. Comparison of total soluble solid between dry season and rainy season grapes

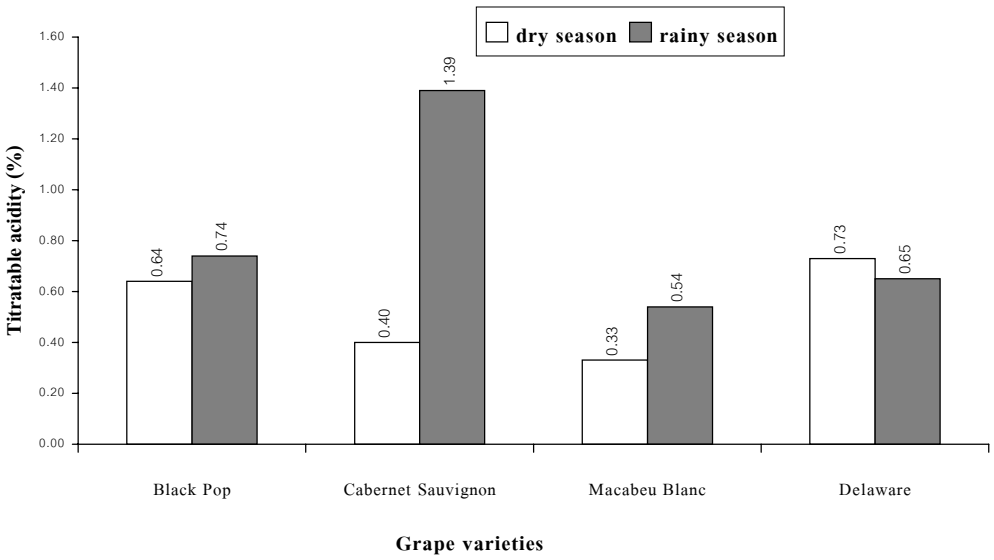


Figure 14. Comparison of titratable acidity between dry season and rainy season grapes

For the fruit size among red varieties, Black Pop was the largest in dry season whereas Big Black was in rainy season. For white varieties, White Gogo in rainy season was the largest while Macabeu Blanc in dry season was the largest. Comparison of fruit size between dry and rainy season grapes was depicted in Figure 15.

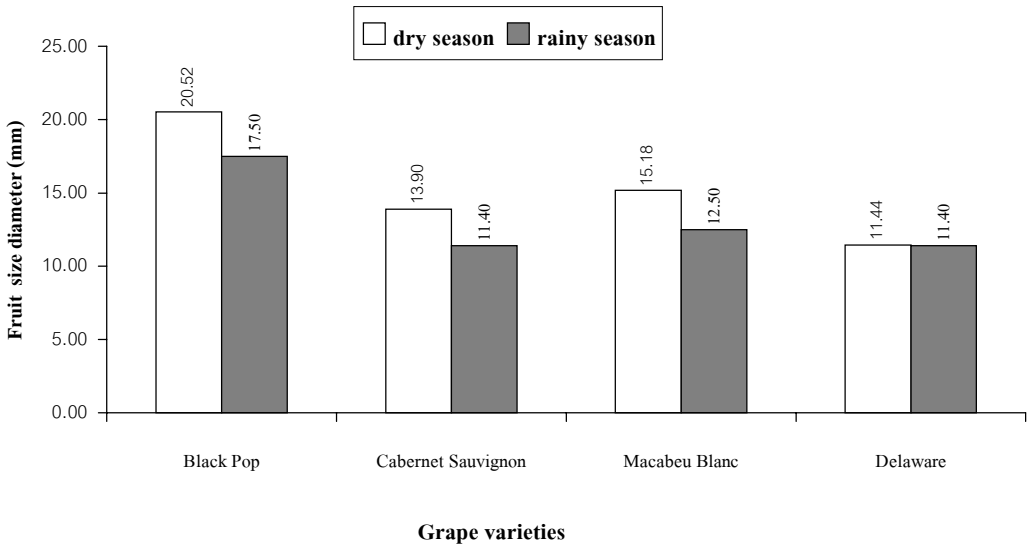


Figure 15. Comparison of fruit size between dry and rainy season grapes

All varieties harvested in dry season were larger than in rainy season. Fruit size or berry size has an effected on juice yield. Small berries produced less juice yield due to more skin. Therefore in dry season grapes should be more juice yield than rainy season grapes. According to the experiment, it was unable to compare juice yield between both seasons due to a lot of berry damaged in rainy season grapes. Winemaking from SUT in dry season grapes found that stem content ranged from 2.38-10.65%, pomace 29.39-35.05% and juice 55.89-65.90% as indicated in Table 7 whereas in commercial standard are of 3% (2-8%) stem, 19% (5-26%) pomace and 78% (74-90%) of juice (Singleton et al., 1996). High stem content depends on each grape variety. All varieties from SUT Farm were low juice yield due to the pomace separation step which was done by hand squeezing.

Table 7. Juice yield of grapes harvested in dry season.

Grape varieties	Stem (%)	Pomace (%)	Juice (%)	Damaged and loss (%)
Red				
Black Pop	2.38	18.26	62.84	16.52
Cabernet Sauvignon	8.05	20.86	65.56	5.53
Carignane noir	6.11	20.50	62.70	10.69
Delaware	3.03	27.55	65.90	3.52
Average	3.08	20.18	64.00	12.54
White				
Niagara	2.42	21.26	62.53	13.79
Macabeu Blanc	4.52	20.77	66.09	8.62
Riesling	10.65	21.86	55.89	11.63
Albany	6.24	16.76	60.39	9.1
Average	5.10	20.35	62.78	11.77

In the chemical properties view point, most varieties of grapes harvested in dry season were matured enough as well as a few varieties in rainy season such as Black Pop, Delaware and Macabeu Blanc. Overall chemical characteristics of grapes planted in SUT Farm indicated that sugar and acid content in the must should be adjusted prior to conducting alcoholic fermentation. In addition, there was great variation in grape quality between both seasons. Thus the timing of harvesting grapes should be considered in wine production in Thailand.

However, chemical characteristics may not be enough to be indicators for physiological maturity or potential wine character and palatability. Therefore, other maturity gauges should also be further considered. Consideration should also include general fruit condition, taste assessment of grape flavor and tannin maturity in red grapes, assessment of varietal aroma intensity and berry softness. Moreover, the recent development of molecular biology techniques to direct investigation of the genes in the pathway of berry ripening like change in color, accumulation of

sugar, flavor and aroma compounds formation and the berry softening might be useful tool improving grape quality. The molecular biology techniques has potential to develop an understanding of complex biological pathway in grape berries (Davies et al, 1996). Then high quality grapes would be resulted in high quality wines.

3.2 Chemical analysis of wines

After completion of fermentation, followed by racking, then fermented broth of each varieties has been sampling for chemical analysis. The samples were then finally analyzed for chemical properties and sensory evaluation at the maturation step at 22^{o}C for 6 months.

3.2.1 Dry season wines

Chemical analysis of fermented broth from dry season grapes was summarized in Table 8.

Table 8. Chemical properties of fermented broth produced from dry season grapes

Varieties	Chemical properties							
	pH	Titratable acidity (g/100ml)	Tartaric acid (g/100ml)	Malic acid (g/100ml)	Lactic acid (g/100ml)	Acetic acid (g/100ml)	Glucose (g/100ml)	Ethanol (%v/v)
Red								
Black Pop	3.12	0.82	0.69	0.05	0.24	*	0.31	12.47
Cabernet Sauvignon	2.81	1.24	0.92	0.25	0.12	*	0.20	11.56
Carignane noir	2.87	0.97	0.67	0.17	0.35	*	0.13	10.23
Delaware	3.16	0.88	0.50	0.21	0.32	*	0.20	11.87
Average	2.99	0.98	0.70	0.17	0.26	-	0.24	11.53
White								
Niagara	2.90	0.74	0.45	0.20	0.25	*	0.15	8.88
Macabeu Blanc	2.82	0.77	0.55	0.22	0.12	*	0.32	9.65
Riesling	3.13	0.80	0.41	0.24	0.18	*	0.15	8.27
Albany	2.67	0.75	0.62	0.27	0.13	*	0.23	11.08
Average	2.88	0.77	0.51	0.23	0.17	-	0.21	9.47

* Cannot be detected due to small amount (less than 0.005 g/100 ml)

The results obtained from all fermented broth were rather low in pH value as well as high in titratable acidity. Average pH value for red fermented broths were 2.99 and 2.88 for white fermented broths. Tartaric acid content were still high amount for all varieties but this acid will be removed in the next step by cold stablization. Malic acid content represented at average 0.17

g/100 ml in red fermented broths which were also still high. This cause by incompletion in MLF step. The highest malolactic activity in wine was measured at pH 3.2-3.5, pH value less than 3.2 and above 3.5 could reduce malolactic activity of *Leuc. oenos.* Bousbouras and Kunkee (1971) reported that completion of MLF by *Leuc. oenos* (ML-34) was 164 days at wine pH 3.15. Delaware variety had the highest amount of malic acid, this indicated that extended timing of MLF could overcome this problem.

However, all white fermented broths were too low in pH. Niagara and Macabeu Blanc had high malic acid content. In order to balance the taste and stabilize wine, the MLF was conducted. It was found that ethanol content in red wines were ranged from 10.23-12.47% v/v with average of 11.58% v/v whereas white wines ranged from 8.27-11.08% v/v with average of 9.47% v/v. However, white wine produced from Niagara and Riesling were slightly low in ethanol content which should ranged from 9-15% v/v for table wines.

Chemical properties of wines after cold stabilization and completed in maturation step were summarized in Table 9.

Table 9. Chemical properties of wines produced from dry season grapes

Varieties	Chemical properties						
	pH	Titratable acidity (g/100ml)	Tartaric acid (g/100ml)	Malic acid (g/100ml)	Lactic acid (g/100ml)	Acetic acid (g/100ml)	Ethanol (%v/v)
Red							
Black Pop	3.41	0.54	0.30	0.02	0.23	0.16	12.21
Cabernet Sauvignon	3.25	0.72	0.55	0.22	0.11	0.02	11.51
Carignane noir	3.05	0.95	0.38	0.12	0.32	0.02	10.20
Delaware	3.14	0.89	0.48	0.15	0.31	0.10	11.67
Average	3.21	0.78	0.43	0.13	0.24	0.08	11.40
White							
Niagara	3.04	0.71	0.43	0.18	0.17	*	8.68
Macabeu Blanc	3.07	0.77	0.46	0.19	0.14	0.01	9.62
Riesling	3.29	0.70	0.38	0.20	0.15	0.02	8.22
Albany	2.99	0.82	0.52	0.16	0.26	0.05	11.07
Average	3.10	0.75	0.45	0.18	0.18	0.02	9.40

* Cannot be detected due to small amount (less than 0.005 g/100 ml)

After maturation step it was found that pH value was slightly increased from 2.99 to 3.21 in red wines and from 2.88 to 3.10 in white wines as indicated in Table 9. This increment was resulting from cold stabilization step due to precipitation of tartaric acid in form of potassium bitartrate at low temperature. Tartaric acid in all varieties were also decreased in different portion. However, pigments in red wines could also form complexes with tartaric acid (Balakain and Berg, 1968) resulting in delayed precipitation of potassium bitartrate. Optimum temperature needed for bitartrate stabilization could be calculated from the equation below;

$$\text{Temperature}(-^{o}\text{C}) = \left(\frac{\text{ethanol \%v/v}}{2}\right) - 1$$

Thus cold stabilization at 4-6^{o}C should accelerate precipitation in order to improve efficiency by contact seeding technique which was done by addition of excess of finely powdered potassium bitartrate which creates a supersaturated solution.

Due to its unique composition, each wine will achieve unique solubility under imposed temperature conditions. Therefore, cold stabilization evaluation must be established in order to predict wine stability. One method to determine the potassium bitartrate stability is measurement the conductivity of wine after seeding with finely ground potassium bitartrate (KHT) powder at 0^{o}C for white and 5^{o}C for red wine. Estimation of KHT stability is then analyzed on the basis of the reduction in electrical conductivity of the juice or wine from the beginning to end of the test. Changes of less than 5% in electrical conductance may be considered as stable at or above the test temperature (Zoecklein et al., 1995).

Acetic acid content presented in the range of 0.02-0.16 g/100 ml while the average content was 0.08 g/100 ml for red wines, whereas spoilage become sensorily occurs at 0.06-0.09 g/100 ml (Ough and Amerine, 1980). For white wines, all varieties were under threshold value. In this case, presence of acetic acid could be come from the degradation of tartaric acid by some strains of *Lactobacillus plantarum* and *L. brevis* (Krumperman and Vaughn, 1966) which contaminated during the process.

For both malic and lactic acids contents produced from all varieties were decreased after maturation step. Decreasing of these acids resulted in balanced taste of wines. In order to

compare wine quality, some samples were also analyzed. Average chemical properties of red wine compared with wine samples from France and from winery in Thailand are showing in Table 10 and Fig. 16.

Table 10. Comparison of chemical properties of SUT red wines produced from dry season grapes and wine samples from market.

