INFLUENCE OF GRAPE BERRY MATURITY AND PRESSING CYCLE ON CHAMPAGNE BASE WINE COMPOSITION

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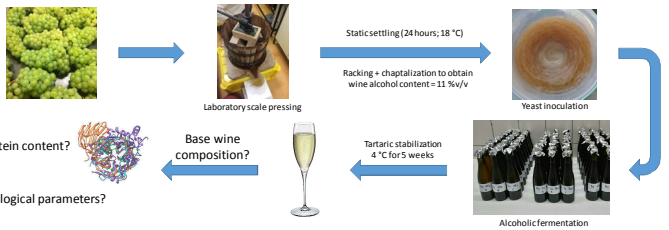
Introduction

The date of harvest is an important decision in the production of sparkling base wines, especially in cool climate regions. This is because the development of *Botrytis* is often a real danger and sometimes it is necessary to pick the bunches with a relatively low maturity level to avoid the deleterious effects of grey mold. In the Champagne region, grapegrowers produce grape berries able to give a sparkling wine with a foam, in which proteins are especially implicated, appreciated by the consumers. In such conditions, many oenological parameters change. But we have little information concerning the impact of **grape berry maturity degree (MD)** on base wine protein content [1]. Besides, pressing fractioning is a crucial winemaking step in order to separate different grape juice qualities [2]. In this study, two grape varieties (Chardonnay and Pinot meunier) were harvested at 3 different maturity stages (13 < MD < 25, vintage 2015). For each pressing cycle, grape juices were separated into 5 squeezes (from S1 to S5). **The aim of this study is to determine the relationships between musts/wines characteristics and MD along with the pressing cycle**.

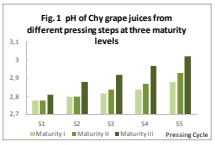


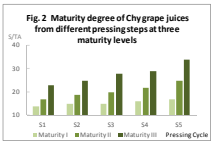
Chardonnay Juices

Throughout the pressing cycle, the pH and grape berry MD increased respectively by 7% and 48% at the Maturity III (Figs. 1 and 2). Concerning MD, it is because the total acidity of Chardonnay (Chy) grape juices decreased and the sugar content varies slightly along with the pressing cycle from S1 to S5. The two main acids of grape juices, malic and tartaric acid, showed a decreased tendency between S1 and S5 (Table 1).

Table 1. Current analysis of Chardonnay grape juices from different pressing steps at three maturity levels

Maturity of grapes	Pressing step	pH	Total Acidity (TA, g/L H_2SO_4)	Malic acid (MA, g/L)	Tartaric acid (TartA, g/L)	Sugars (g/L)	Total potential alcohol content (TAP, %v/v)	Yeast assimilable nitrogen (YAN, mg/L)	ammonium nitrogen (NH_4^+, mg/L)	alpha amino nitrogen (-NH_2, mg/L)	K^+ (mg/L)	Ca^{++} (mg/L)	Maturity degree (MD, S/TA)
I	S1	2.78	9.9	8.3	8.2	134.5	7.99	139	53	86	868	126	14
	S2	2.8	9.3	7.7	8.1	135	8.02	134	53	81	854	124	15
	S3	2.82	8.6	7.1	8	132.2	7.85	121	50	71	841	121	15
	S4	2.84	8.3	6.8	7.8	130.6	7.76	121	51	70	842	124	16
	S5	2.88	7.6	6.2	7.7	127	7.55	117	51	66	927	129	17
II	S1	2.78	9.3	7	8.6	157.8	9.38	79	24	55	838	108	17
	S2	2.8	8.4	6.7	8.1	157.3	9.35	93	29	65	879	94	19
	S3	2.84	7.9	6	7.6	158.1	9.39	95	33	62	911	95	20
	S4	2.87	7.1	5.3	7.4	159.1	9.45	101	36	64	864	101	22
	S5	2.93	6.3	4.7	7	159.4	9.47	101	37	63	853	105	25
III	S1	2.81	7.4	5.2	8.6	167.8	9.97	177	71	106	891	89	23
	S2	2.88	6.9	5	8.4	170.6	10.14	185	69	116	932	86	25
	S3	2.92	6.3	4.4	7.7	175.3	10.41	176	64	113	796	84	28
	S4	2.97	5.8	4.2	7.9	169.9	10.09	169	66	103	880	91	29
	S5	3.02	5.1	3.8	7.5	172.2	10.23	169	59	110	897	102	34



