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FOLIAR APPLICATION OF SPECIFIC INACTIVATED YEAST WITH ACTION ON PHENOLIC AND AROMATIC METABOLISM OF GRAPES

APPLICATION FOLIAIRE DE LEVURES INACTIVEES SPECIFIQUES AVEC ACTION SUR LE METABOLISME AROMATIQUE ET PHENOLOGIQUE DES RAISINS

APPLICAZIONE FOGLIARE DI SPECIFICI LIEVITI INATTIVATI CON AZIONE SUL METABOLISMO AROMATICO E FENOLICO DELLE UVE

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Abstract. In order to obtain high quality wines, it is necessary to have proper aromatic and polyphenolic ripening. With this goal, two foliar spray treatments (previously approved and registered) with the patent pending application technology of Lallemand Inc. Canada have been tested in the vineyard during a four-year period (2013-2016). LalVigne™ Mature was tested on Merlot grape variety whereas LalVigne™ Aroma was tested on Glera grape variety. The application of the specific inactivated yeast for both of the products includes two foliar treatments; the first spray has to be done at the beginning of the veraison and the second spray approximately ten days after the first.

During the four-year program, the impact of the treatments was evaluated on aromatic precursor content of Glera and total and extractable polyphenols on Merlot. Finally, wines were produced from the treated grapes in order to fully understand the organoleptic properties of the treatments. In years 2015 and 2016 the results of the LalVigne™ Mature treatment on Merlot wine variety have been compared with a thinned thesis.

There was no treatment effect on the pH, total acidity and sugars content in all the considered vintages. Regarding the LalVigne™ Mature treatment on Merlot, we observed a general increase of the flavonoids content as well as for the total and extractable anthocyanins. Similarly, the analysis of the content in glycosylated aromatic precursors on Glera variety, when treated with LalVigne™ Aroma, showed an increase in terpene compounds. These compounds are typical of the Glera variety. Furthermore, we observed an increase in benzenoids and norisoprenoids compounds.

For wines sensory analyses of both varieties, we confirmed the results of the chemical analyses, evidenced by a higher intensity of the treated wines' aroma (floral note in treated Glera and ripe fruit in treated Merlot). We also observed a decrease in vegetal character, an overall better balance, and a reduction in bitterness.

The comparison between the results of treated Merlot's variety and the thinned thesis showed the same content in polyphenolic compounds. However, this effect has been obtained in thinned thesis because of a 30% lower production level. As a consequence, the level of sugar content strongly increased whereas the total acidity decreased and the pH was raised. All those characteristics have led to a final outcome that was determined to be out of equilibrium. The experiment confirmed the efficacy of the use of the products tested in the vineyard during various vintages, with different whether condition.

The tested products can be considered a useful tool capable of acting on the secondary metabolism of the plant, improving the aromatic profile (LalVigne™ Aroma) and improving the polyphenolic profile (LalVigne™ Mature).

Moreover, the products worked without altering the peculiar features of the varieties and without any impact on sugar content, degradation of acids and pH.