Varieties	Chemical properties						
	pH	Titratable acidity (g/100ml)	Tartaric acid (g/100ml)	Malic acid (g/100ml)	Lactic acid (g/100ml)	Acetic acid (g/100ml)	Ethanol (%v/v)
Red							
Black Pop	3.41	0.54	0.30	0.02	0.23	0.16	12.21
Cabernet Sauvignon	3.25	0.72	0.55	0.22	0.11	0.02	11.51
Carignane noir	3.05	0.95	0.38	0.12	0.32	0.02	10.20
Delaware	3.14	0.89	0.48	0.15	0.31	0.10	11.67
Average	3.21	0.78	0.43	0.13	0.24	0.08	11.40
Beaujolaise (France)	3.32	0.68	0.54	0.45	0.14	*	12.56
Shiraz (Thailand)	3.18	0.72	0.40	*	0.36	*	12.53
Cabernet Sauvignon (Chile)	3.51	0.48	0.20	0.06	0.19	0.06	12.89

* Cannot be detected due to small amount (less than 0.005 g/100 ml)

From Table 10, the data showed slight difference in main chemical properties between these wines. However, these wines were difference in the detail composition such as flavor and aroma compounds which were complex compounds resulting in difference sensory evaluation and finally wine quality.

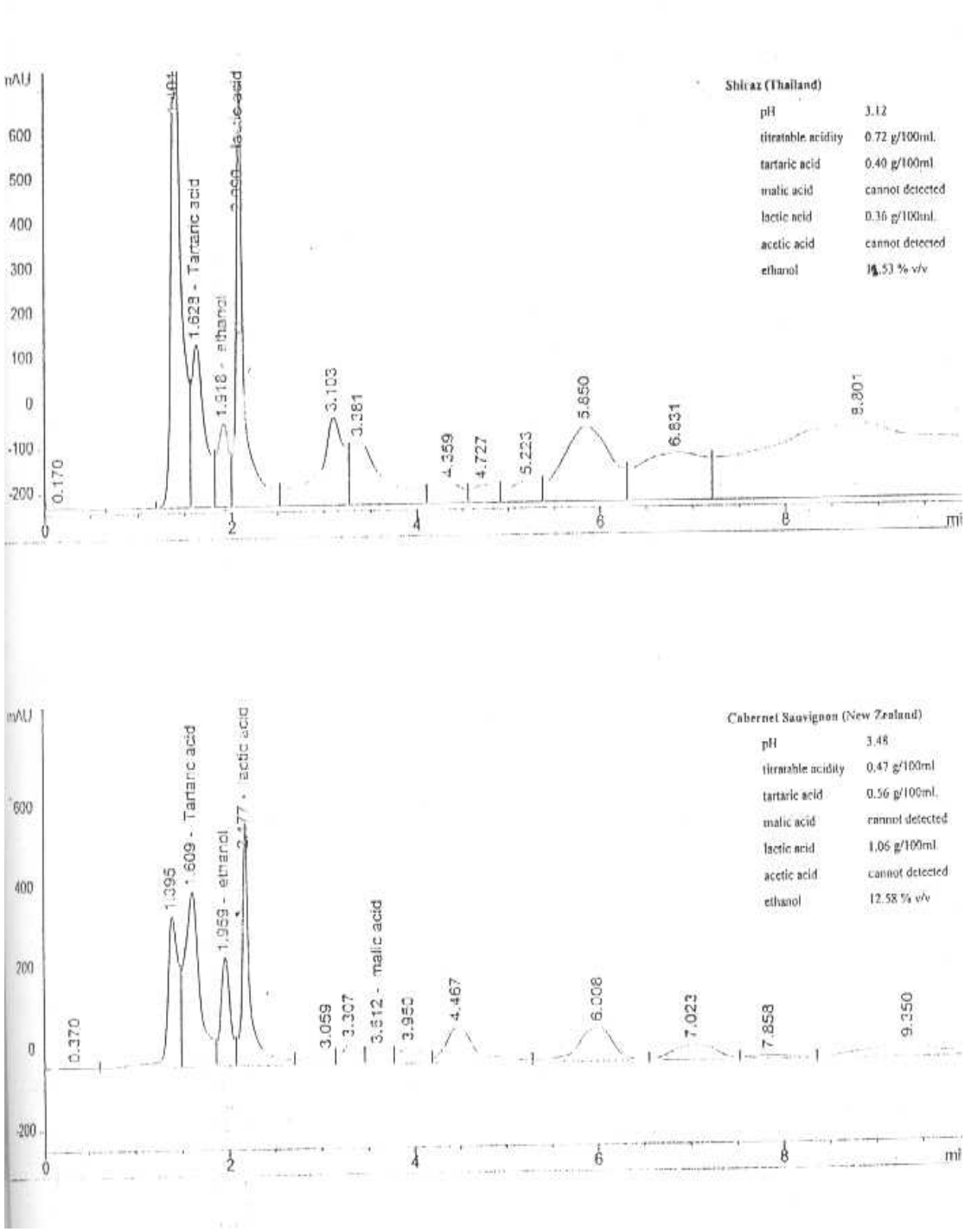


Figure 16. Chromatogram of red wine samples.

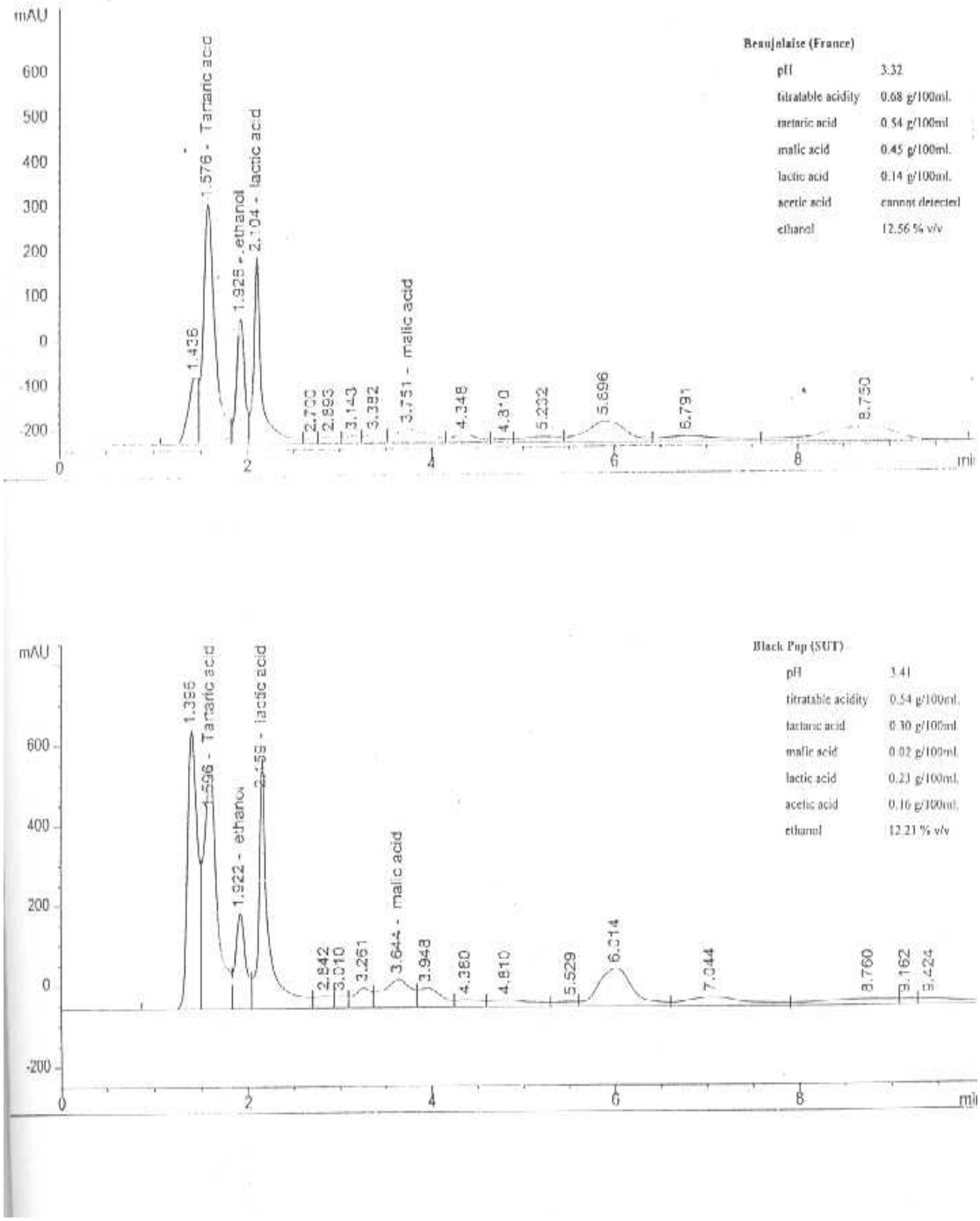


Figure 16. (continued)

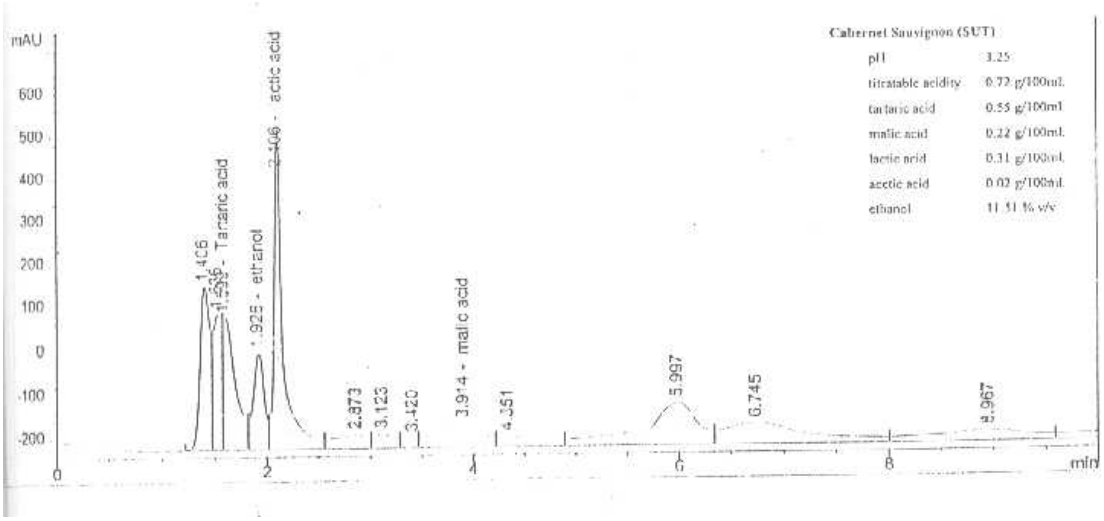


Figure 16. (continued)

Comparison of SUT white wines with samples was compared in Table 11 and Fig. 17.

Table 11. Comparison of chemical properties of SUT white wines produced from dry season grapes and wine samples from market.

Varieties	Chemical properties						
	pH	Titratable acidity (g/100ml)	Tartaric acid (g/100ml)	Malic acid (g/100ml)	Lactic acid (g/100ml)	Acetic acid (g/100ml)	Ethanol (%v/v)
White							
Niagara	3.04	0.71	0.43	0.18	0.17	*	8.68
Macabeu Blanc	3.07	0.77	0.46	0.19	0.14	0.01	9.62
Riesling	3.29	0.70	0.38	0.20	0.15	0.02	8.22
Albany	2.99	0.82	0.52	0.16	0.26	0.05	11.07
Average	3.10	0.75	0.45	0.18	0.18	0.02	9.40
Chenin Blance (Thailand)	2.82	0.74	0.41	0.31	0.07	0.007	12.90
Riesling (Switzerland)	2.80	0.81	0.45	0.24	0.15	*	11.22

* Cannot be detected due to small amount (less than 0.005 g/100 ml)

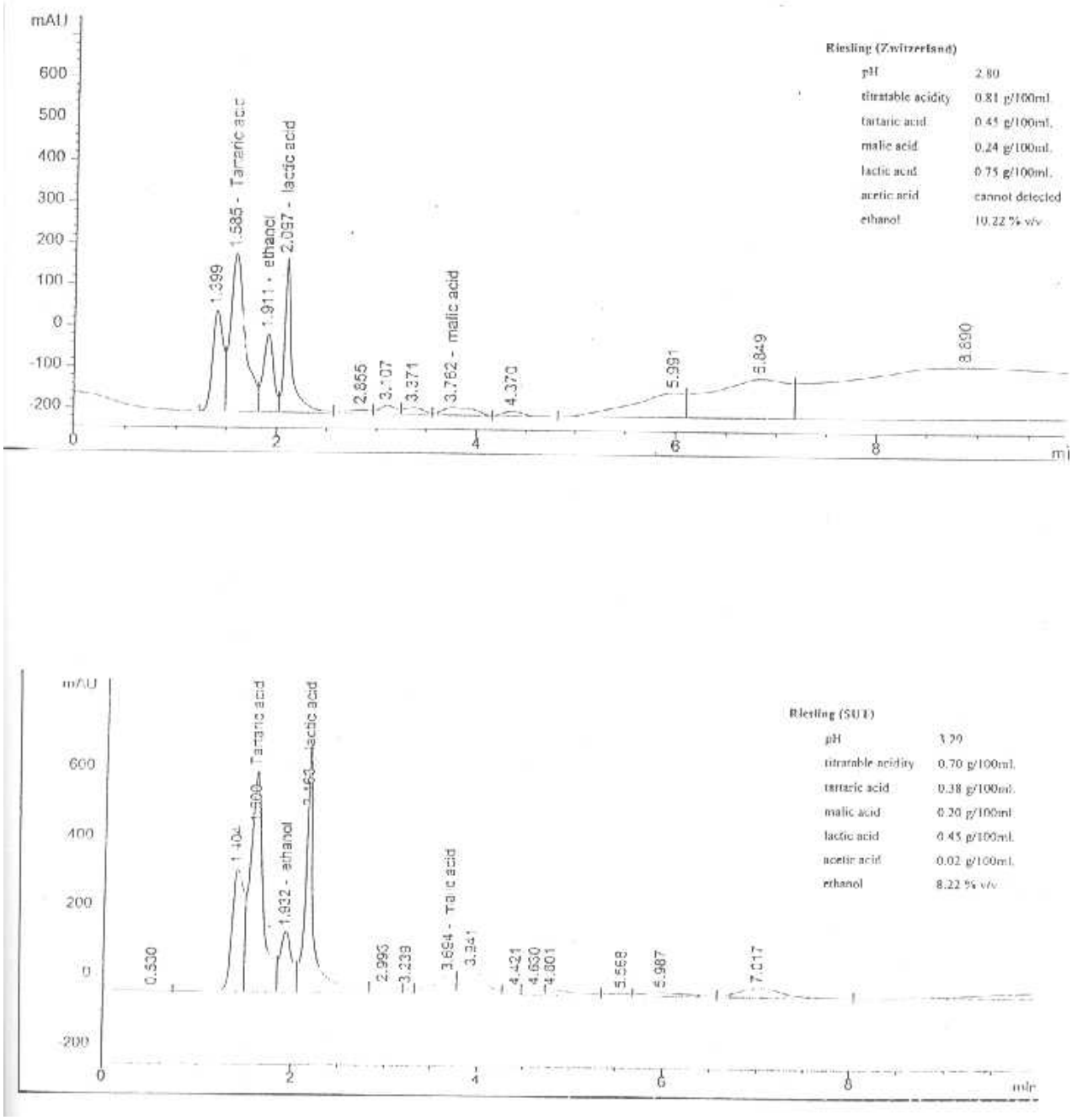


Figure 17. Chromatogram of white wine samples

These results indicated that neither white wines nor red wines was different in major chemical compositions. However, the different in taste might be resulting from complexity of flavor and aroma compounds which did not measured in this study. Further study was recommended to characterize and investigate chemical profile of these compounds in various wines which leading to difference in wine quality.

