

# [研究報文]

## QUALITY COMPARISON OF WINES PRODUCED FROM NEW VARIETIES OF GRAPES PLANTED ON KAMPANGSAN CAMPUS

Pradit Karuwanna, Malai Boonyaratanakornkit,  
Chakamas Wongkhalaung and Wimolsiri Porntaveewat.

Institute of Food Research and Product Development,  
Kasetsart University, Bangkok 10900, Thailand.

### Abstract

Twenty one varieties of white grape and 22 varieties of red grape cultivated on Kampangsan Campus were harvested in different seasons. The musts were analysed and compared. Wines made from different grapes harvested in the same and different seasons were tasted to compare the qualities. Then the top score wines were selected and blended to give 7 samples each of white blended wines (WB) and red blended wines (RB). Sensory evaluation of the white blended wines showed that WB<sub>3</sub>, WB<sub>2</sub> and WB<sub>4</sub> got the highest scores from the tasters but analysis of variance showed significant difference only in color. Among the red blended wines, RB<sub>5</sub> got the highest scores in aroma and taste but RB<sub>2</sub> got the highest scores in color and acceptability, Significant difference on analysis of variance was found in color, taste and acceptability among the blended reds. Grapes of high potential for white wines production were W<sub>16</sub>, W<sub>5</sub> and W<sub>15</sub> but for the reds were R<sub>4</sub>, R<sub>16</sub>, R<sub>17</sub>, R<sub>2</sub>, R<sub>3</sub> and R<sub>18</sub>.

### Introduction

Yeast is the crucial microorganism that has great influence to flavor, taste, quality and spoilage of wines (Amerine et al.,

1972. Amerine and Singleton, 1972). Pasteur (1876, 1878) was the first scientist who discovered different yeasts on the skin of grapes. Mrak and Phaff (1948), Lund (1954, 1958) and Ingram (1951) studied yeasts in some fruits and found yeasts of very few numbers inside the fruits but appeared plenty on the skins. Van Kerken (1963) studied ecology of yeasts in natural vinification. She also classified the isolated yeasts. Wine may be produced by spontaneous fermentation but in the industry it is practically produced by inoculating pure culture of one or more strains of selected yeasts (Karuwanna, 1976). The general strain of wine yeast is known as Saccharomyces cerevisiae.

Besides proper technology of producing, quality of wine will also depend on the quality of grapes. In Thailand, Chaitiemwong (1973), Wattana (1976) and Karuwanna (1978) carried out small scale wine making from White Malaga table grapes and yielded with disappointed results. Department of Horticulture, Faculty of Agriculture, Kasetsart University, is currently cultivating new varieties of wine grape on Kampangsan Campus. It is, therefore, necessary to process and compare the quality of wines produced from these grapes. This research intended to compare the quality of wines made from different varieties of grapes harvested in the same and in different seasons in Thailand.

#### Materials and Methods

Grape: Code numbers and varieties were shown in Table 1. The grapes were cultivated on Kampangsan campus, Kasetsart University. They consisted of 21 varieties of the white and 22 varieties of the red. Harvested dates were made in May 1987 (Summer season), in October 1987 (Rainy season) and in February 1988 (Winter season).

Must preparation : Musts of the white varieties of grape were adjusted to  $20 \pm 1^\circ$  Brix and  $6.5 \pm 0.5$  g/l. by white cane sugar and tartaric acid respectively. Musts of the red varieties were also adjusted to  $20 \pm 1^\circ$  Brix and  $6.0 \pm 0.5$  g/l. To prevent oxidation and inhibit natural undesirable microbes in the musts, 150 ppm. of  $\text{Na}_2\text{S}_2\text{O}_5$  was added to the musts and left overnight.

Yeast starter preparation : About 0.04% of active dry wine yeast (Lalvin K1-V. 1116, Canada) was added to warm grape juice. Propagation took 20-24 hr, then inoculation was made with 4% (v/v) of the yeast starter.

Fermentation : Fermentation was carried out in 5-20 l. glass bottles at  $20-22^\circ\text{C}$ . Samples of fermenting musts were taken for dairy measuring of  $^\circ\text{Brix}$  by sugar hydrometer. The skin of red musts was pressed out at about  $5 \pm 2^\circ$  Brix.