Résumé. Obtenir des raisins dotés d'une bonne maturité aromatique et polyphénolique est nécessaire à l'obtention de vins de qualité. Pour atteindre cet objectif, deux produits commerciaux, déjà enregistrés et autorisés et avec la technologie d'application en instance de brevet de Lallemand Inc. Canada, ont été testés sur des vignobles pendant quatre ans, de 2013 à 2016. Il s'agit de LaIVigne™ Mature sur Merlot et LaIVigne™ Aroma sur Glera. L'application de ces produits prévoit deux traitements foliaires : le premier au début de la véraison et le deuxième dix jours après. Les quatre ans d'expérimentation ont permis d'évaluer l'impact des traitements sur la teneur en précurseurs aromatiques sur Glera et sur la teneur en polyphénols totaux et en polyphénols extractibles sur Merlot. Les vins issus de ces raisins ont ensuite été élaborés dans le but d'établir un bilan organoleptique complet sur le produit fini.En 2015 et 2016 les résultats du traitement avec LaIVigne™ Mature sur Merlot ont été aussi confrontés à un essai des vendanges en vert (éclaircissage des grappes).
Aucun des deux produits n'a eu un impact significatif sur les teneurs en sucres, en acides et sur le pH. En revanche, le Merlot traité avec LaIVigne™ Aroma a enregistré une augmentation des flavonoïdes totaux et des anthocyanes totaux et extractibles. L'analyse des précurseurs aromatiques glycosylés sur les raisins Glera traités avec LaIVigne™ Aroma a montré une teneur plus importante en composés terpéniques, typiques de la variété Glera, ainsi qu'en certains composés benzenoïdes et norisoprenoïdes. Pour les deux variétés, les analyses sensorielles ont confirmé les résultats analytiques. Les vins produits avec les raisins traités avec les produits LalVigne™ avaient une plus grande intensité olfactive avec des notes plus marquées de fruits mûrs (pour le Merlot) et florales (pour la Glera), des notes végétales moins intenses, une plus grande harmonie et une amertume moindre.
Le Merlot, confronté avec l'essai éclairci, a mis en évidence un niveau égal de composés polyphénoliques, mais dans l'essai éclairci, cet effet a été obtenu grâce à une baisse de la production de 30 % environ, ce qui a entrainé une augmentation de la teneur en sucres, une baisse de l'acidité totale et une hausse du pH, avec comme conséquence, l'obtention de grappe moins équilibrés.
L'expérimentation a confirmé l'efficacité des produits LalVigne™ testés sur des millésimes très différents. Ils peuvent ainsi être considérés comme des outils intéressants pouvant agir sur le métabolisme secondaire de la plante et capables d'améliorer le profil aromatique (dans le cas du produit LaIVigne™ Aroma) et le profil polyphénolique (dans le cas de LaIVigne™ Mature), sans dénaturer les caractéristiques variétales et sans influencer la teneur en sucres, la dégradation des acides et le pH des raisins.

Riassunto. Ottenere uve con una buona maturazione aromatica e polifenolica è un requisito indispensabile per avere vini di qualità. Con questo obbiettivo nel corso di quattro anni di sperimentazioni (2013-2016) sono stati testati in vigneto due diversi prodotti commerciali, già registrati ed autorizzati e con domanda di brevetto depositata da Lallemand Inc. Canada, LalVigne™ Mature su Merlot e LalVigne™ Aroma su Glera. L'applicazione del derivato di lievito per entrambi i prodotti prevede due trattamenti fogliari, il primo ad inizio invaiatura ed il secondo dieci giorni dopo. Nei quattro anni di sperimentazione si è valutato l'impatto dei trattamenti sul contenuto in precursori aromatici su Glera ed il contenuto in polifenoli totali ed estraibili su Merlot. Nelle annate 2015 e 2016 i risultati del trattamento con LalVigne™ Mature su Merlot sono stati confrontati anche con una tesi diradata. Infine dalle uve sono stati elaborati i vini allo scopo di cogliere appieno il risultato organolettico sul prodotto finito.
Per entrambi i prodotti in tutte le annate di studio non sono stati evidenziati effetti sul contenuto di zuccheri, acidi e sul pH. Per quanto riguarda il Merlot trattato con LalVigne™ Mature si è sempre registrato un incremento dei flavonoidi totali e degli antociani sia totali che estraibili. Analogamente l'analisi dei precursori aromatici glicosidati eseguita sulle uve Glera trattate con LalVigne™ Aroma ha fatto registrare un incremento dei composti terpenici, tipici della varietà Glera, e di alcuni composti benzenoidi e norisoprenoidi.
Per entrambe le varietà, quanto osservato dal punto di vista analitico è stato confermato dalle analisi sensoriali, che hanno evidenziato per i vini prodotti con le uve trattate una maggiore intensità olfattiva con note di frutta matura (per il Merlot) e floreali (per la Glera) più marcate, una diminuzione delle note vegetali a cui si è accompagnata una maggior armonia e minori sensazioni di amaro.
Nel Merlot, il confronto con la tesi diradata, ha evidenziato un pari livello di composti polifenolici, ma nella tesi diradata questo effetto si è ottenuto grazie ad un calo produttivo di circa il 30% a cui è conseguito un alto incremento del contenuto zuccherino, una diminuzione dell'acidità totale ed un innalzamento del pH. Questi effetti hanno portato ad uve alla vendemmia che nel loro complesso sono state valutate "meno equilibrate".
La sperimentazione ha confermato l'efficacia dell'utilizzo del prodotto testato in vigneto, effetto che è risultato essere consistente anche in annate molto diverse tra loro.
I due prodotti testati possono essere considerati un utile strumento in grado di agire sul metabolismo secondario dalla pianta, andando a migliorare il profilo aromatico nel caso del prodotto LalVigne™ Aroma ed il profilo polifenolico nel caso del LalVigne™ Mature senza snaturare le peculiari caratteristiche varietali e senza alcun impatto sull'accumulo zuccherino, sulla degradazione di acidi e sul pH delle uve.