3.2.2 Rainy season wines

Hence, the less yield of Macabeu Blanc obtained from farm, thus it was not used for wine production. Chemical properties of fermented broth and wines produced from various varieties of rainy season grapes are presented in Table 12, 13 and Fig. 18.

Table 12. Chemical properties of fermented broth produced from rainy season grapes

Varieties	Chemical properties							
	pH	Titratable acidity (g/100ml)	Tartaric acid (g/100ml)	Malic acid (g/100ml)	Lactic acid (g/100ml)	Acetic acid (g/100ml)	Glucose (g/100ml)	Ethanol (%v/v)
Red								
Black Pop	4.11	0.52	0.35	0.03	0.21	0.20	0.36	4.56
Cabernet Sauvignon	3.75	0.68	0.38	0.14	0.19	0.17	0.31	7.16
Muscat Hamburg	4.35	0.70	0.45	0.11	0.06	0.18	0.40	3.40
Big Black	3.68	0.62	0.43	0.06	0.08	0.21	0.23	5.29
Delaware	3.68	0.65	0.43	0.04	0.05	0.16	0.82	5.35
Average	3.91	0.53	0.41	0.08	0.12	0.18	0.42	5.15
White								
White Gogo	3.57	0.59	0.83	1.54	1.05	*	0.46	10.03

* Cannot be detected due to small amount (less than 0.005 g/100 ml)

Table 13. Chemical properties of wines produced from rainy season grapes

Varieties	Chemical properties						
	pH	Titratable acidity (g/100ml)	Tartaric acid (g/100ml)	Malic acid (g/100ml)	Lactic acid (g/100ml)	Acetic acid (g/100ml)	Ethanol (%v/v)
Red							
Black Pop	3.94	0.50	0.30	0.02	0.20	0.20	4.58
Cabernet Sauvignon	3.64	0.58	0.35	0.09	0.18	0.18	7.13
Muscat Hamberg	4.22	0.68	0.40	0.07	0.02	0.20	3.44
Big Black	3.70	0.56	0.41	0.09	0.03	0.25	5.21
Delaware	3.72	0.63	0.50	0.05	0.006	0.19	5.37
Average	3.84	0.59	0.39	0.06	0.09	0.20	5.15
White							
White Gogo	3.51	0.65	0.60	0.20	0.16	*	10.06

* Cannot be detected due to small amount (less than 0.005 g/100 ml)

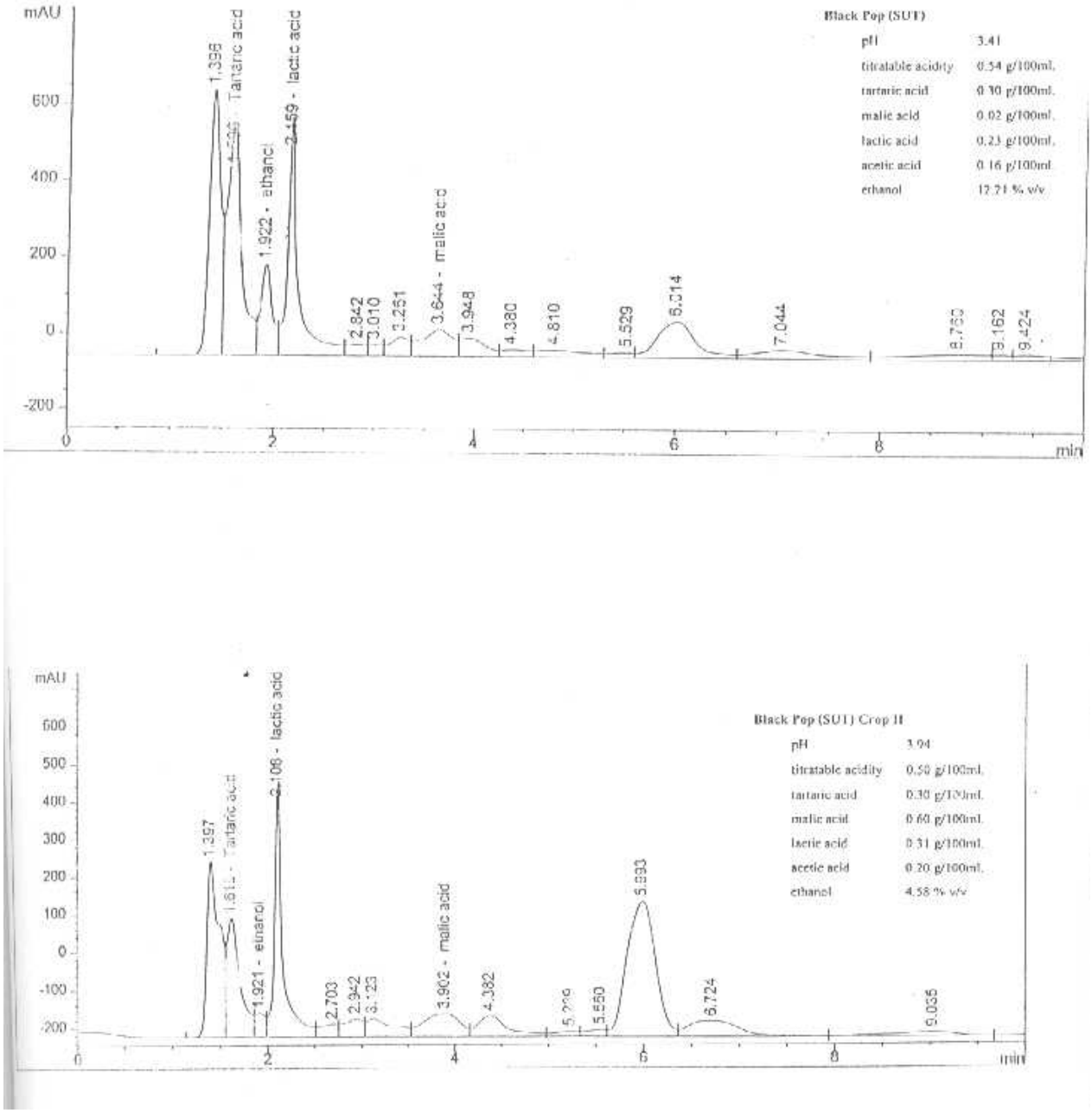


Figure 18. Chromatogram of wines produced from rainy season grapes

Sluggish fermentation would possibly due to spoilage of grapes and finally could cause stuck alcoholic fermentation which occured in all varieties except for White Gogo. Stuck fermentation resulting in irregular chemical composition in wines, as presented in Table 12 and 13. All Red varieties were high in pH value and very low in ethanol content, this was not found in non-spoilaged grape, White Gogo. For red grapes harvested in rainy season, alcoholic fermentation extended from 2 weeks to 6 weeks, nevertheless reinoculated with a new starter culture was unsuccessful. Two situations that would generate stuck fermentation were:

1) Nutrient deficiency

Grape juice generally contains sufficient micronutrients, vitamin, mineral to support yeast growth. Mold and bacterial infestation of the grape berries may deplete nutrients or introduce inhibitors leading to a stuck fermentation (Boulton et al., 1996). In addition, reduction in the levels of most amino acids and vitamins by mold and other organisms not only effects on stuck alcoholic fermentation but also on MLF. *Leuc. oenos* was more fastidious than *S. cerevisiae* in nutritional requirements (Denayrolles, et al., 1995). They required 3-16 different amino acids for growth, and their requirements for various vitamins such as nicotinic acid, pantothenic acid, riboflavin and folic acid were greater than for yeasts. It has to be supplemented with these nutrients to overcome limitation.

2) Toxins

Toxins might also be arise as a consequence of microbial activity. *Saccharomyces* will be inhibited by many organic acids, medium chain-length acids such as decanoic acid and octanoic acid which produced by wild yeast are also inhibitory to cell metabolism (Rosi and Bertuccioli, 1984). These compounds are not normally presented in grape berries or grape juices, but can be synthesized by microorganisms found in the berries or juice, or can be derived from grape components. These toxic products could be eliminated by addition of yeast cell-wall hulls at a concentration of 1 g/l to fermentation medium (Lafon-Lafourcade et al., 1984). Organic acid inhibition of yeast growth is thought to be due to the reduction of cytoplasmic pH caused by uptake of these compounds (Cardoso and Leâo, 1992). The trichothecene mycotoxin, T2 produced by *Fusarium, Mycothecium, Trichothecium, Cephalosporium* and *Stachybotrys* species inhibits *Saccharomyces* (Koshinsky et al., 1992). These mold genera are less commonly found on

fruit but fairly wide spread in nature. An inhibitory product, botrycin produced from *Botrytis* has also been involved.

From Table 13, after cold stabilization and maturation step, all red wines had lowering in pH. This phenomenon was in contrast with healthy grapes harvested in dry season which was higher pH due to tartrate precipitation. This might cause from acidification by lactic acid bacteria from damaged grapes. These bacteria included various species of *Lactobacillus, Pediococcus* and *Leuconostoc*. They were usually represent on grapes and in must at population not exceeding 10^3 cells/ml, but in damaged grapes they represented at higher (Lafon-Lafourcade, 1983). They could survive in wine and regrowth when reached the appropriate condition. Wines containing high residual sugar have the potential for acidification by lactic acid bacteria, especially this possibility arises if there was a delay in the onset of alcoholic fermentation when other nutrients were available for the stimulation of bacterial growth (Wibowo et al., 1985). These wines would had high concentrations of acetic acid, ethyl acetate and D-lactic acid which produced by fermentation of sugars by homofermentative species of *Lactobacillus* and *Pediococcus*. At the same time, wine at pH more than 3.5 will promote the growth of *Pediococcus* in MLF, strong growth of this genus can lead to off-flavors and to an oily consistency as well (Fleet, 1993). Thus, red wines produced from rainy season grapes were low in quality. Comparison between dry season and rainy season wine made from Black Pop variety was showed in Fig. 19.