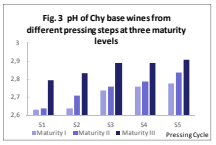


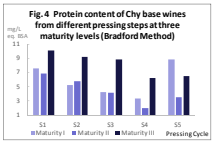
Chardonnay wines

From S1 to S5, the pH value of Chardonnay base wines increased while the total acidity, tartaric and malic acid contents dropped. The wine protein content estimated by SDS-PAGE method decreased respectively by 69%, 77% and 34% between S1 and S5 at three maturity stages. While with Bradford method, the decrease in wine protein concentration between S1 and S4 reached respectively 56%, 70% and 38% at three maturity stages (Table 2). The protein content of Champagne base wines produced from different press fractions exhibit quantitative differences [3].

Table 2. Current and proteic analysis of Chy base wines from different pressing steps at three maturity levels

Maturity of grapes	Pressing step	pH	TA (g/L H_2SO_4)	MA (g/L)	TartA (g/L)	K^+ (mg/L)	Ca^{++} (mg/L)	-NH_2 (mg/L)	Protein content (Bradford, mg/Leq. BSA)	Protein content (SDS-PAGE, %S1 III)
I	S1	2.635	9.5	6.45	5.75	427	99	12	7.62	52%
	S2	2.64	9	6.1	5.4	402	98.5	11	5.29	54%
	S3	2.74	8.3	5.6	5.4	400	105	10	4.26	54%
	S4	2.76	7.9	5.2	5.1	423	113	10	3.38	20%
	S5	2.78	7.7	4.6	5.2	527	113	9	8.89	16%
II	S1	2.64	8.9	5.75	4.85	457.5	81	12	6.93	65%
	S2	2.71	8.4	5.45	4.95	481.5	79.5	12	5.79	64%
	S3	2.76	7.6	5	4.8	456	80	12	4.21	62%
	S4	2.79	7	4.3	4.7	382	87	10	2.07	23%
	S5	2.84	6.2	3.7	4.2	386	94	10	3.54	15%
III	S1	2.795	7.5	4.3	6.05	523.5	82	16	10.14	100%
	S2	2.835	7.15	4.1	5.55	539.5	76.5	15.5	9.21	93%
	S3	2.89	6.9	3.8	4.6	536	68	14	8.90	82%
	S4	2.89	6.1	3.4	4.6	508	77	12	6.26	74%
	S5	2.91	5.7	3	3.5	478	90	11	6.56	66%



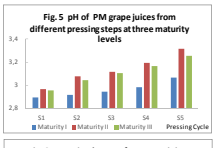


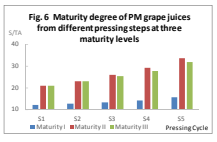
Pinot meunier Juices

Similar changes in current parameters of Pinot meunier (PM) and Chardonnay grape juices throughout the pressing cycle are consistent with latest researches [2, 4]. But unlike Chardonnay, there is no significant difference in PM pH value or MD between the last two maturity stages (Figs. 5 and 6). This is due to *Botrytis* development that occurred at the third maturity level. With the selection of healthy grapes, the fruit maturity degree has been thus reduced.