1 Introduction

Achieving well-balanced grapes at harvest time is one of the main aims in agriculture and winemaking for producing quality wines. Considering climate change today, with increasing average, minimum and maximum temperatures, and more extreme rainfall events, achieving balance in grapes has become an endless challenge for the vigneron. It is now well established that high temperatures accompanied by long periods of water stress lead to a decline in grape quality, increasing risks of having to vinify a raw material with excessive sugar content (so more alcoholic wines) accompanied by low acidity. Moreover, numerous studies report that accumulation of sugar is no longer accompanied by an optimal polyphenolic and aromatic ripening of the grapes, so the actual gap between technological (sugar/acid ratio) and aromatic–phenolic maturity is widening constantly.

Table 1. Main climate change effects

Climate change effects on grape quality
Phenological phases ahead of time
Alteration of disease and pest cycles
Increased water deficit
Decrease in overall grape acidity (higher alcohol and lower acidity in wines)
Lower accumulation of anthocyanins and polyphenols
Less aromatic grapes with loss of varietal character
Burning and shrivelling of berries

In this respect (Table 1), winegrowers seek vineyard practices that will allow them to combat climate changes. Many agricultural practices, however, do not work selectively so are unable to reduce the offset between the two abovementioned maturations: stripping and thinning, for example, facilitate the accumulation of secondary metabolites but also cause excessive increase in sugar levels.

In the quest for new technical solutions to solve these problems CREA-VIT (the Conegliano Viticulture Research Centre) partnered with Lallemand in 2013 to assess the effect of treatment with specific fractions of inactive yeast on secondary plant metabolism Two different commercial products, tested in over four years of experimentation, have already been registered and authorized: LalVigne™ Mature for Merlot and LalVigne™ Aroma for Glera. The manufacturer reports that LalVigne™ Mature applied at veraison has the effect of increasing phenolic maturity and the body and softness of wines, while LalVigne™ Aroma, again applied at veraison, fosters accumulation of aromatic precursors, giving the wine enhanced varietal aromas and pleasurability on the palate.

The aim of the research was to assess the impact of the treatment on grape and wine quality parameters.

2 Materials and Methods

Two different commercial products – tested in over four years of trials (2013–16) – have already been registered and authorized: LalVigne™ Mature for Merlot and LalVigne™ Aroma for Glera. Both trials were carried out on commercial vineyards over ten years in age, using an experimental full-randomization pattern, with three repetitions per thesis.

Both products are 100% specific inactive yeasts (Saccharomyces cerevisiae) and differ in composition as the inactivated strain is not the same. The yeast derivative was applied followed the guidelines of the manufacturer, who recommended two foliar treatments per product, the first at veraison onset and a second ten days later. A prescribed amount of 1 kg/ha was calculated for each treatment with LalVigne™ Mature, while for LalVigne™ Aroma the amount was 6 kg/ha per treatment.