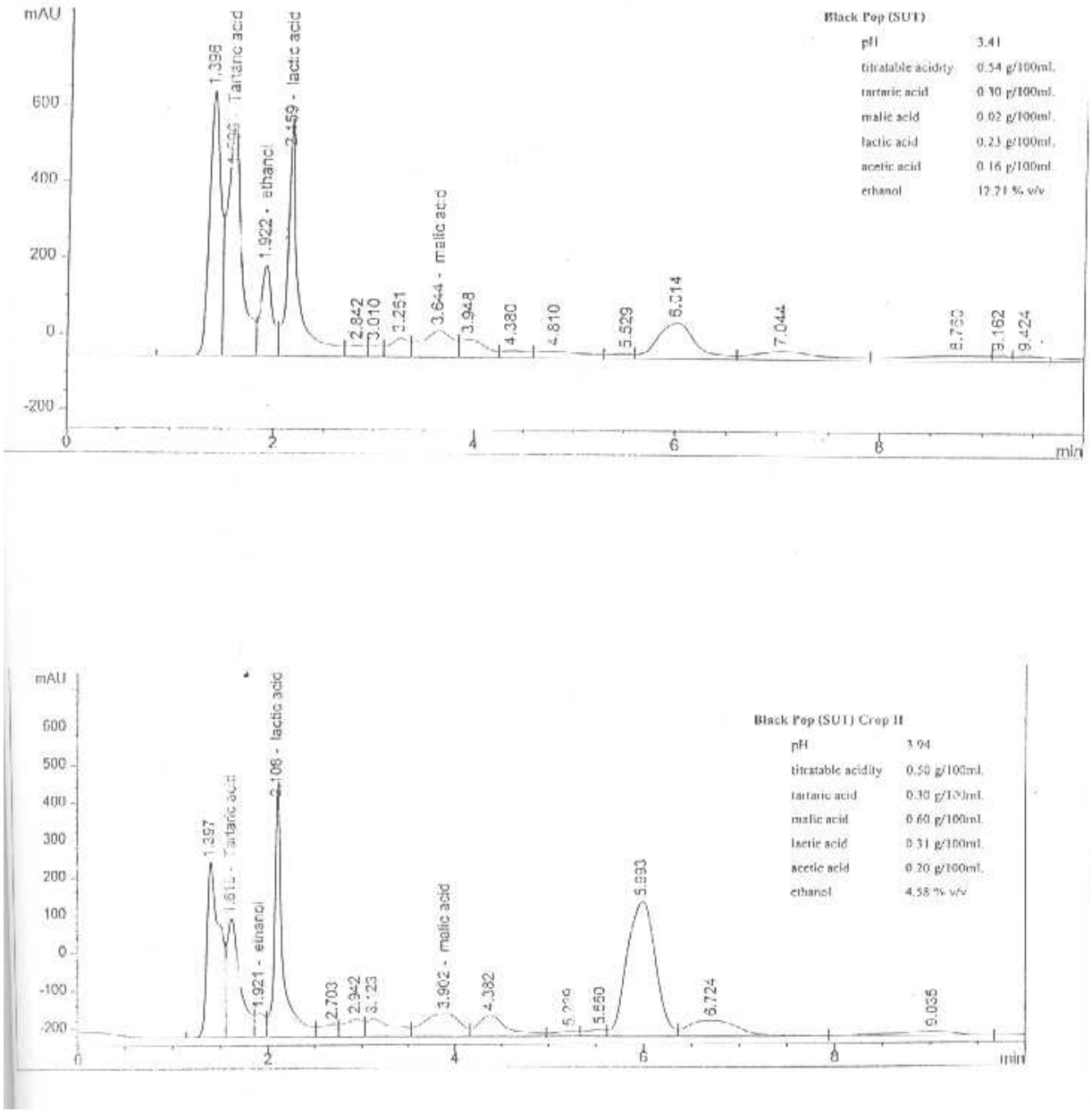


Figure 19. Chromatogram of wine (Black Pop) produced from dry season and rainy season grape (Crop II)

Eventhough it is difficult to make good quality of wine from low quality grapes. However, if necessary, it could slightly enhanced by these following approaches;

1. Raw material inspection

Low quality grapes had to be measured in special components which affect on wine quality before conducted to further process. Detection amount of, for example, glucose, gluconic acid, medium-chain fatty acids and acetic acid would be guided to raw material treatment process.

2. Winemaking process

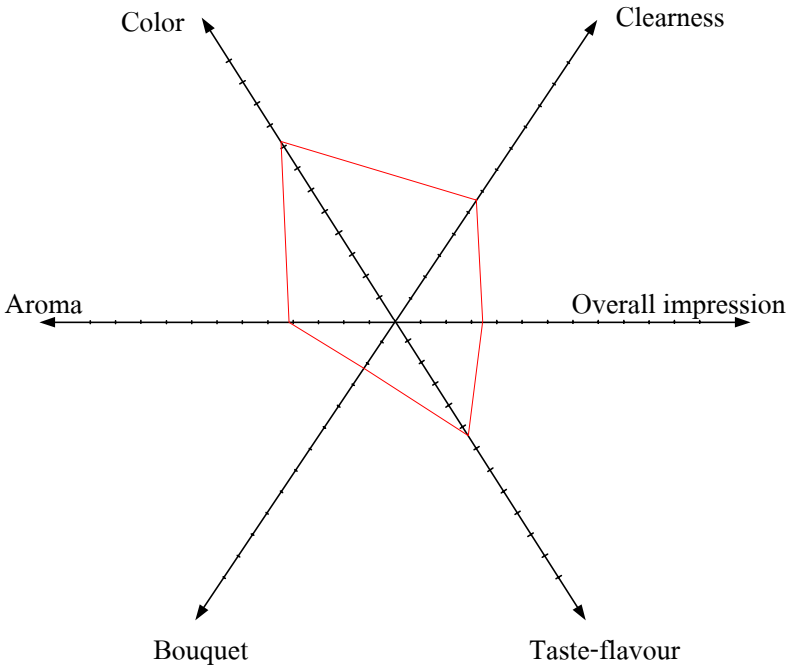
It had to modified process, this could be done by, for example, thermovinification in red wine. Thermovinification will enhance color extraction from skins and inactivation of juice and mold derived-enzymes. However, unacceptable level of phenol extracted during the process should also be considered.

3.3 Sensory evaluation

Sensory evaluation was presented as spider web plot in order to compare attributes profile and consequently analysis of variance.

3.3.1 Spider web plot

After completion in sensory evaluation then score for each attribute has been converted from scorecard. Average score for each attribute was ploted in spider web plot as indicated in Figure 20 - 29.



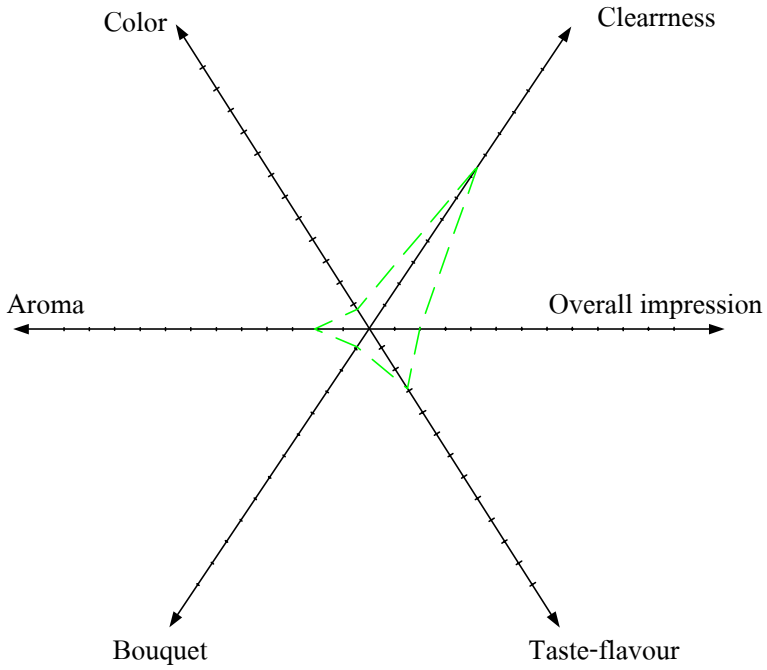
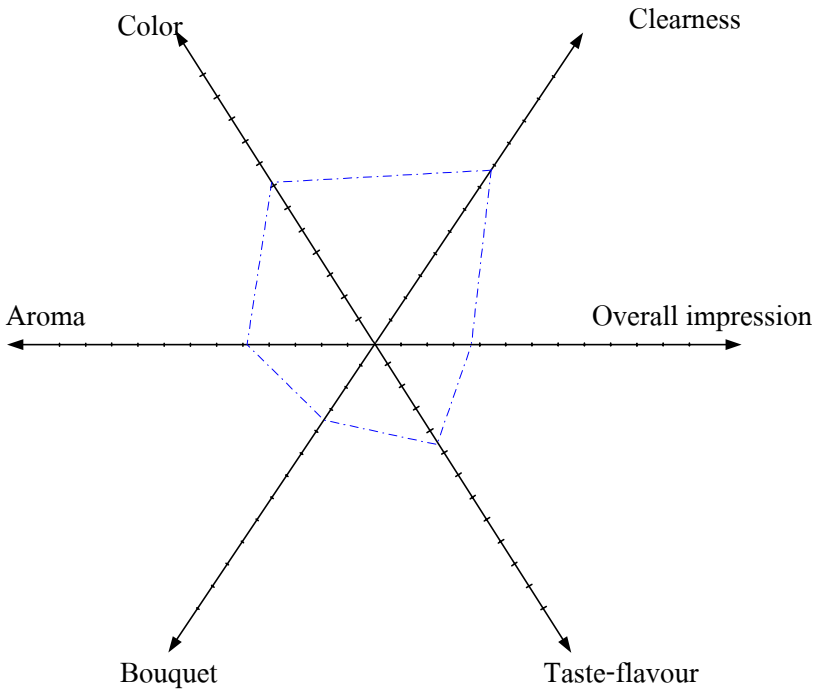
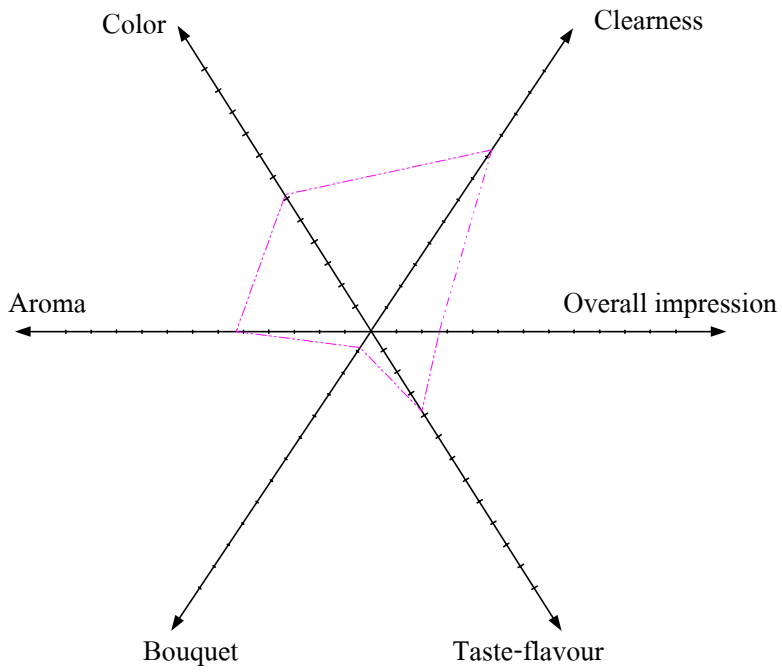


Figure 20. Spider web plot for each variety (red wine)



Shiraz



Cabernet Sauvignon

Figure 20. (continued)

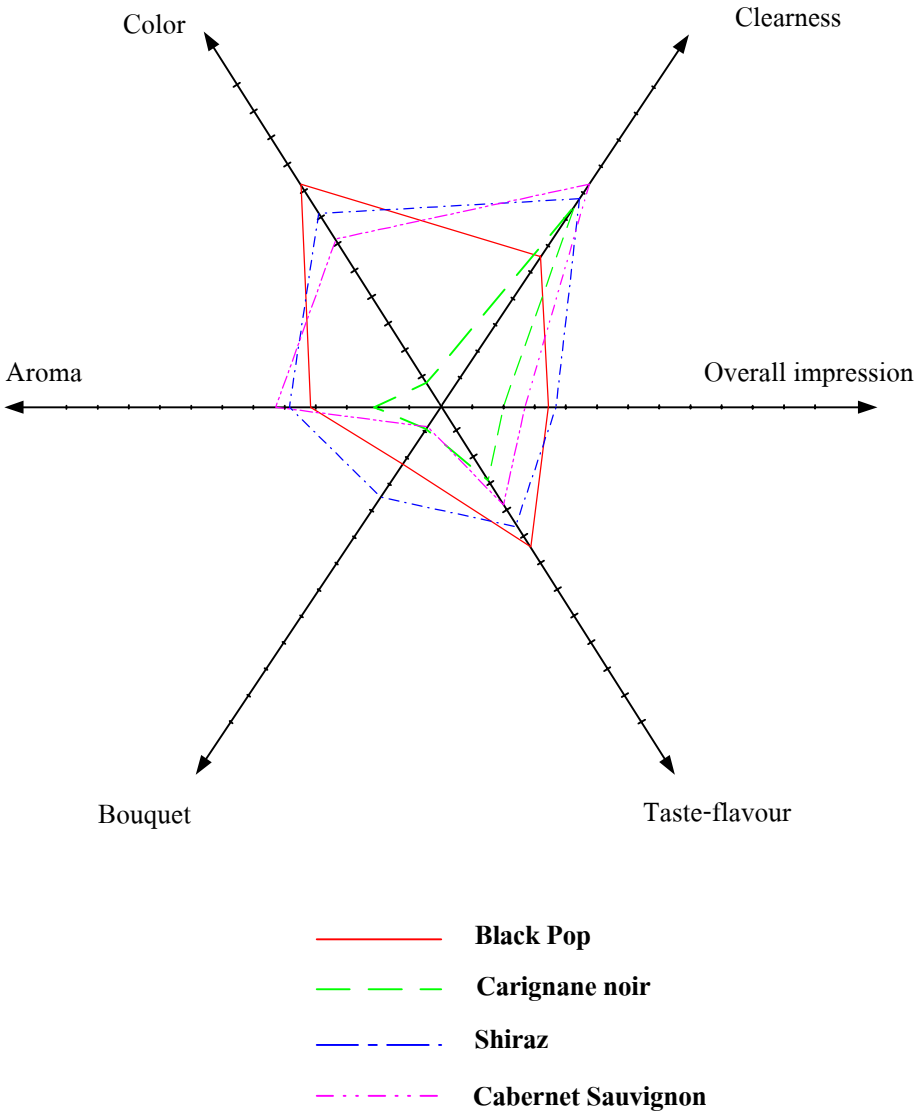


Figure 21. Spider web plot for all varieties (red wines)