Table 3. Current analysis of Pinot meunier grape juices from different pressing steps at three maturity levels

Maturity of grapes	Pressing step	pH	TA (g/L H_2SO_4)	MA (g/L)	TartA (g/L)	Sugars (g/L)	TAP (%v/v)	YAN (mg/L)	NH_4^+ (mg/L)	-NH_2 (mg/L)	K^+ (mg/L)	Ca^{++} (mg/L)	MD (S/TA)
I	S1	2.9	10.8	10.2	8.2	133.2	7.91	303	148	155	1162	73	12
	S2	2.92	10.4	9.7	8	133.5	7.93	252	119	132	1381	86	13
	S3	2.95	9.7	9.1	8.2	130.4	7.75	251	122	130	1351	77	13
	S4	2.99	8.8	8	7.9	127.8	7.59	235	113	122	1377	80	15
	S5	3.07	7.9	7.2	8	125.7	7.47	242	112	130	1380	84	16
II	S1	2.97	7.9	7	7	167.1	9.93	302	142	160	1179	45	21
	S2	3.08	7.4	6.7	7.1	171.9	10.21	291	124	167	1517	51	23
	S3	3.12	6.5	6.3	6	168.9	10.04	302	124	178	1102	52	26
	S4	3.2	5.6	5.9	5	164.7	9.79	288	114	174	1351	59	29
	S5	3.32	4.9	5.5	4.6	165	9.80	290	108	182	1351	63	34
III	S1	2.96	8.6	7.2	9.4	182.9	10.87	333	156	177	1262	61	21
	S2	3.05	7.8	6.8	8.9	180.1	10.7	331	143	188	1464	67	23
	S3	3.11	7.1	6	8.7	180.4	10.72	320	137	183	1228	62	25
	S4	3.17	6.4	5.5	7.8	177.6	10.55	331	134	197	1584	60	28
	S5	3.26	5.6	5	7.8	178.3	10.6	318	120	198	1428	67	32



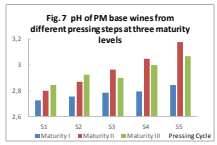


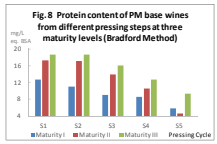
Pinot meunier wines

The protein content of Pinot meunier base wines (from S1 to S4) increased when the grapes getting mature (Fig. 8). Even though there is no important difference in Pinot meunier grape berry MD between the second and the third grape maturity stage. Apart from sugar accumulation and acid metabolism, proteins synthesis also occurs in some other biochemical and metabolic pathways, such as biosynthesis of phenolic and aromatic compounds [5]. In addition, the base wine protein content and composition could be a key role in the foaming characteristics of Champagne wines.

Table 4. Current and proteic analysis of PM base wines from different pressing steps at three maturity levels

Maturity of grapes	Pressing step	pH	TA (g/L H_2SO_4)	MA (g/L)	TartA (g/L)	K^+ (mg/L)	Ca^{++} (mg/L)	-NH_2 (mg/L)	Protein content (Bradford, mg/Leq. BSA)	Protein content (SDS-PAGE, %S1 III)
I	S1	2.73	9.75	7	5.45	564	52.5	21.5	12,74	88%
	S2	2.76	9.1	6.65	5.4	542	60	17.5	11,07	79%
	S3	2.79	8.5	5.95	5.1	589	57.5	16	9,15	72%
	S4	2.8	8	5.9	4.7	553	61	15	8,63	59%
	S5	2.85	6.6	4.8	3.8	473	66	15	5,87	48%
II	S1	2.805	7.6	5.85	4.35	483.5	40.5	20.5	17,36	78%
	S2	2.875	6.85	5.6	3.6	569	45	23	17,21	74%
	S3	2.965	6.45	5.4	3.45	558	46	18.5	13,99	55%
	S4	3.05	5.5	5.2	2.4	509	51	21	10,63	54%
	S5	3.18	4.8	4.6	2.3	545	58	22	4,64	33%
III	S1	2.85	7.9	5.85	5.25	602.5	45.5	47.5	18,75	100%
	S2	2.925	6.75	5.25	4.5	584.5	52.5	41.5	18,77	78%
	S3	2.905	6.05	4.75	3.65	544.5	50	25.5	16,13	65%
	S4	3	5.2	4.5	2.9	517	50	26	12,78	61%
	S5	3.07	4.6	4	2.3	626	54	20	9,42	52%





Correlation coefficients

These measures gave 420 Pearson's correlation coefficients *($p < 0.05$)*, and **276** of them being statistically interesting: **86** *($r > 0.95$)*, **76** *($0.95 > r > 0.8$)*, **65** *($r < -0.95$)* and **49** *($-0.95 < r < -0.8$)*. As expected, results showed very high *r* values between parameters related to the acidity (pH, tartaric and malic acid contents, total acidity). Strong correlations are also observed between grape berry maturity degree and most of current oenological analysis. Interestingly, correlation coefficients between wine protein content, grape berry maturity degree and pretty all of the analyzed grape juice parameters showed high *r* values, excepted for NH_4^+ and Ca^{++}.