Clarification and aging : When fermentation was terminated, the wines were racked and kept at  $2^\circ\text{C}$ . for at least 4 weeks, then clarified and filtered under reduced pressure using diatomaceous earth as filter aid. The brilliant wines were then added with 80 ppm of  $\text{Na}_2\text{S}_2\text{O}_5$ , bottled and refrigerated at least 2 months before sensory evaluation was made.

Chemical analysis : Analysis of chemical constituents of the finished wines was made according to the methods described by Amerine and Ough (1974)

Sensory evaluation : Quality of the finished wines was evaluated by scoring. Wines produced from different grapes harvested in the same season were firstly screened and scored only on color, aroma and taste (max 10 points each). Then some top score wines were

selected and blended to give 7 samples each of white wines and red wines. For scoring these blended wines, maximum 20 points each was then set for aroma, taste and acceptability but only 10 for color. Analysis of variance was used to determine whether there were significant differences in the mean scores of the blended wines.

### Results

Musts analysis of the grapes harvested in different seasons was shown in Table 2. It was found that most of the grapes harvested in all 3 seasons in Thailand had lower in °Brix but better °Brix and TA may be noticed if they were harvested in Summer (May) and in Winter (February) seasons. The average °Brix was 16.1, 11.8 and 16.6 for the white varieties and 16.1, 10.8 and 17.3 for the reds harvested in Summer, Rainy and Winter respectively.

Sensory evaluation of the finished wines was made and the 4 top scores each of white and red wines produced in different seasons was shown in Table 3 and 4 . It was found that  $W_5$  (Italia),  $W_7$  (Shimo),  $W_{16}$  (Early Muscat) and  $W_{18}$  (SK 16) were rated most like among the white wines. For red wines, the tasters gave the highest scores to  $R_2$  (Barbera),  $R_6$  (Rubired),  $R_3$  (Nebbiolo) and  $R_4$  (PP). Preliminary blending of winter wines resulted with 3 whites ( $W_x$ ,  $W_y$  and  $W_z$ ) and 3 reds ( $R_x$ ,  $R_y$  and  $R_z$ ). The taste of these blended wines was better than the unblended ones.

The top score wines were selected and final blending was carried out to give 7 samples each of white wine and red wine. The blended proportion with code numbers of these wines was shown in Table 5. Italia ( $WB_2$ ) and PP ( $RB_1$ ) were the control samples. Some major chemical composition of the blended wines were shown in Table 6. Average scores for color, aroma, taste and acceptability of the final

blended wines from sensory evaluation were shown in Fig. 1 and Fig. 2. It was found that among the white blended wines, WB<sub>3</sub> was scored most like in taste and acceptability. WB<sub>2</sub> got the highest score in aroma and WB<sub>4</sub> was ranked second in aroma and acceptability. Among the red blended wines, RB<sub>5</sub> got the highest scores in aroma and taste but RB<sub>2</sub> got the highest scores in color and acceptability. RB<sub>4</sub> was ranked second in both aroma and acceptability.

The result of an analysis of variance from sensory evaluated scores of the blended white wines was shown in Table 7. and of the blended red wines in Table 8. It was found that at F<sub>0.05</sub> level, there was significant difference in the mean scores of the color of the white blended wines. For the red blended wines, there was significant difference in color, taste and acceptability.

#### Discussions

Musts of different grapes harvested in different seasons in Thailand should have amelioration before fermentation. Grapes harvested in Winter season (February) had more sugar content than those harvested in Summer (May) and Rainy seasons (October). Musts of the grapes harvested in Rainy season had the lowest quality due to lower in °Brix and higher in total acidity especially the reds which had only 10.8° Brix but 1.14% in total acidity. Since much rain which also created many diseases was the major grape's enemy in Thailand, so growers had to harvest before grapes were fully matured. Selection of suitable better yield varieties with high tolerant to the rain should be considered otherwise no harvesting was made in this season.