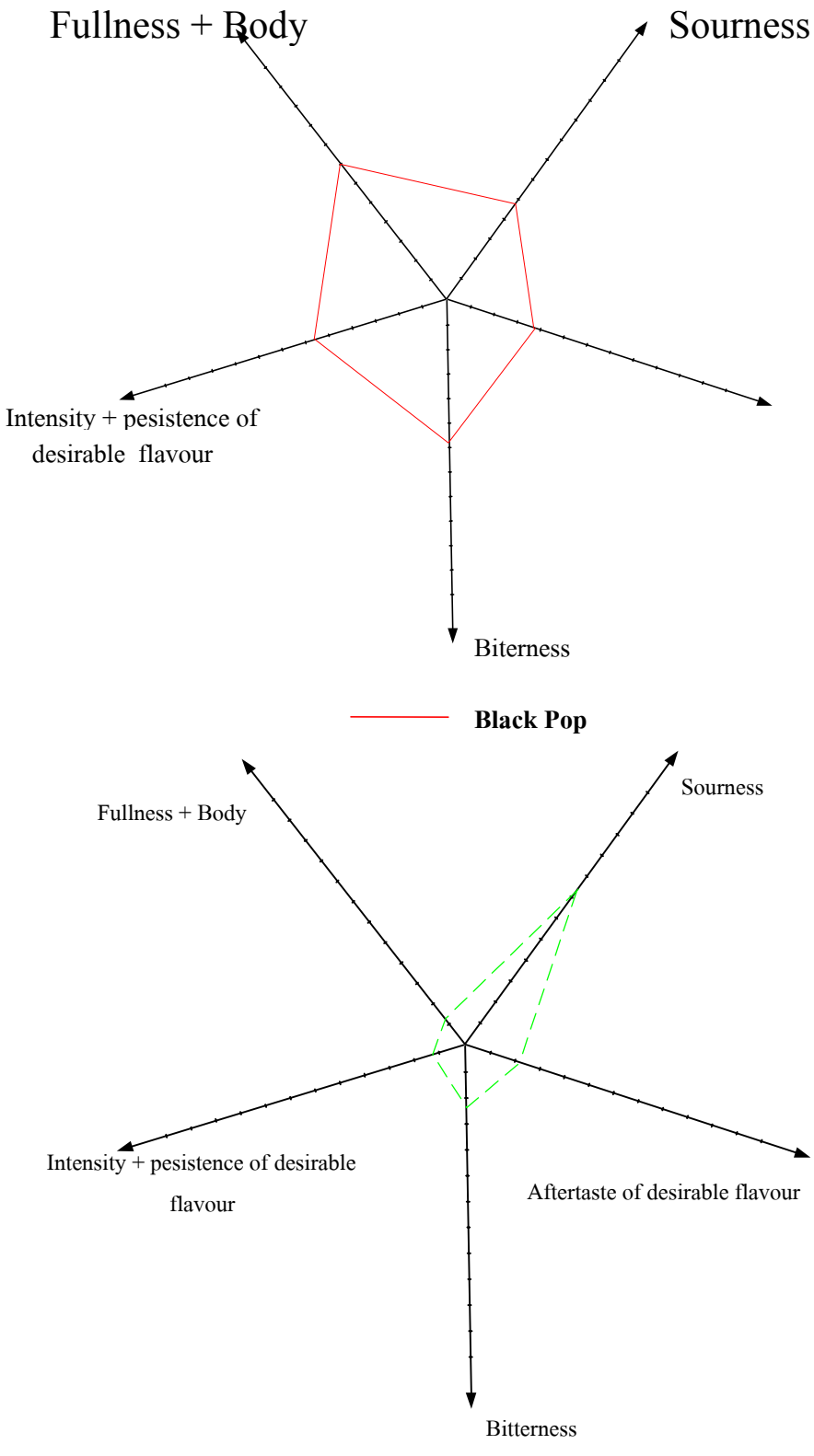


Figure 22. Taste-Flavour profile of each variety (red wine)

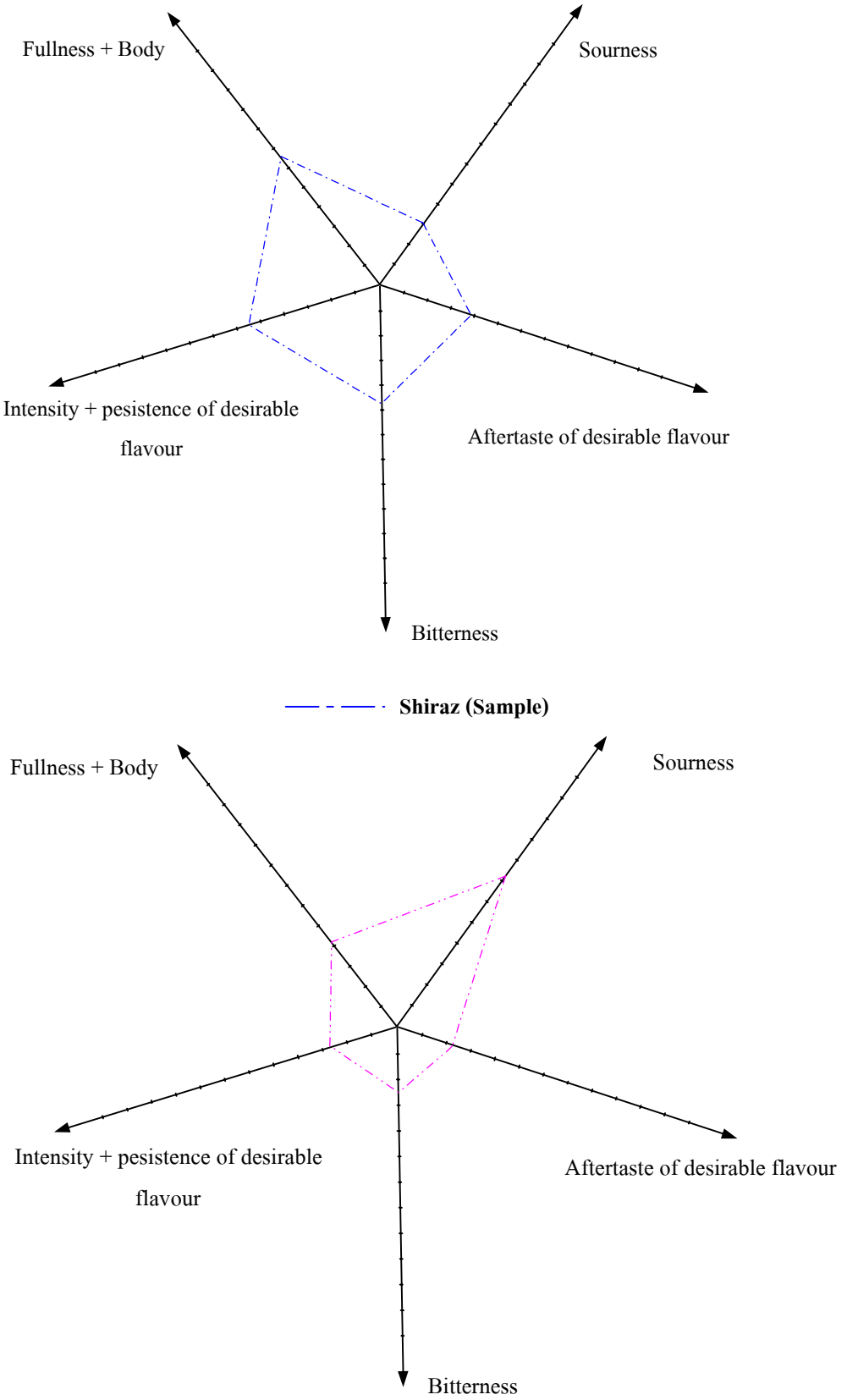


Figure 22. (continued)

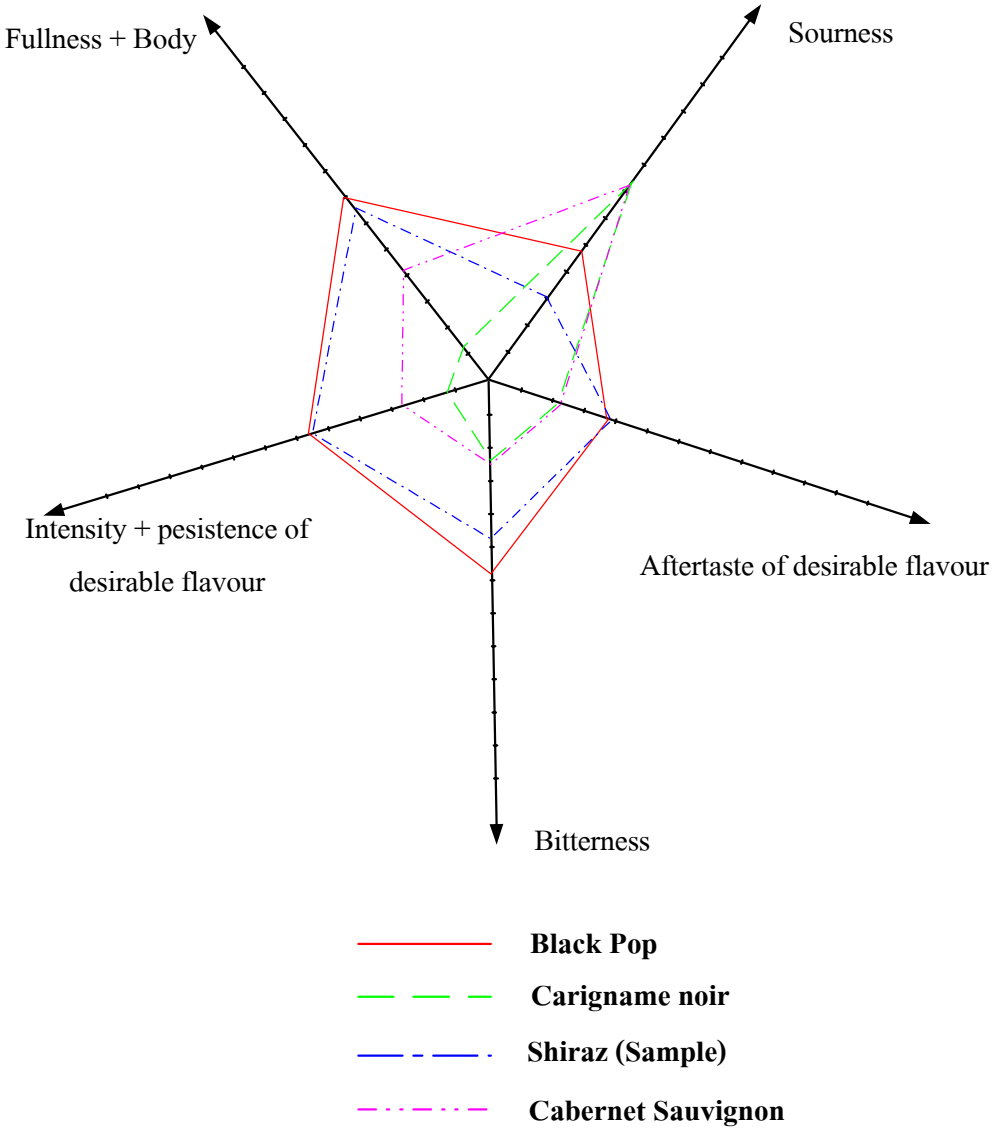


Figure 23. Taste-Flavour profile for all varieties (red wine)

Fig. 20-23 showed that each variety had its own unique characteristic. Among SUT red wines, Black Pop had highest score in color, bougquet, taste-flavour and overall impression. In addition, it had better taste-flavour and color than sample (Shiraz). Cabernet Sauvignon had the highest score in clearness and aroma, whereas subsequent from Black Pop in taste-flavour and overall impression. Carignane noir had the lowest score in almost attributes. The data indicated that it was too difficult to enhanced quality in Carignane noir variety planted on SUT Farm. Black Pop, is table grape, so it has low in aroma. When considered in taste-flavour profile of red wines, from Fig. 23 it was concurrence data.

However, all varieties have to be improved in overall quality, this could be done by various techniques such as blending with appropriate varieties. In this study, Black Pop was blended with Cabernet Sauvignon based on varietal blending in order to enhance in aroma, bouquet and taste-flavour profile.

The results from sensory evaluation showed that varietal blending using 75% of Black Pop with 25% of Cabernet Sauvignon, could enhance in clearness, bouquet and overall impression as shown in Fig 24. However, overall impression showed no statistically significance difference. Varietal blending with various ratio higher than 75% Black Pop was recommended for further study. Moreover, quality enhancing by blending with other varieties and blending at various stages in winemaking should be considered.