In 2015 and 2016, in addition to the comparison between treated and control theses, a further option was added for Merlot, with about 25% thinning, performed before veraison.

In the four years of study, specific sampling took place at harvest time, to assess the impact on the quality of the grapes. Yield per vine was assessed in four samples per repetition, while in three grape samples per repetition, sugar (° Brix using a refractometer), total acidity (g/l by titration), malic and tartaric acid (g/l by HPLC), and pH were measured.

, Total flavonoids and total and extractable anthocyanins [1,2] were measured in the Merlot.

For the Glera, glycosylated aromatic precursors were measured by GC/MS using the method suggested by [3,4].

Finally, the grapes were used to proceed with vinification, applying the same winemaking protocol to treated and control theses, so as to assess the sensory impact on the finished product. A panel of experts then tasted the wines and drew up a sensory profile.

3 Results and discussion

From a weather perspective, the four years being researched were very different. In particular, 2014 was a cold and rainy year, while 2015 was very hot and dry. The 2013 and 2016 seasons may be considered average years for this study.

3.1 Effect of the treatment on Merlot

Harvest data can be found in Table 2, where it is evident that in the years under observation no effects were seen on sugar content, acidity and pH.

In addition to these chemical macro parameters of the grape, the index of total flavonoids was drawn up, including the main classes of grape phenolic compounds like anthocyanins, flavanols and flavonols.
Anthocyanins are the substances that give red grapes their colour and their accumulation in the grape skins occurs from veraison onwards, which is when the grape ripening phase begins. The main grape flavanols are (+)-catechin, (-)-epicatechin and proanthocyanidins (dimers and oligomers). As they condense, these units generate tannins, which define the structure and astringency of wine [3]

Table 2. Comparison of analytical parameters for the Merlot grape treated with LalVigne Mature (LM), control sample (C), and thinned grapes (D).

	2013			2014			2015				2016			
	LM	C	Sig	LM	C	Sig	LM	C	D	Sig	LM	C	D	Sig
Production (kg/plant)	3.2	3.1	*ns*	3.8	3.9	*ns*	3.2^{a}	3.2a	2.6^{b}	**	4.1^{a}	4.1a	2.9^{b}	**
Sugar (° Brix)	22.6	22.1	*ns*	19.73	19.83	*ns*	21.23^{b}	21.30^{b}	23.20^{a}	**	22.70^{b}	22.80^{b}	23.70^{a}	*
pH	3.37	3.34	*ns*	3.13	3.14	*ns*	3.38^{b}	3.43^{b}	3.53^{a}	*	3.36^{b}	3.35^{b}	3.44^{a}	*
Acidity (g/L)	5.3	5.5	*ns*	8.32	8.52	*ns*	6.45^{a}	6.57^{a}	5.37^{b}	*	5.98^{a}	5.94^{a}	5.09^{b}	*
Tartaric acid	-	-		6.17	6.48	*ns*	5.72^{a}	5.70^{a}	6.21^{b}	*	7.26	7.34	6.81	*ns*
Malic acid	-	-		3.94	3.86	*ns*	2.10^{b}	2.05^{b}	1.33^{a}	**	1.94	1.87	1.74	*ns*
Flavonoids (mg/kg grapes)	1925^{a}	1762^{b}	**	763^{a}	721^{b}	*	1964^{a}	1731^{b}	1940^{a}	**	2223^{a}	1868^{b}	2195^{a}	**
Total anthocyanins (mg/kg grapes)	896^{a}	789^{b}	*	290	317	*ns*	639^{b}	530^{c}	747^{a}	*	801^{a}	674^{b}	870^{a}	**
Extractable anthocyanins (mg/kg grapes)	337^{a}	312^{b}	*	215	225	*ns*	284^{a}	236^{b}	317^{a}	*	394^{a}	313^{b}	416^{a}	*

*,**: statistically significant differences in test samples (T-test, respectively $p \leq 0,05$ e $p \leq 0,01$). n.s., difference not significant between the two samples