From quality comparison of wines produced from grapes harvested in different seasons, it was found that the best quality white wines of every harvesting seasons should be produced from W<sub>5</sub> (Italia) and W<sub>7</sub> (Shimo). Quite good varieties of the whites were W<sub>16</sub> (Early Muscat), W<sub>4</sub> (Cortese) and W<sub>18</sub> (SK 16). Wines of the best aroma should be produced from W<sub>5</sub> and W<sub>16</sub>. The best red wines of all producing seasons should be made from R<sub>2</sub> (Barbera) and R<sub>6</sub> (Rubired). The good red wines should be produced from R<sub>3</sub> (Nebbiolo) and R<sub>4</sub> (PP) especially deep red color was observed in the latter. Pronounced aroma in red wines came from R<sub>2</sub> and R<sub>6</sub>.

Quality of both white wines and red wines were much improved by blending techniques. Analysis of variance of the sensory evaluated scores found that color of the blended white wines was significant difference due to bottle aging and some oxidation. No significant difference in aroma of the blended red wines was noticed since the pronounced aroma varieties were used in blending.

Table 1. List of grape varieties used

Code	White variety	Code	Red variety
W <sub>1</sub>	Vermentino	R <sub>1</sub>	Muscat Hamburg
W <sub>2</sub>	Chardonnay	R <sub>2</sub>	Barbera
W <sub>3</sub>	Chenin blanc	R <sub>3</sub>	Nebbiolo
W <sub>4</sub>	Cortese	R <sub>4</sub>	PP
W <sub>5</sub>	Italia	R <sub>5</sub>	Hirohamberg
W <sub>6</sub>	Riesling Italicco	R <sub>6</sub>	Rubired
W <sub>7</sub>	Shimo - sara - Jensu	R <sub>7</sub>	Alfonso
W <sub>8</sub>	No. 311	R <sub>8</sub>	Red Tokay
W <sub>9</sub>	Trebbiano Toscano	R <sub>9</sub>	Cabernet sauvignon
W <sub>10</sub>	Tokay	R <sub>10</sub>	Sangiovese
W <sub>11</sub>	Villard Blanc	R <sub>11</sub>	Villard noir
W <sub>12</sub>	Rkaziteli	R <sub>12</sub>	Ruby Okuyama
W <sub>13</sub>	Moscato Bianco	R <sub>13</sub>	Alicante Bouschet
W <sub>14</sub>	Garganega	R <sub>14</sub>	Cardinal
W <sub>15</sub>	Trebbiano di Soave	R <sub>15</sub>	Seibel
W <sub>16</sub>	Early Muscat	R <sub>16</sub>	Lambrusco
W <sub>17</sub>	No. 316	R <sub>17</sub>	Black Muscat
W <sub>18</sub>	SK 16	R <sub>18</sub>	Portugieser
W <sub>19</sub>	Riesling Klonen	R <sub>19</sub>	Aglionico
W <sub>20</sub>	No 322	R <sub>20</sub>	Benizu (Misawa)
W <sub>21</sub>	Excelsior	R <sub>21</sub>	Benifugi
		R <sub>22</sub>	Benizuihou

Table 2. Musts analysis of the grapes harvested in different seasons.