Table 5. Correlation coefficients 'r' of Pearson test ($p<0,05$) between current and proteic parameters of Chardonnay and Pinot meunier grape juices and base wines from squeeze 2 at three maturity levels

Chardonnay Squeeze 2 / Pinot meunier Squeeze 2		Grape juices												Base wines								
		pH	sugars	TA	MD	TAP	MA	TartA	K^+	Ca^{++}	YAN	NH_4^+	-NH_2	pH	TA	MA	TartA	K^+	Ca^{++}	-NH_2	prot content (Bradford)	prot content (SDS-PAGE)
Grape juices	pH	1																				
	sugars (g/L)	0,785 0,942	1																			
	Total acidity (g/L H_2SO_4)	-0,929 -0,999	-0,959 -0,959	1																		
	maturity degree (MD)	0,918 0,984	0,966 0,986	-1,000 -0,992	1																	
	TAP %v/v	0,756 0,941	0,999 1,000	-0,945 -0,958	0,954 0,986	1																
	Malic acid (g/L)	-0,931 -0,989	-0,957 -0,981	1,000 0,996	-0,999 -1,000	-0,943 -0,981	1															
	Tartaric acid (g/L)	1,000 -0,176	0,785 0,165	-0,929 0,123	0,918 0,000	0,756 0,167	-0,931 0,029	1														
	K^+ (mg/L)	0,949 0,976	0,940 0,846	-0,998 -0,963	0,996 0,922	0,923 0,845	-0,998 -0,933	0,949 -0,387	1													
	Ca^{++} (mg/L)	-0,663 -0,956	-0,984 -0,802	0,893 0,939	-0,906 -0,890	-0,991 -0,801	0,891 0,903	-0,663 0,457	-0,864 -0,997	1												
	YAN (mg/L)	0,896 0,760	0,427 0,934	-0,667 -0,794	0,645 0,862	0,386 0,935	-0,670 -0,847	0,896 0,506	0,711 0,600	-0,261 -0,536	1											
	NH_4^+ (mg/L)	0,803 0,518	0,261 0,776	-0,524 -0,564	0,500 0,661	0,217 0,777	-0,529 -0,639	0,803 0,750	0,575 0,320	-0,086 -0,246	0,984 0,950	1										
	-NH_2 (mg/L)	0,952 0,849	0,557 0,977	-0,770 -0,876	0,752 0,929	0,519 0,978	-0,773 -0,917	0,952 0,371	0,807 0,713	-0,401 -0,657	0,989 0,989	0,947 0,892	1									
Base wines	pH	0,935 0,893	0,953 0,992	-1,000 -0,916	0,999 0,958	0,939 0,993	-1,000 -0,949	0,935 0,286	0,999 0,773	-0,885 -0,722	0,680 0,971	0,540 0,848	0,781 0,996	1								
	Total acidity (g/L H_2SO_4)	-0,948 -0,977	-0,941 -0,992	0,998 0,987	-0,996 -0,999	-0,925 -0,992	0,999 0,998	-0,948 -0,038	-1,000 -0,907	0,866 0,871	-0,708 -0,881	-0,572 -0,690	-0,805 -0,942	-0,999 -0,968	1							
	Malic acid (g/L)	-0,948 -0,928	-0,941 -0,999	0,998 0,947	-0,996 -0,979	-0,925 -0,999	0,999 0,973	-0,948 -0,203	-1,000 -0,824	0,867 0,778	-0,707 -0,947	-0,573 -0,800	-0,805 -0,985	-0,999 -0,996	1,000 0,986	1						
	Tartaric acid (g/L)	0,693 -0,941	0,097 -0,772	-0,376 0,921	0,350 -0,866	0,052 -0,770	-0,381 0,880	0,693 0,500	0,432 -0,992	0,080 0,999	0,942 -0,494	0,986 -0,197	0,881 -0,619	0,393 -0,687	-0,428 0,846	-0,428 0,746	1					
	K^+ (mg/L)	0,818 0,850	0,998 0,978	-0,973 -0,878	0,979 0,930	0,995 0,978	-0,972 -0,919	0,818 0,368	0,957 0,715	-0,973 -0,659	0,476 0,988	0,313 0,891	0,602 1,000	0,969 0,996	-0,958 -0,943	-0,958 -0,985	0,152 -0,621	1				
	Ca^{++} (mg/L)	-0,605 -0,927	-0,968 -0,747	0,857 0,905	-0,872 -0,846	-0,979 -0,745	0,855 0,861	-0,605 0,533	-0,824 -0,986	0,997 0,996	-0,188 -0,460	-0,011 -0,160	-0,332 -0,588	-0,848 -0,658	0,827 0,825	0,827 0,720	0,154 0,999	-0,951 -0,591	1			
	-NH_2 (mg/L)	0,977 0,518	0,898 0,776	-0,986 -0,564	0,981 0,661	0,877 0,777	-0,987 -0,639	0,977 0,750	0,994 0,320	-0,806 -0,246	0,781 0,950	0,659 1,000	0,865 0,892	0,989 0,848	-0,994 -0,690	-0,994 -0,800	0,525 0,197	0,921 0,891	-0,760 -0,160	1		
	protein content (mg/L eq. BSA) by Bradford	0,993 0,930	0,852 0,999	-0,966 -0,949	0,958 0,980	0,827 1,000	-0,967 -0,974	0,993 0,197	0,980 0,828	-0,746 -0,782	0,837 0,945	0,728 0,796	0,909 0,983	0,970 0,996	-0,979 -0,987	-0,979 -1,000	0,604 -0,751	0,879 0,984	-0,694 -0,725	0,995 0,796	1	
	protein content (mg/Leq. MT50kDa) by SDS-PAGE	0,988 0,893	0,870 0,992	-0,974 -0,916	0,967 0,958	0,847 0,993	-0,975 -0,949	0,988 0,286	0,986 0,773	-0,769 -0,722	0,818 0,971	0,703 0,848	0,894 0,996	0,978 1,000	-0,985 -0,968	-0,985 -0,996	0,576 -0,687	0,896 0,996	-0,719 -0,658	0,998 0,848	0,999 0,996	1