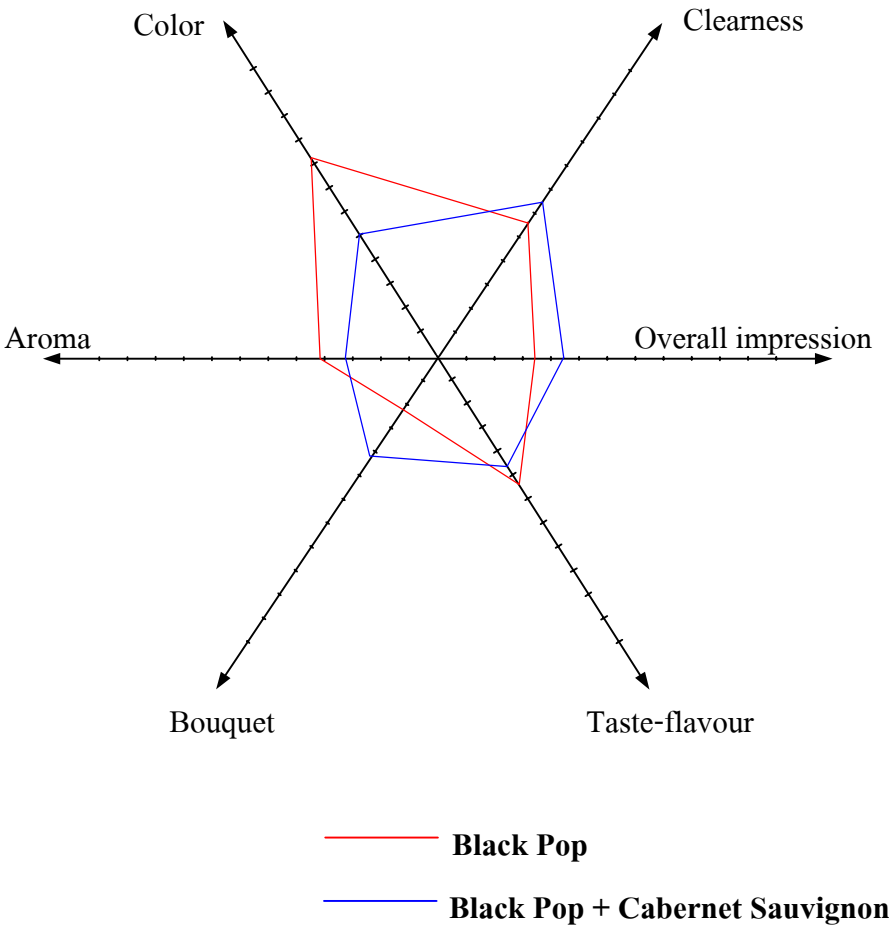


Figure 24. Spider web plot for pure and blended wines (red)

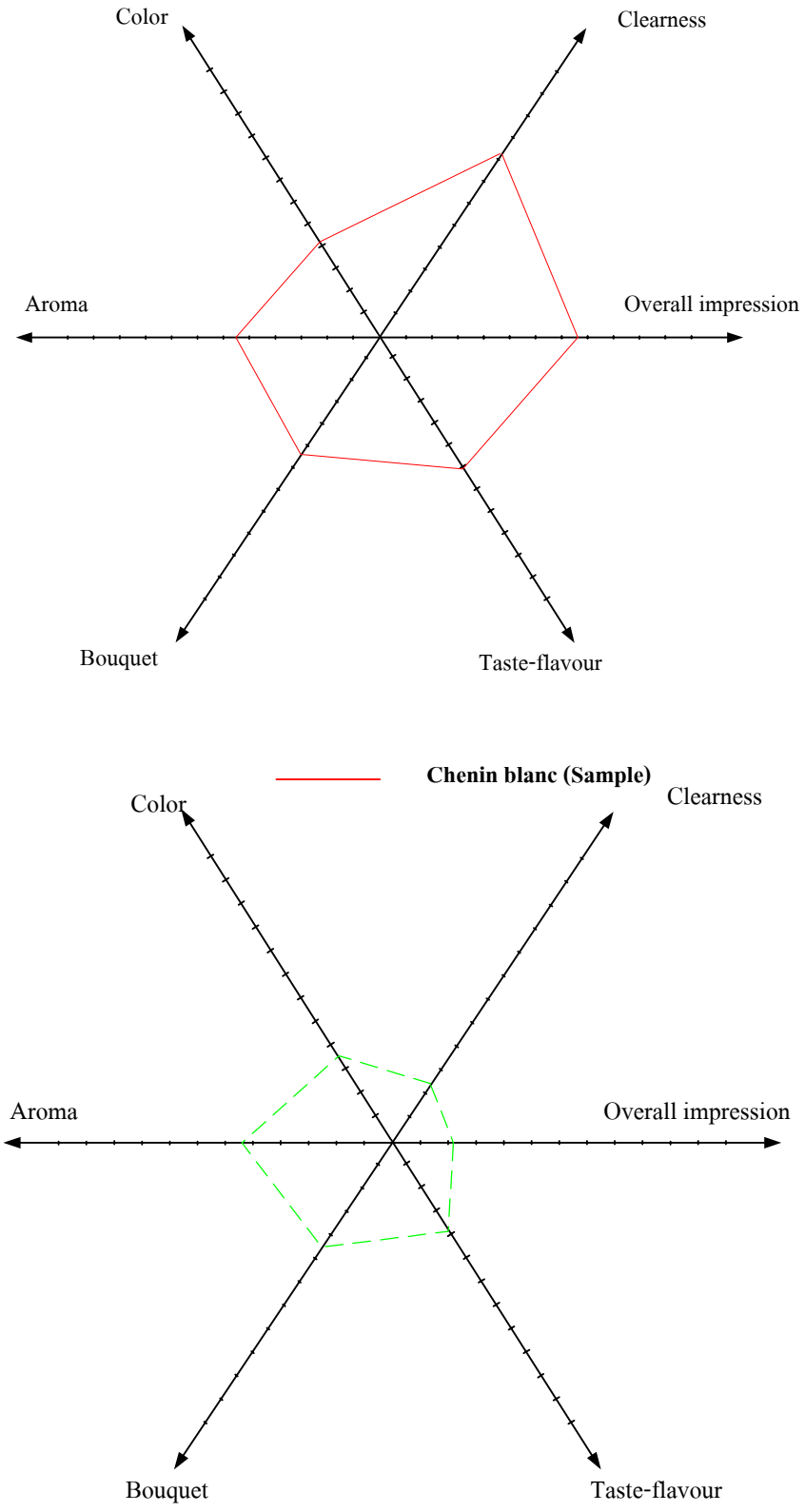
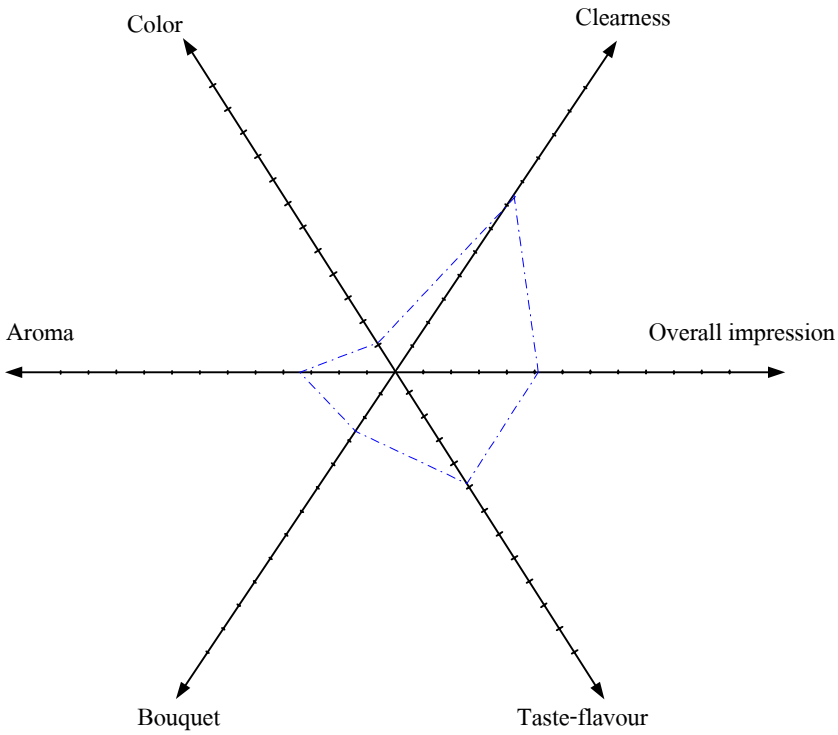


Figure 25. Spider web plot for each variety (white wine)



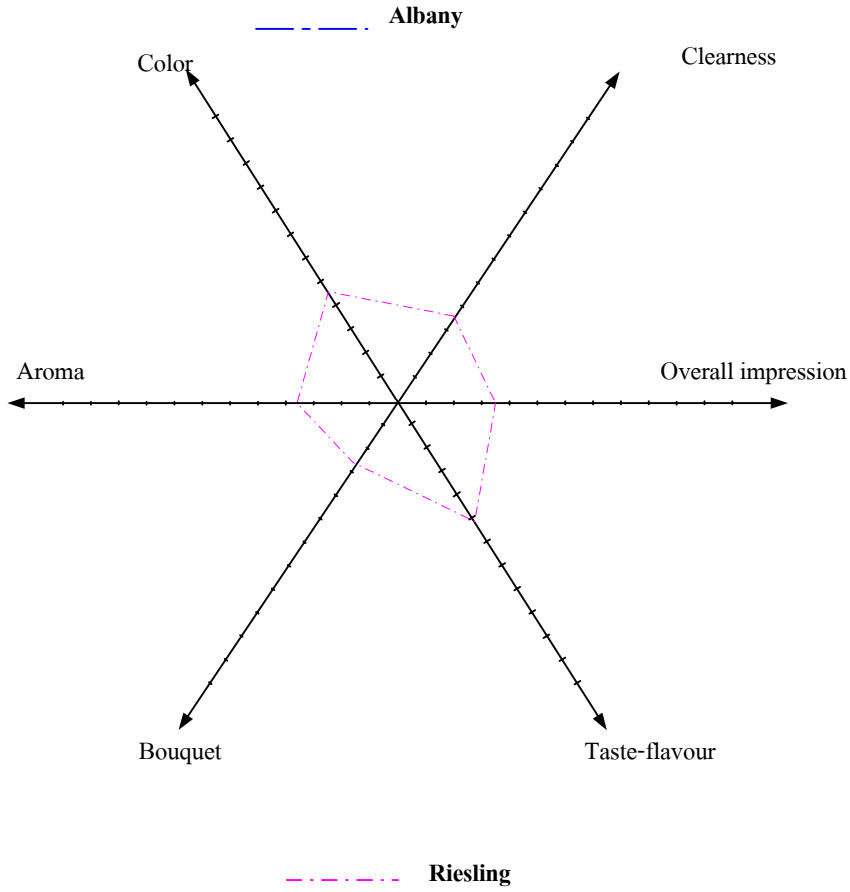


Figure 25. (continued)

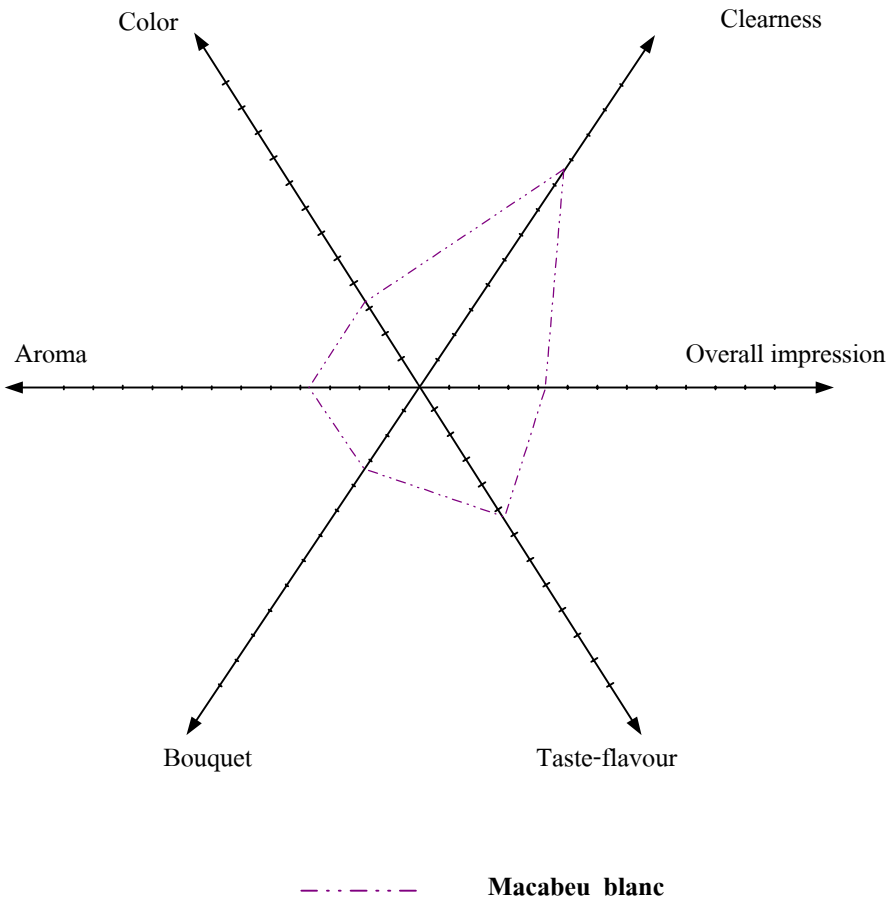


Figure 25. (continued)