Code	Summer <sup>A</sup>			Rainy <sup>B</sup>			Winter <sup>C</sup>			Code	Summer <sup>A</sup>			Rainy <sup>B</sup>			Winter <sup>C</sup>		
	°Brix	pH	TA	°Brix	pH	TA	°Brix	pH	TA		°Brix	pH	TA	°Brix	pH	TA	°Brix	pH	TA
W <sub>1</sub>	16.2	4.05	0.52	13.6	3.65	0.83				R <sub>1</sub>	15.4	4.64	0.26	8.5	3.40	0.65	17.0	4.05	0.34
W <sub>2</sub>	15.0	4.15	0.50							R <sub>2</sub>	17.4	3.98	0.63	11.2	3.64	1.19	14.7	3.40	0.71
W <sub>3</sub>	14.4	3.82	0.59				17.6	3.50	0.68	R <sub>3</sub>	17.2	3.90	0.60	12.4	3.73	0.99			
W <sub>4</sub>	15.0	3.85	0.58	9.0	3.59	0.58	16.5	3.50	0.65	R <sub>4</sub>	13.8	4.17	0.67	8.4	3.58	1.66	16.6	3.30	1.15
W <sub>5</sub>	15.8	4.20	0.34	10.0	3.76	0.81	13.6	3.50	0.56	R <sub>5</sub>							17.4	3.90	0.38
W <sub>6</sub>	16.2	4.35	0.25	9.0	3.92	0.52	16.3	3.90	0.34	R <sub>6</sub>	18.0	3.92	0.87	9.0	3.34	2.30	19.5	3.50	0.87
W <sub>7</sub>	18.4	4.33	0.34	16.0	3.92	0.52	18.0	3.75	0.37	R <sub>7</sub>									
W <sub>8</sub>	20.0	3.47	0.96				18.2	3.30	0.67	R <sub>8</sub>							17.0	3.40	0.51
W <sub>9</sub>	13.3	3.68	0.89	12.5	3.75	0.82	14.0	3.50	0.59	R <sub>9</sub>	13.4	3.83	0.56				16.1	3.70	0.55
W <sub>10</sub>	17.4	4.39	0.37							R <sub>10</sub>	17.0	3.95	0.69	12.2	3.56	1.01			
W <sub>11</sub>	17.4	3.84	0.68							R <sub>11</sub>	18.0	4.06	0.51				17.5	3.80	0.50
W <sub>12</sub>	17.4	3.92	0.68							R <sub>12</sub>	15.0	4.31	0.41				14.8	3.80	0.37
W <sub>13</sub>	17.0	4.04	0.48							R <sub>13</sub>				15.0	4.0	0.52	16.3	3.60	0.57
W <sub>14</sub>	12.5	3.81	0.53	12.0	3.58	0.74	16.0	3.35	0.53	R <sub>14</sub>				10.0	3.3	0.76	18.2	3.30	0.95
W <sub>15</sub>				10.0	3.75	0.92	14.0	3.60	0.52	R <sub>15</sub>							17.0	3.70	0.63
W <sub>16</sub>				14.2	4.00	0.50				R <sub>16</sub>							19.0	3.20	1.10
W <sub>17</sub>							17.6	3.50	0.58	R <sub>17</sub>							17.0	4.20	0.26
W <sub>18</sub>							16.5	3.50	0.59	R <sub>18</sub>							16.9	4.30	0.30
W <sub>19</sub>							17.2	3.40	0.68	R <sub>19</sub>							13.6	3.15	0.93
W <sub>20</sub>							21.4	3.60	0.59	R <sub>20</sub>							18.2	3.80	0.37
W <sub>21</sub>							15.4	3.60	0.76	R <sub>21</sub>							20.4	3.75	0.43
										R <sub>22</sub>							20.8	3.80	0.38
av.W	16.1	3.99	0.55	11.8	3.77	0.69	16.6	3.54	0.58	av.R	16.1	4.14	0.52	10.8	3.57	1.14	17.3	3.67	0.60

A : May 1987

B : October 1987

C : February 1988

TA : % as tartaric acid



Table 3. The 4 top score white wines fermented in different seasons.

Rank	color			aroma			taste		
	Summer	Rainy	Winter	Summer	Rainy	Winter	Summer	Rainy	Winter
1 st.	$W_7(7.06)$	$W_5(8.32)$	$W_7(8.20)$	$W_5(7.32)$	$W_{16}(8.08)$	$W_5(7.90)$	$W_7(6.79)$	$W_5(6.83)$	$W_x(7.70)$
2 nd.	$W_4(7.03)$	$W_7(8.10)$	$W_{18}(8.20)$	$W_4(6.85)$	$W_5(7.92)$	$W_{18}(7.40)$	$W_3(6.47)$	$W_{16}(6.67)$	$W_y(7.20)$
3 rd.	$W_{12}(7.00)$	$W_4(7.8)$	$W_5(8.10)$	$W_7(6.40)$	$W_{15}(7.08)$	$W_x(7.30)$	$W_5(6.29)$	$W_{15}(5.92)$	$W_z(7.10)$ $W_5$
4 th.	$W_3(7.00)$	$W_3(7.4)$	$W_y(8.00)$	$W_3(6.29)$	$W_1(6.50)$ $W_{14}$	$W_{17}(6.90)$	$W_4(6.12)$	$W_9(5.92)$	$W_{18}(6.80)$

$$W_x = W_5 + W_{17} (1 : 1), \quad W_y = W_{18} + W_7 (3 : 2), \quad W_z = W_{18} + W_8 + W_5 (4:2:3), \quad \text{av. score in ( )}$$

Table 4. The 4 top score red wines fermented in different seasons.