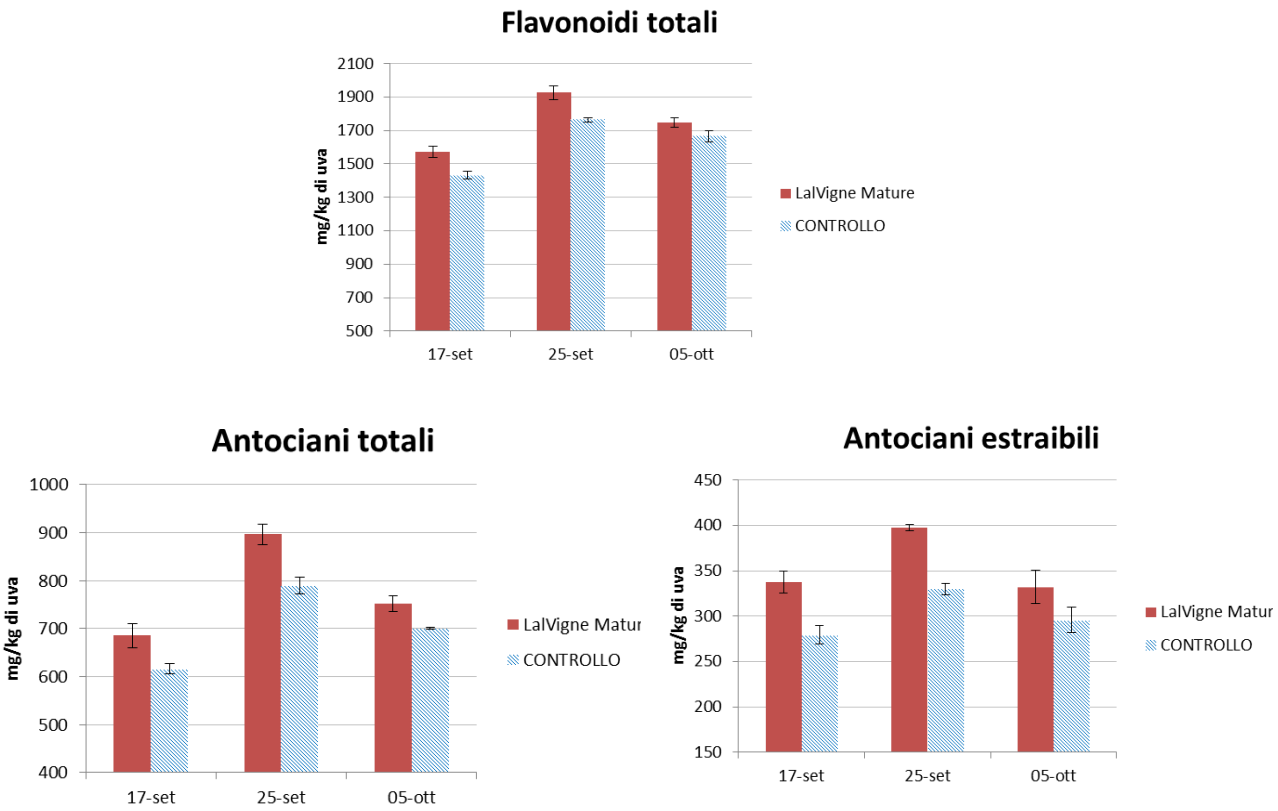
Grape harvest data in Table 2 show that despite weather differences during the years of study, there has been an increase in total flavonoids in response to treatment with yeast derivate. Moreover, there are also higher levels of extractable anthocyanins, namely the fraction that will be extracted during winemaking.

Data from this trial confirm what had previously been observed on other varieties, such as Syrah and Tempranillo, in several viticultural areas [5.6]. Treatment with this product is therefore shown to have an effect on secondary plant metabolism but not on primary metabolites.