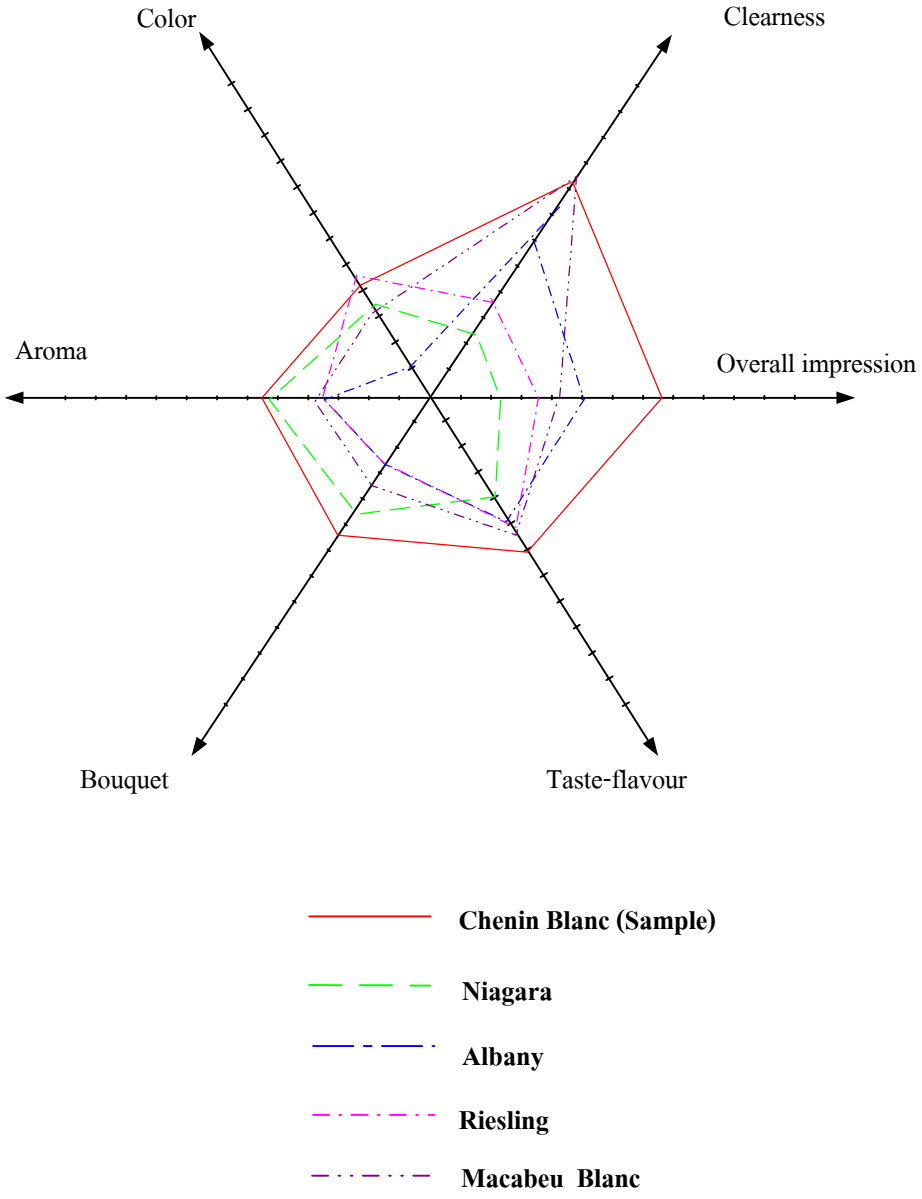


Figure 26. Spider web plot for all varieties (white wines)

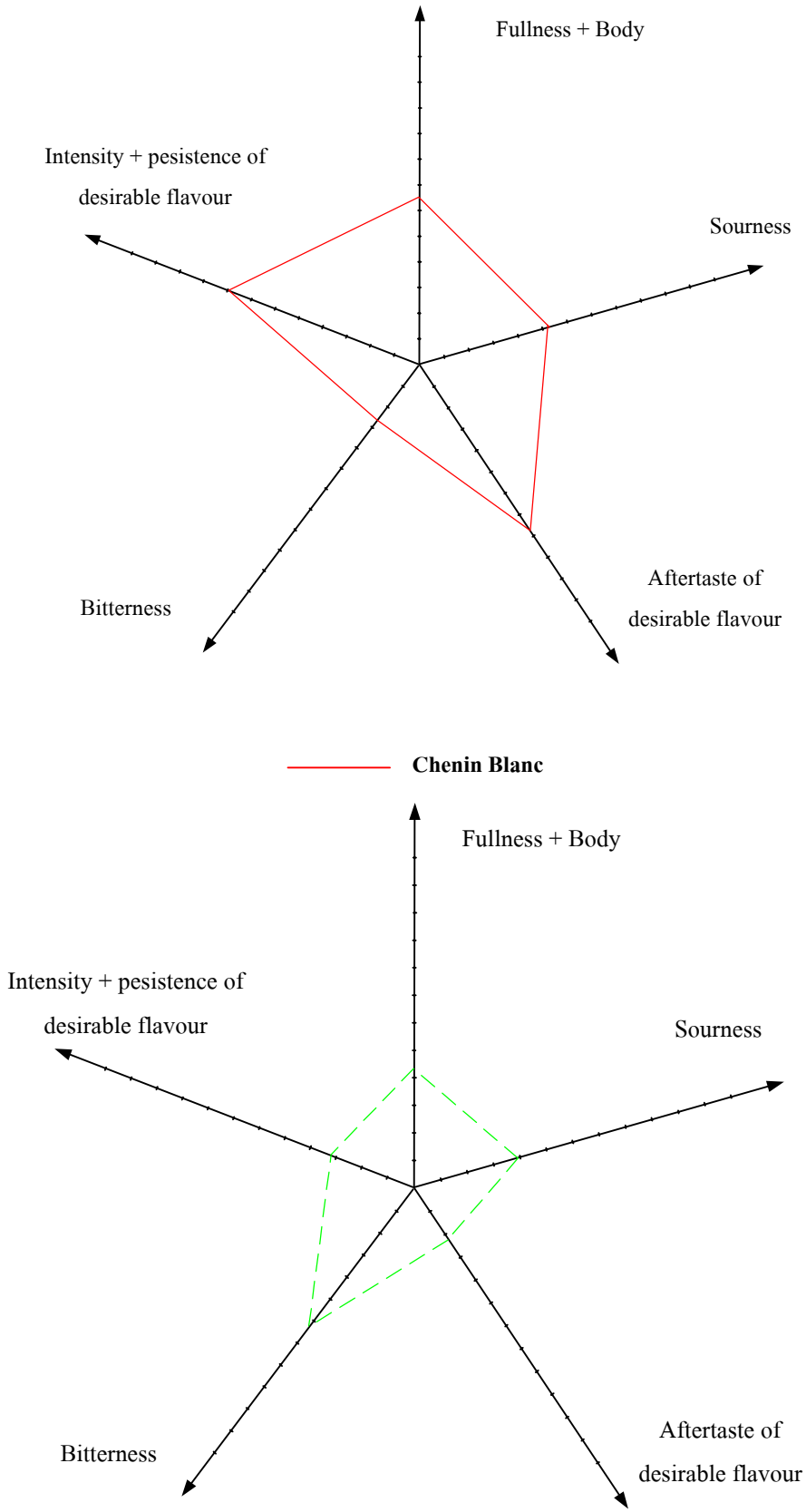


Figure 27. Spider web plot for each variety (white wines)

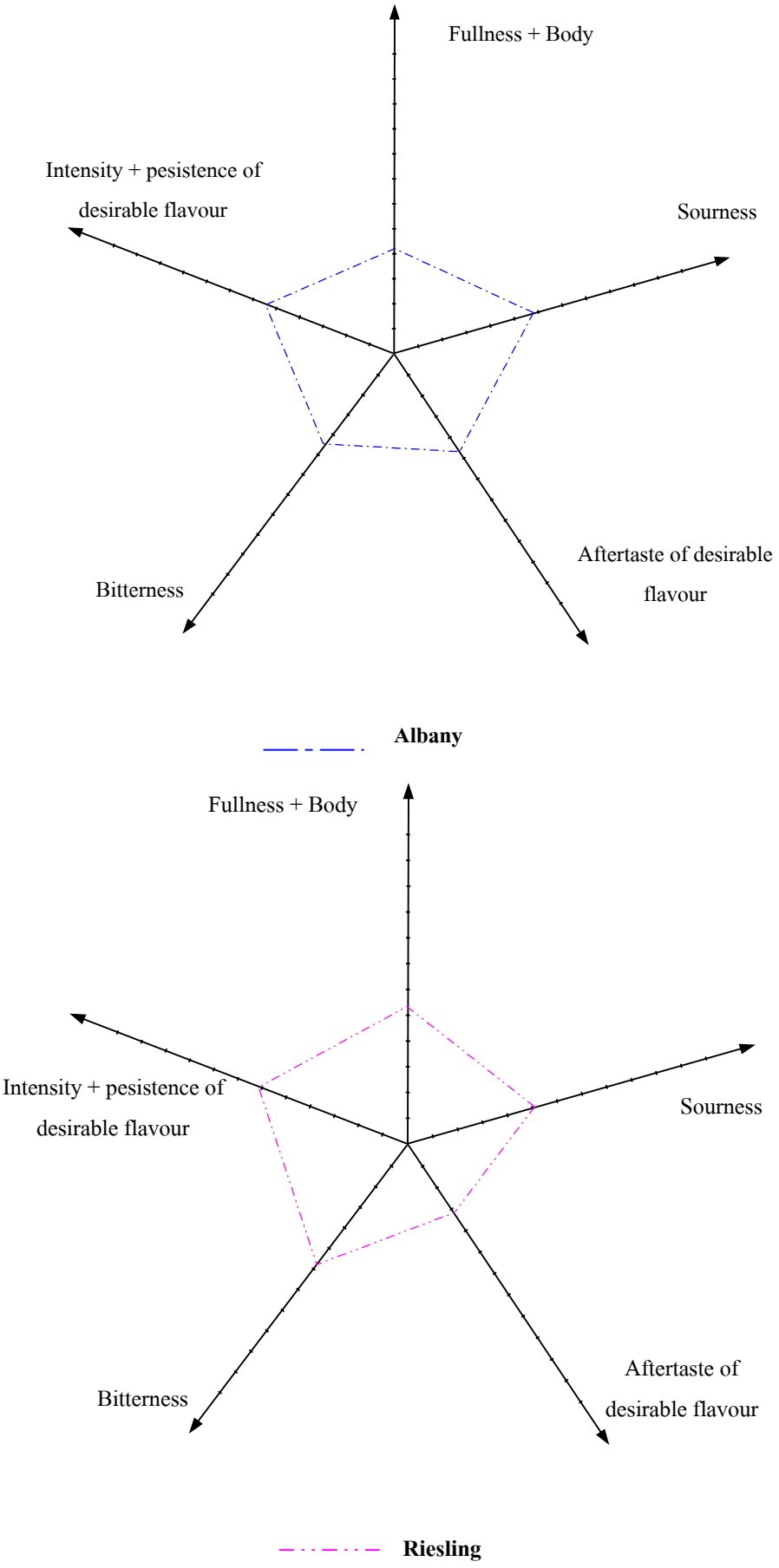
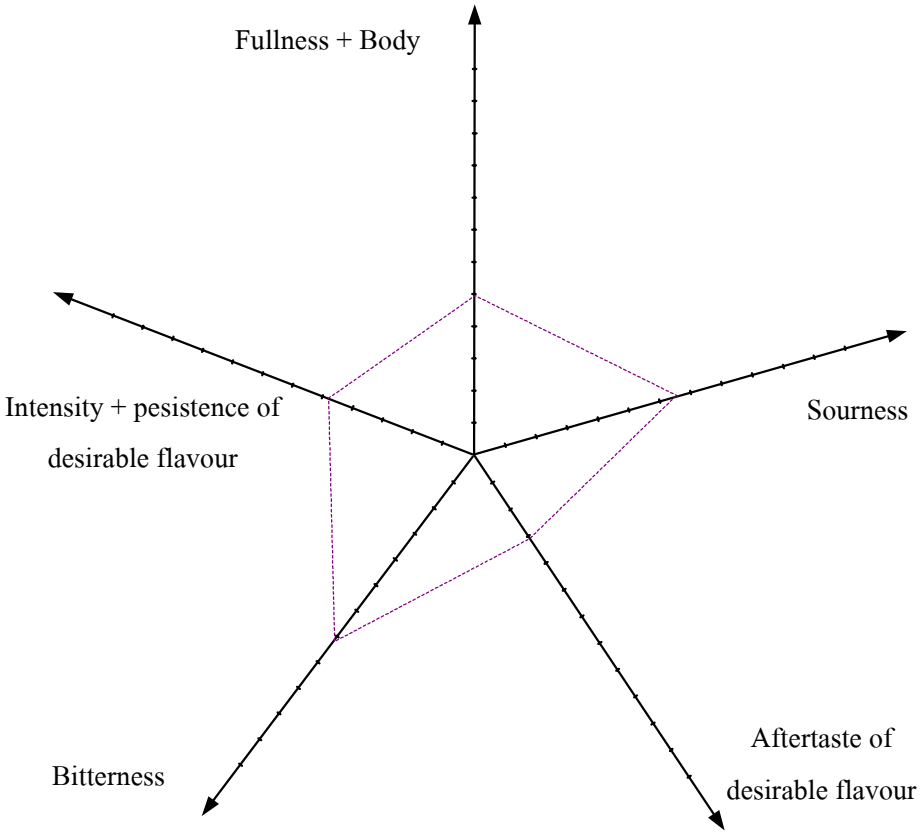


Figure 27. (continued)



Macabeu Blanc

Figure 27. (continued)