Rank	color			aroma			taste		
	Summer	Rainy	Winter	Summer	Rainy	Winter	Summer	Rainy	Winter
1 st.	$R_1(8.22)$	$R_6(8.27)$	$R_2(8.89)$	$R_6(7.61)$	$R_2(6.68)$	$R_{17}(8.40)$	$R_2(7.39)$	$R_{13}(6.55)$	$R_4(7.75)$
2 nd.	$R_6(8.17)$	$R_{13}(8.09)$	$R_2(8.61)$	$R_1(7.22)$	$R_3(6.36)$	$R_z(7.80)$ $R_6$	$R_6(6.89)$	$R_3(6.18)$	$R_y(7.53)$
3 rd.	$R_2(7.44)$	$R_2(6.95)$	$R_4(8.50)$	$R_2(6.56)$	$R_{13}(6.32)$	$R_4(7.60)$	$R_1(6.67)$	$R_2(6.05)$	$R_{17}(7.28)$
4 th.	$R_4(7.44)$	$R_3(6.18)$	$R_y(8.33)$	$R_4(6.17)$	$R_6(6.27)$	$R_{16}(7.58)$	$R_4(6.56)$	$R_1(6.00)$	$R_z(7.22)$

$$R_x = R_{15} + R_{16} + R_{17} (3:1:1), \quad R_y = R_{18} + R_2 + R_4 (2:1:1), \quad R_z = R_{13} + R_{21} + R_9 + R_{11} (1:1:1:1), \quad \text{av. score in ( )}.$$

Table 5. Ratio of the blended wines with code numbers

Code	Blended white wines
WB <sub>1</sub>	Vermentino + Shimo + Italia (1:1:1)
WB <sub>2</sub>	Italia
WB <sub>3</sub>	Trebbiano di Soave + Early Muscat (1:1)
WB <sub>4</sub>	Trebbiano di Soave + Early Muscat + Cortese (1:1:1)
WB <sub>5</sub>	Riesling Italico + Benizuihou (1:1)
WB <sub>6</sub>	Italia + 316 (1:1)
WB <sub>7</sub>	Italia + 316 + Shimo (2:1:2)
Code	Blended red wines
RB <sub>1</sub>	PP
RB <sub>2</sub>	Barbera + Alicante + Nebbiolo + PP (1:1:1:7)
RB <sub>3</sub>	Black Muscat + Aglionico + Seibel + Barbera (1:2:1:2)
RB <sub>4</sub>	PP + Lambrusco + Portugieser + Barbera (1:1:1:1)
RB <sub>5</sub>	Seibel + Lambrusco + Black Muscat (1:1:1)
RB <sub>6</sub>	Hirohamberg + Nebbiolo + Rubired (1:1:1)
RB <sub>7</sub>	Muscat Hamberg + PP (1:1)

Table 6. Analysis of some major chemical composition of the blended wines

Code	color	pH	% TA (Tart.)	% VA (Acet)	% Alc by vol.	% RS	Remarks
WB <sub>1</sub>	0.194	3.1	0.645	0.017	10.68	0.125	color $\lambda$ for WB = 420 nm RB = 520 nm
WB <sub>2</sub>	0.156	3.4	1.070	0.042	11.76	0	
WB <sub>3</sub>	0.249	3.5	0.600	0.015	11.44	0.750	
WB <sub>4</sub>	0.228	3.3	0.607	0.700	12.11	0.250	
WB <sub>5</sub>	0.141	3.5	0.600	0.044	12.25	0	
WB <sub>6</sub>	0.077	3.3	0.592	0.048	11.42	0.50	
WB <sub>7</sub>	0.098	3.9	0.600	0.038	11.71	2.00	
RB <sub>1</sub>	3.080	3.3	0.585	0.067	11.71	0.250	
RB <sub>2</sub>	3.072	3.5	0.787	0.059	11.42	0.125	
RB <sub>3</sub>	2.780	3.5	0.615	0.032	10.88	0.250	
RB <sub>4</sub>	3.170	3.3	0.750	0.039	12.69	0.125	
RB <sub>5</sub>	3.062	3.8	0.607	0.046	12.25	2.250	
RB <sub>6</sub>	1.038	3.9	0.562	0.067	11.32	0.250	
RB <sub>7</sub>	2.852	3.5	0.602	0.052	11.76	0.125	