Table 6. Numbers of correlation coefficients

r	Chy	PM	Chy and PM
r > 0,95 significant positive correlation	43	43	21
0,95 > r > 0,8 high positive correlation	40	36	14
-0,95 < r < -0,8 high negative correlation	24	25	4
r < -0,95 significant negative correlation	36	29	15
Green *(r > 0.8)*			56
Red *(r < - 0.8)*			44

Conclusions

Evident decreasing or increasing trends throughout the pressing cycle and **grape berry maturity** could be observed for some oenological parameters of Chardonnay and Pinot meunier grape juices and wines, such as pH, total acidity, malic and tartaric acid.

The **correlation analysis** in this study was the first to give a better understanding in relationships between oenological parameters such as pH, total acidity, malic and tartaric acid, sugars, maturity degree, TAP, YAN, NH_4^+, -NH_2, Ca^{++} and K^+ for grape juices and pH, total acidity, malic and tartaric acid, Ca^{++}, K^+, -NH_2, total protein content (Bradford and SDS-PAGE quantifications) for base wines.

In general, the **wine protein content** decreased from S1 to S5 and increased when the grapes getting mature. Because of the strong implication of proteins in wine foaming properties, these really new results in a cool climate region could indicate that low grape berry maturity would give base wines with reduced foam when compared with the wines produced with riper fruits. This hypothesis is currently studied with the base wines produced in 2016.

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