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PRIMO CONGRESSO INTERNAZIONALE
SULLA VITICOLTURA DI MONTAGNA E IN FORTE PENDENZA

PREMIER CONGRÈS INTERNATIONAL
SUR LA VITICULTURE DE MONTAGNE ET EN FORTE PENTE

Proceedings - Actes - Atti

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OIV

Regione Autonoma
Valle d'Aosta
Région Autonome
Vallée d'Aoste

ISBN 88-902330-0-1

CD-ROM

Texture characteristics appraisal of mountainous Nebbiolo grapes

Etude des caractéristiques structurales des raisins Nebbiolo cultivés dans les régions montagneuses

Valutazione delle caratteristiche strutturali di uve Nebbiolo coltivate in montagna

L. Rolle[(1)], H. Letaief, G. Zeppa, V. Gerbi
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Abstract

Nebbiolo, is a native Italian grapevine variety adapted to cold climates and various production conditions like mountainous areas, hills and plains. Outside Piedmont hills, where it is intensively cultivated, it is present in Valtellina, Franciacorta and Aosta. It is famous for producing noble red long aged wines from different Denominations of Origin like Barolo, Barbaresco, Carema, Gattinara, Ghemme, Bramaterra and Valtellina. But Nebbiolo is very sensitive to both soil and geography and can yield wines that vary widely in body, tannin and acidity, as well as aroma and flavour.

The technological ripeness level, the anthocyanins concentration, the distribution and evolution of tannins and the phenolics extraction properties, are important for the success of Nebbiolo winemaking choices.

The aim of this study was to compare two Nebbiolo production areas (Carema and Langhe) through the assess of grape mechanical properties, using texture analysis techniques.

Grape berries from the Carema hills were characterised by a very consistent skins with a mean toughness of 0.49N and a mean rupture energy of 0.34 N.mm. These values are significantly superior to those of Langhe grape berries which is probably due to the higher mean skin thickness (270 µm). Even if these characteristics are favourable for vine phytopathological resistance they still can result problematic for maceration efficiency.

Résumé

Le Nebbiolo, cépage autochtone du Piémont par excellence, s'est bien adapté à la culture sur des territoires aux climats hivernaux plus rudes. On le retrouve évidemment abondamment sur tout le territoire du Pièmont : des Langhes au Roero, de Canavese et Biellese aux hauts de Vercelli et Novare. Mais également dans d'autres régions telles le bas Val d'Aoste, la Valtelline et la Franciacorta. En effet, le Nebbiolo est un des cépages italiens duquel dérive la plupart des vins rouges de qualité et à long vieillissement prolongée de la zone nord occidentale de l'Italie. A partir du raisin pur Nebbiolo ou melangé avec d'autres types de raisin sont produits 23 vins A.O.C. parmi lesquels le Barolo, le Barbaresco, le Carema, le Gattinara, le Ghemme, le Bramaterra et le Valtellina. La capacité d'adaptation de ce cépage permet de le cultiver dans diverses zones allant de la colline à la montagne. Cette diversité géographique se traduit à la vendange par une grande variabilité des caractères physico-chimiques du raisin produit et donc au final cette diversité impose des choix de vinification différents. L'application de la technique de transformation la plus opportune dépend effectivement de plusieurs facteurs parmi lesquels le niveau de maturation technologique atteint, la concentration de pigments anthocyanidiques présents, l'évolution de la composante tannique et sa répartition entre la peau et le pépin du raisin. Un autre facteur essentiel dans ce choix est la facilité d'extraction des substances phénoliques à partir des parties solides du raisin. A propos de ce dernier point les connaissances sont encore minimes et surtout concernant le Nebbiolo cultivé dans la zone du début des montagnes.

Dans cette présente étude, à l'aide de la technique d'analyse de structure, nous avons voulu nous concentrer sur les différences existantes entre le raisin Nebbiolo issu de diverses zones: des vignes de Carema DOC et de la zone de production des Langues. Les raisins provenant de la zone de Carema présentent une peau plus consistante, avec une dureté moyenne de 0.49N et une énergie moyenne de rupture de 0.34 N.mm, valeur significativement supérieure à celle obtenue sur les raisins provenant de la zone du Sud du Piémont. Une telle différence dans les résultats provient certainement d'une peau plus épaisse (270 µm). Si ces caractéristiques peuvent se révéler positives d'un point de vue résistance aux phytopathologies d'un vignoble donné, elles semblent moins adaptées d un point de vue de l'efficacité de macération et de l'extraction.