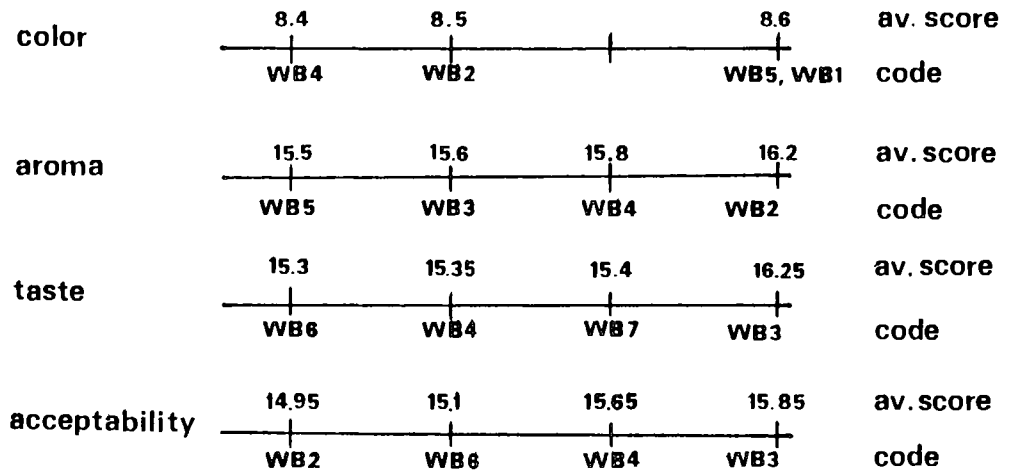


Fig.1 The 4 top rank scores of the blended white wines

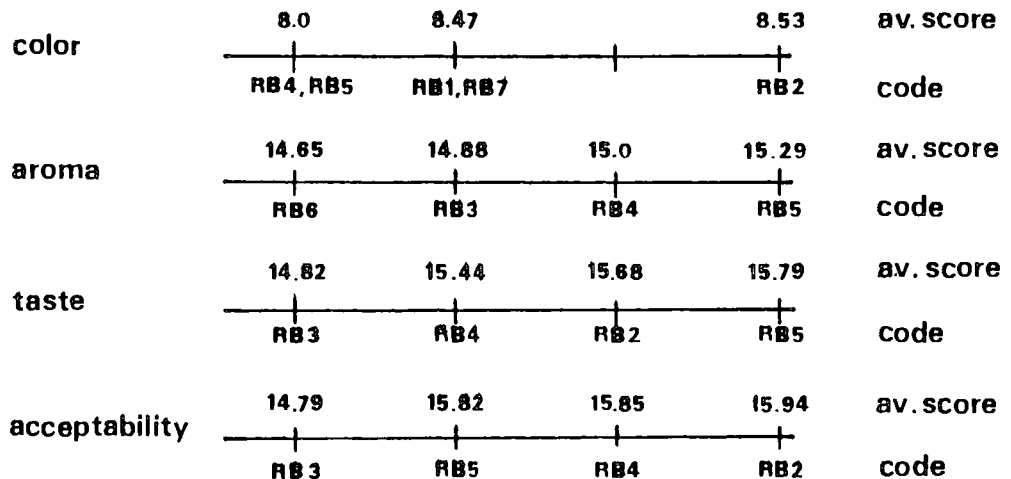


Fig.2 The 4 top rank scores of the blended red wines

Table 7. Analysis of variance from sensory evaluated scores of the blended white wines

category	source	SS	df	ms	F	F <sub>0.05</sub>
color	total	82.7	69			
	sample	14.85	6	2.475	2.298	2.20
	error	67.85	63	1.077		
aroma	total	457.86	69			
	sample	24.59	6	4.098	0.596	2.20
	error	433.27	63	6.877		
taste	total	373.861	69			
	sample	25.886	6	4.313	0.781	2.20
	error	347.975	63	5.523		
accept	total	378.960	69			
	sample	18.836	6	3.139	0.549	2.20
	error	360.124	63	5.716		