To assess whether the effect seen was simply early accumulation of polyphenolic substances or whether there was an actual increase over time, in 2013 the Merlot grapes were harvested in three different periods. The winery harvest for the wine produced and later analysed and tasted was on 25 September. Figure 1 shows the polyphenolic indices compared with the data relative to a harvest brought forward by one week (17 September), and another postponed by one week (5 October). In all samples there is

a statistically significant increase in polyphenolic content, with a greater accumulation of flavonoids and anthocyanins in grapes treated compared to the control sample.

Figure 1. Comparison of content of total flavonoids, total anthocyanins and extractable anthocyanins in Merlot grapes treated with LalVigne Mature and in the control samples for the three harvest periods for the year 2013. Vertical bars indicate standard error of the three replications.



Antociani totali - total anthocyanins *Antociani estraibili – extractable anthocyanins*

flavonoidi totali – total flavonoids *controllo – control sample* *set – Sept.* *ott – Oct.*

From a sensory point of view, the wines derived from treated grapes were generally found to have broader profiles than the control sample (Figure 2). In particular, there was greater intensity on the nose, with more fruity notes and decreased vegetal nuances. This datum is in line with the results of other research, which reported higher degradation of methoxypyrazines following the treatment. From the flavour perspective, wines from treated grapes showed better structure and greater elegance, while bitter notes were less evident. At the same time, the astringent notes were not as evident, in the same way observed for Nebbiolo wines where, in addition to higher polyphenol content, the polyphenols were found to have a higher level of polymerization and softness [7].

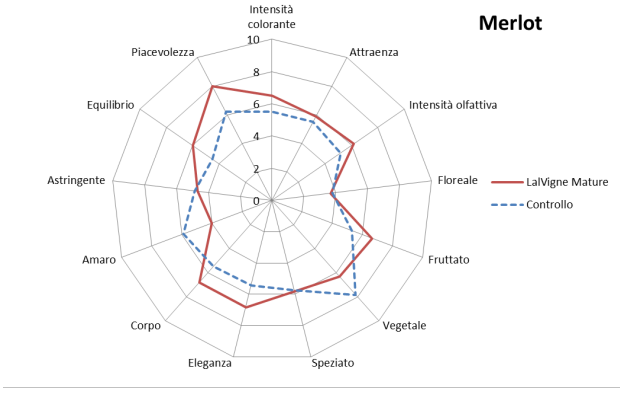


Figure 2. Comparison of the average sensorial profile of wines produced with grapes treated with LalVigne Mature and a control sample. The data are the average of the years studied (2013, 2014, 2015, and 2016).

Merlot
controllo - control
floreale - floral
fruttato - fruity
speziato - spicy

vegetale - vegetal
amaro - bitter
astringente - astringent
elegance - eleganza
corpo - body
equilibrio - balance
intensità colorante - colour intensity
piacevolezza - pleasurability
attraenza - attractiveness
intensità olfattiva - olfactory intensity

3.2. Comparison of treated and thinned Merlot grapes

In 2015 and 2016 the Merlot vines were thinned to be able to compare the efficacy of the application of LalVigne Mature. Data in Table 2 show that thinning generated levels of polyphenolic compounds similar to the thesis treated with yeast derivate, showing comparable flavonoid and total anthocyanin content. In the thinned thesis, however, this result was accompanied by some negative effects, including a decrease of 30% in yield, excessive increase of sugar content, decrease in total acidity and increased pH. The effects led to the grapes from this harvest being judged less "balanced" overall.

3.3. Effect of the treatment on Glera

In a similar way to what was observed for the previous product, treatment with LalVigne Aroma showed no significant effects on production and sugar content, acidity and pH (Table 3).

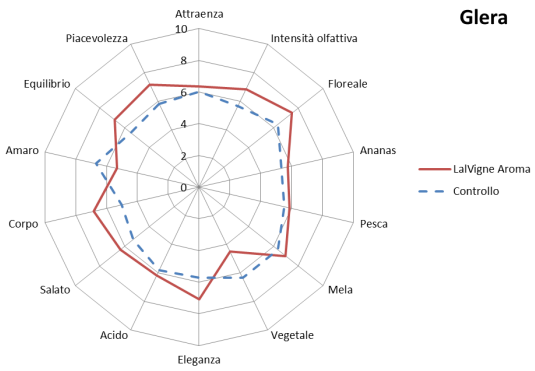
Table 3. Comparison of analytical parameters for the Glera grape treated with LalVigne Aroma (LA), control sample (C), and thinned grapes (D).