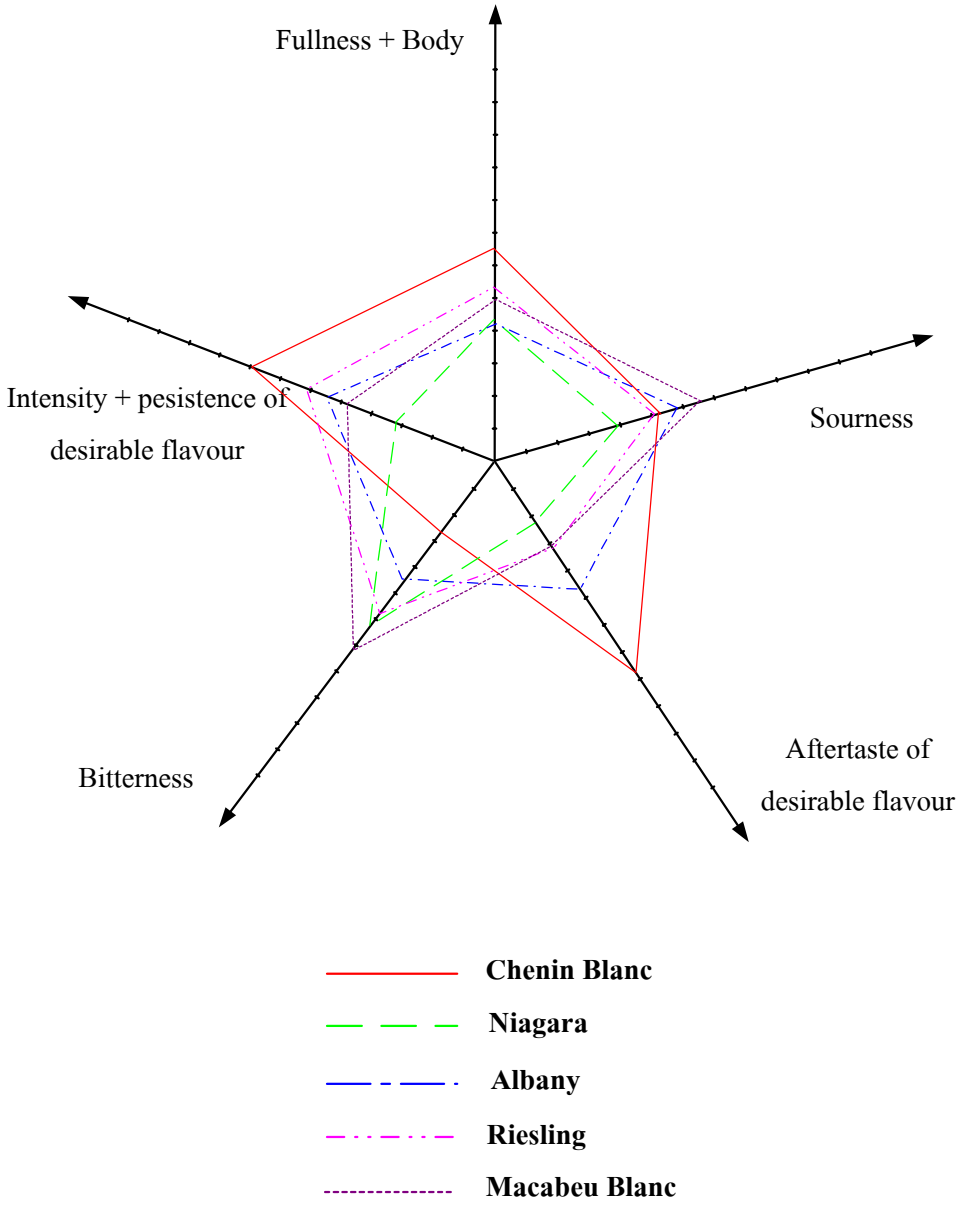


Figure 28. Taste-flavour profile for all varieties (white wines)

For determining white wine quality as indicated in Fig. 25-28, Albany had highest score in overall impression but lowest in color due to strong browning. Niagara had the highest score in aroma and bouquet followed by Macabeu blanc whereas its lowest in taste-flavor, clearness and overall impression. Riesling had dominated in color. Quality improving techniques could be overcome as in red wines. Albany could be blended with Niagara to increase overall impression or blended with Riesling to enhance in color. In same case, could blended Macabeu blanc with Niagara to increase taste-flavour, clearness and bouquet.

Varietal blending of white wines as well as in red wines, Albany was blended with Niagara and Riesling. The data received from sensory evaluation showed that blended wine improved colour, aroma and bouquet but not overall impression. This results agreed with the mathematical blending that changes linearly proportional to the amounts of the blended wine for chemical composition, not for sensory characteristics (Boultan et al., 1996). However, if only two wines are to be blended and one chemical component is of interest, a simple proportion is usable by the Pearson square, Computer are particularly used for several wines are to be blended to a specific standard for several components. In this experiment wines has been blended for optimum sensory quality. Macabeu Blanc was blended with Niagara showed that would enhance in colour, aroma, bouquet and overall impression. All data of blended white wines was presented in Fig 29.

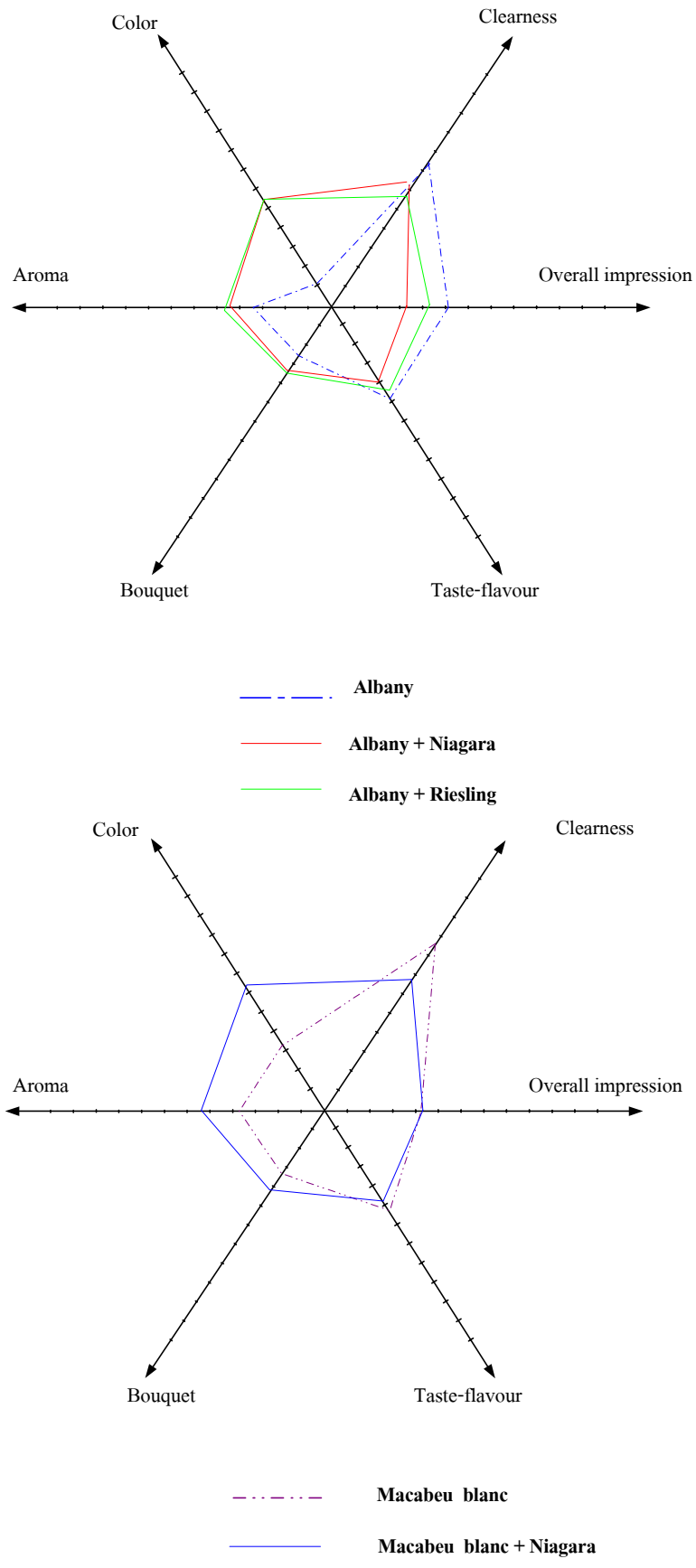


Figure 29. Spider web plot for pure and blended wines (white)

3.3.2 Analysis of variance (ANOVA)

All data were analyzed by using SPSS 9.05 for Windows program with one way ANOVA. The mean difference was significant at the 0.05 level at 95% confidence interval.

3.3.2.1 White wines

All white wines had significant in clearness which Macabeu Blanc was maximum followed by Chenin Blanc while Niagara was minimum. The other attributes were not significantly different include overall impression. Nevertheless, it had significantly found in overall impression when compared Chenin Blanc with Niagara and Chenin Blanc with Riesling. Among SUT white wines, Albany was maximum in overall impression whereas Niagara was minimum. Varietal blending of Albany showed that it could be enhanced in some attributes but no significantly different in overall impression.

3.3.2.2 Red wines

Red wines were significant in color which Carignane noir was minimum whereas Black Pop was maximum. The other attributes were not significantly different. However, it had significant in taste-flavor when compared between Black Pop and Carignane noir. Blended wine of Black Pop as well as blended white wines.

CHAPTER IV

CONCLUSION

Suitable varieties and quality of grape was the first key to produced high quality of wine. Almost varieties of grapes especially white varieties from dry season were satisfied in total soluble solid but titratable acidity was in the level of unsatisfaction due to it's extremely low. The low acidity and high pH of grapes could be resulted from acid respiration occur at high temperature. This phenomenon had agree with the previous study. However, Black Pop and Niagara from dry season were highest in acidity among red and white varieties, respectively. Rainy season grapes were low in total soluble solid due to unripened and climatic conditions which generated bunch rot of grapes. Almost wines from rainy season grapes were sluggish and finally stuck fermentation. This study showed that winemaking process from low quality grapes had to be modified by various techniques. This suggested that timing of harvesting and vineyard management were also important since they effect grape quality and consequently wine quality. Wines from dry season grapes contained almost the same chemical properties within group and between sample wines. Sensory evaluation showed that they were generally low in overall impression but no statistically significant. Taste-flavour profiles showed that each variety had its own characteristic. Thus high quality of wines could be obtained from various techniques such as blending or modified in maturation step which will be emphasized in further studied. In addition, quality control techniques in critical control points should be also provided. Data analysis from sensory evaluation indicated that they were different in complexity compounds which effected on quality. Varietal blending at 75% level of Black Pop and Albany showed that can enhance in some attributes whereas no statistically significant in overall impression were found. Nevertheless, this study showed that Black Pop and Albany which performed highest in overall impression will be the good potential varieties to promote as better of quality wine.

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APPENDIX A

Scorecard for sensory evaluation

Judge no ----------

Date ----------

Note for tasters

Please evaluate these characteristics by making a vertical mark across the horizontal line at the point that best reflects, the relatively intensity for each sample.

	low	moderate	high
Clearness			
Colour			
Aroma			
Bouquet			
Taste-Flavour			
- Sourness (acidity)			
- Fullness & body			
- Intensity persistence of desirable flavouar			
- Bitterness			
- Aftertaste of desirable quality			
Overall impression			

Definition

Clearness is the free of any visible particles.

Colour

White wines can be considered in the range of colourless, light yellow-green, light straw yellow and light yellow, medium yellow through light gold and medium gold, and finally to brown hues.

Red wines can be range from pink to light red, medium red, and dark red.

Aroma is the pleasant and desirable odors that come from the grapes.

Bouquet is the odors that come from fermentation of yeast and/or bacteria, wood essences, and other components.

Taste-Flavour is actually odors or "in-mouth smells" that reach olfactory epithelium when the wine in the mouth.

Sourness is amount of tartness in the wines.

Fullness and body refers to the viscosity or mouth-filling property of wines.

Intensity persistence of desirable flavour is the observation and distinguish between the flavour, taste, and tactile sensations that perceive when the wine is in the mouth.

Bitterness is the taste perceived at the back of the tongue.

Aftertaste of desirable quality refers to the taste-flavour after swallow the wines.

Overall impression refers to the evaluation of typicality and quality of wines after complete the sensory analysis in order to precise the degree of excellence of wine.

APPENDIX B

Calibration curves for HPLC analysis

BIBLIOGRAPHY

Lumphrai Dithavibool, her former family name was In-aium, was born in Mahasarakham, Thailand on Wednesday May 31th ,1967. She studied in primary school at Satreesongklaurniyom school Khon Kaen, then finished high school from Padungnaree School in Mahasarakham. In 1990 she received Bachelors degree in B.Sc. (Biotechnology) from the Faculty of Technology, Khon Kaen University. While she was in the third year student at Khon Kaen University she had worked as trainee student at the L-lysine production factory, Ajinomoto company for 3 months where she was appreciated in the field of fermentation technology. After graduation, she worked as quality control staff at the vinegar, soy sauce and chilli sauce production factory named Thaitheparos Food Products Company for 1 year. Then she worked in the fruits and vegetables processing factory, named Doi Kham Food Products Company (Royal Project-Royal Recommended Project, Food Processing Section) in the position of quality control, research and development division manager for 5 years. During she was working here she went to Kato Sangyo Company, Hyogo, Japan, as trainee staff in jam and jelly production department for 1 month. Because of further education, she retired working from this company following by start working as university staff at Suranaree University of Technology, where next 2 years she was also studying as master student as the same time in the field of Biotechnology at Institute of Agricultural Technology. Her research topic was Quality of wines produced from grape varieties grown on Suranaree University of Technology Farm. This research has been presented as poster presentation and oral presentation in The 5th Asia-Pacific Biochemical Engineering Conference 15-18 November 1999 and First National Symposium on Graduate Research 10-11 June 2000 at Phuket and Chiang Mai University, Thailand, respectively.