Table 8. Analysis of variance from sensory evaluated scores of the blended red wines

category	source	SS	df	ms	F	F <sub>0.05</sub>
color	total	127.983	118			
	sample	18.924	6	3.154	3.238	2.180
	error	109.059	112	0.974		
aroma	total	615.424	118			
	sample	10.306	6	1.718	0.318	2.180
	error	605.118	112	5.403		
taste	total	587.731	118			
	sample	62.260	6	10.377	2.212	2.180
	error	525.471	112	4.692		
accept	total	474.242	118			
	sample	72.139	6	12.023	3.349	2.180
	error	402.103	112	3.590		

## Conclusion

Quality of the musts and wines produced from new grape varieties planted on Kampangsan Campus, Kasetsart University depended on their varieties and harvesting seasons. It is possible to harvest grapes 2 or 3 seasons in Thailand but rainy season is probably the worst. Amelioration of the musts was certainly necessary. Quality of the wines was much improved by blending. Trebbiano and Chenin blanc were good productive varieties but neutral in taste and aroma. They should be used as basis white wines and be blended with good aroma wines from Italia, Early Muscut and Shimo-sara-Jensu. For good quality red wines, Portugieser and Seibel should be used to produce basis wines and be blended with good color of PP, with good aroma of Black Muscat, Barbera, Rubired or Lambrusco. At present, special consideration should be paid to some table grapes such as Italia, Early Muscat and Black Muscat which can be used to produce standard wines. Farmers and new growers will not hesitate to supply these table grapes to contracted wineries and normal markets. Some of special wine grapes should be cultivated by winery's proprietor for his blending purpose.

## Acknowledgement

We would like to express our sincere thanks to Kasetsart University for 3 year research grants from 1986 to 1988. Special thanks are also given to the Institute of Food Research and Product Development for laboratory and equipment facilities. Lot of appreciation will be passed to Miss Noi Sarikaputi and Miss Vipa Kamda for their help in preparation of the musts.

## References

- Amerine, M.A., Berg, H.W. and Cruess, W.V. 1972. The Technology of Wine Making. 3rd Ed., Connecticut, The AVI Publishing Co. Inc., Westport. 802 pages.
- Amerine, M.A. and Ough, C.S. 1974. Wine and Must Analysis. John Wiley & Sons. New York. 121 pages.
- Amerine, M.A. and Singleton, V.L. 1972. Wine : An Introduction for American. Univ. of Calif. Press, Berkeley, Calif. 357 pages.
- Chaitiemwong, S. 1973. Selection of Yeasts for Wine Making in Thailand. Thesis, M.S in Microbiology. Kasetsart Univ.
- Ingram, M. 1958. Yeasts in food spoilage. In Cook, A.H. (Ed.), The Chem. and Biol. of Yeasts. Acad. Press Inc. N.Y., page 603-633.
- Karuwanna, P. 1976. Wine Fermentation with Mixed Yeast Cultures. Thesis, M.S in Food Sc., Univ. of Calif., Davis. 75 pages.
- Karuwanna, P., Fuengfoopong, P., Wongkhalaung, C. and Wattana, P. 1978. Selection of Yeasts for Wine Making. Food. IFRPD, Kasetsart Univ. 10 (3) 187-198.
- Lund, A. 1954. Studies on the ecology of yeasts. Munksgard, Copenhagen. 133 pages.
- Lund, A. 1958. Ecology of Yeasts. In Cook, A.H. (Ed.), The Chem. and Biol. of Yeasts. Acad. Press Inc., N.Y., page 63-91.

Mrak, E.M. and Phaff, H.J. 1948. Yeast. Ann. Rev. Microbiol.  
2 : 1 - 46.

Pastèur, L. 1876. Etudes sur la biere. Paris.

Pasteur, L. 1878. Examen critique d'um ecrit posthume de Claude  
Bernard sur la fermentation alcoolique. C.R. Acad. Sci.  
87 : 813

Van Kerken, A.E. 1963. Contribution to the ecology of yeasts  
occurring in wine. Doctor of Science Degree Thesis. Univ. of  
the Orange Free State, Pretoria, South Africa.

Wattana, P. 1976. Pectic Enzyme : Production from Aspergillus  
niger and Use in Wine Making. Thesis, M.S in Food Sc.,  
Kasetsart Univ. 92 pages.