	2013			2014			2015			2016		
	LA	C	Sig	LA	C	Sig	LA	C	Sig	LA	C	Sig
Production (kg/plant)	7.1	7.2	*ns*	7.8	7.6	*ns*	6.9	6.9	*ns*	8.3	8.2	*ns*
Sugar (° Brix)	16.4	16.2	*ns*	13.7	13.5	*ns*	17.2	16.7	*ns*	16.3	15.9	*ns*
pH	3.20	3.20	*ns*	3.13	3.15	*ns*	3.18	3.16	*ns*	3.18	3.22	*ns*
Acidity (g/L)	7.5	7.7	*ns*	6.9	7.1	*ns*	6.8	6.4	*ns*	6.7	6.6	*ns*
Tartaric acid	6.5	6.6	*ns*	4.3	4.9	*ns*	6.5	6.5	*ns*	6.9	7.3	*ns*
Malic acid	3.3	3.6	*ns*	4.6	4.2	*ns*	2.6	2.3	*ns*	3.2	2.9	*ns*

n.s., difference not significant between the two samples

The effect of treatment with yeast derivative on the aromatic component was assessed through the study of glycosylated aromatic precursors in the grapes. From veraison onwards, aromas begin to build up in the skins with a constant increase in relation to the maturation trend. The main classes of aromatic compounds present in white grapes are terpeneols (floral, fruity and citrus notes), norisoprenoids (spice and tropical fruit), and benzenoid compounds (balsamic and spicy notes) (Flamini, 2010).
Data in Table 4 show that all vintages recorded better synthesis of all main aromatic precursors in treated Glera compared with the control sample, both in 2015, which was warmer than average, and in 2014, which was rainier and cooler. A detailed analysis of the different aromatic compound data shows that the main differences are related to increased terpene compounds typical of the Glera grape, in particular geraniol and linalool (floral and rose notes), hydroxygeraniol, hydroxylinalool, and geranic acid. A number of benzenoid compounds also responded positively to the treatment, including benzyl alcohol, β-phenyl-ethanol, and homovanillic acid, which bring aromatic complexity (notes of rose, carnation, spice) when combined. In relation to norisoprenoid compounds, vomifoliol and 3-oxo-α-ionol in general were found to increase with treatment (compounds associated with hints of tropical fruit and ripe fruit).
When subjected to sensory analysis, it was essentially confirmed that wines produced with treated grapes showed increased olfactory intensity with more pronounced floral notes and, as already noted for red wines, there was a considerable decrease of vegetal notes. These wines had better palate balance and less bitter notes (Figure 3).

Figure 3. Comparison of the average sensorial profile of Glera wines produced with grapes treated with LalVigne Aroma and a control sample. The data are the average of the years studied (2013, 2014, 2015, and 2016).



Glera
controllo - control
attraenza - attractiveness
intensità olfattiva - olfactory intensity floreale - floral
ananas – pineapple
pesca – peach
mela – apple
vegetale - vegetal
elegance - eleganza
acido - acid
salato – salty
corpo - body
amaro – bitter
equilibrio - balance
piacevolezza - pleasurability

Table 4. Glycosylated aromatic precursors were (µg/Kg grapes) measured in Glera grapes treated with LalVigne® Aroma and in the control samples for the three years studied.

μg/Kg grapes	2013		2014		2015		2016	
	LA	C	LA	C	LA	C	LA	C
Terpenes								
linalool	26±4.6	17±2.8	12±4.2	8±2.8	31±5.1	16±0.4	12±0.9	8±1.6
α-terpineol	4±0.9	2±0.2	2±0.1	1±0.1	2±0.1	2±0	12±0.5	7±0.1
trans piran linalool oxide	9±2.6	6±0.5	5±0	5±1.6	10±1	6±0.2	5±0.1	3±0
cis piran linalool oxide	1±0.3	1±0.2	1±0.3	2±1	2±0.2	1±0.1	1±0.1	0±0.1
nerol	10±0.7	9±1.4	10±1	10±0.7	9±0.4	5±0.3	28±1.8	11±1.3
geraniol	149±1.5	136±2.8	286±3.1	276±4.3	296±2.8	201±2.1	100±8.5	93±6.4
trans 8-hydroxylinalool	58±16.2	43±6.6	38±9.8	30±3.4	59±4.3	39±0.6	36±1.5	25±2.5
hydroxygeraniol	156±5.1	137±7	265±4.5	230±3	198±8.3	169±3.8	202±22.1	173±18.8
cis 8- hydroxylinalool	343±18.1	287±13.8	537±29.2	393±16.6	406±26.6	258±2.2	269±20.9	189±20
geranic acid	398±1.4	368±2.1	366±1.5	326±1.9	207±0	134±2.8	256±21.5	214±7.9
TOTAL	**1158±25**	**1009±18**	**1525±27**	**1287±17**	**1225±24**	**835±6**	**926±39**	**727±29**
Benzenoids								
benzaldehyde	9±1	15±5	1±0	0±0.1	4±0.5	8±1.3	5±0.8	6±0.6
methyl salicylate	3±2.1	3±0.3	5±0.1	3±0.3	3±0.2	1±0.1	26±2.1	18±1.8
benzylic alcohol	529±9.4	491±1.2	484±6.2	465±3.5	296±11.4	244±23.5	742±55.3	605±47.9
β-phenylethanol	237±2.2	198±5.5	244±4.1	250±6.2	198±4.7	157±8.9	312±14.7	246±0.5
eugenol	7±0.9	8±2.7	8±0.8	10±3.1	8±0	6±0.1	18±3.7	14±1.6
vanillin	6±0.1	7±2.2	7±0.6	7±0.6	8±0.3	5±0	10±1.3	10±1.2
homovanillic acid	84±2.4	69±4	48±12.8	20±8.8	39±2.7	29±0.2	97±12.7	107±41
TOTAL	**877±9**	**794±10**	**800±12**	**760±11**	**558±10**	**452±17**	**1213±45**	**1009±47**
Norisoprenoids								
3-hydroxy-β-damascone	98±4.5	63±5.5	40±1.8	44±4.1	50±0.6	53±8.5	62±3.8	57±0.9
3-oxy-α-ionol	130±2.6	116±2.9	280±5.5	250±7.3	92±8.4	65±2.5	114±4.1	107±2.7
3,9-dihydroxy megastigma-5-ene	42±5.2	39±8	9±1	9±2	17±0.3	14±0.5	23±0.9	16±0.6
3-hydroxy-7,8-dehydro-β-ionol	66±3.2	60±6.5	9±2.1	10±1.9	19±0	17±0.9	28±2.8	25±1.2
vomifoliol	299±18.2	176±27.3	556±23.2	478±12.3	595±32.1	466±16.3	517±6.5	439±5.3
TOTAL	**636±16**	**457±25**	**895±16**	**793±13**	**776±20**	**616±14**	**746±9**	**647±5**

4 Conclusions

The trials confirmed the effectiveness of the use of the product tested in the vineyards. The effect was found to be consistent even in very different vintages.

This cutting-edge application can therefore be considered a useful agricultural tool that will impact solely secondary plant metabolism, namely improving the aromatic profile in the case of LalVigne Aroma, and polyphenolic profile in the case of LalVigne Mature, without distorting the varietal characteristics and without affecting sugar accumulation, degradation of acids, and grape pH.

In addition to the effects reported here, several recent international publications highlighted another positive effect of both products on skin thickness [6.7], which is a critical aspect also in susceptibility to a number of diseases and infections.

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