Riassunto

Vitigno autoctono piemontese per eccellenza, il Nebbiolo ben si adatta alla coltivazione in territori con climi invernali freddi. Intensamente presente su tutto il territorio regionale, dalle Langhe al Roero, dal Canavese e

Biellese all'alto Vercellese e Novarese, nonchè fuori regione in bassa valle d'Aosta, Valtellina e Franciacorta, e' uno dei vitigni nobili italiani dal quale derivano la maggior parte dei vini rossi di qualità a lungo invecchiamento della zona nord-occidentale dell'Italia. Sono infatti prodotti con uve Nebbiolo, in purezza od in uvaggio, 23 vini a Denominazione di Origine tra cui Barolo, Barbaresco, Carema, Gattinara, Ghemme, Bramaterra e Valtellina. La forte adattabilità alla coltivazione in areali diversi, dalle zone collinari agli ambienti pedemontani e montani si traduce, alla vendemmia, in una elevata variabilità delle caratteristiche chimico-fisiche delle uve prodotte che impongono scelte di vinificazione differenti. L'applicazione della tecnica di trasformazione più opportuna dipende infatti da molteplici fattori tra cui il livello di maturità tecnologica raggiunto, la concentrazione di pigmenti antocianici presenti, l'evoluzione della componente tannica e la sua ripartizione tra buccia e vinaccioli, nonché, soprattutto, dalla facilità di estrazione delle sostanze fenoliche dalle parti solide dell'uva. Ancora poche sono le conoscenze acquisite su quest'ultimo aspetto, in particolare se riferite ai Nebbioli coltivati in ambienti pedemontani.
In questo studio si è voluto pertanto indagare con tecniche di Texture Analysis sulle proprietà strutturali delle uve Nebbiolo coltivate nella zona di produzione del Carema DOC e valutare le differenze esistenti con quelle di uve di vigneti siti nelle Langhe. Le uve provenienti dall'ambiente pedemontano di Carema hanno presentato una buccia molto consistente con una durezza media di 0.49N ed una energia media richiesta per la rottura pari a 0.34 N.mm, valori significativamente superiori a quelli riscontrati sulle uve Nebbiolo provenienti dal sud Piemonte. Tale differenza è probabilmente imputabile ad uno spessore medio della buccia più elevato (270 μm). Se queste caratteristiche possono risultare favorevoli in vigneto determinando una maggiore resistenza alle avversità fitopatologiche, possono risultare problematiche nell'impostare una efficace macerazione.

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The technological ripeness level, the anthocyanins concentration, the distribution and evolution of tannins and the phenolics extraction properties, are important for the success of Nebbiolo winemaking choices.
The aim of this study was to compare two Nebbiolo production areas (Carema and Langhe) through the assess of grape mechanical properties, using texture analysis techniques.
Grape berries from the Carema hills were characterised by a very consistent skins with a mean toughness of 0.49N and a mean rupture energy of 0,34 N.mm. These values are significantly superior to those of Langhe grape berries which is probably due to the higher mean skin thickness (270 µm). Even if these characteristics are favourable for vine phytopathological resistance they still can result problematic for maceration efficiency.

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infatti da molteplici fattori tra cui il livello di maturità tecnologica raggiunto, la concentrazione di pigmenti antocianici presenti, l'evoluzione della componente tannica e la sua ripartizione tra buccia e vinaccioli, nonché, soprattutto, dalla facilità di estrazione delle sostanze fenoliche dalle parti solide dell'uva. Ancora poche sono le conoscenze acquisite su quest'ultimo aspetto, in particolare se riferite ai Nebbioli coltivati in ambienti pedemontani. In questo studio si è voluto pertanto indagare con tecniche di Texture Analysis sulle proprietà strutturali delle uve Nebbiolo coltivate nella zona di produzione del Carema DOC e valutare le differenze esistenti con quelle di uve di vigneti siti nelle Langhe. Le uve provenienti dall'ambiente pedemontano di Carema hanno presentato una buccia molto consistente con una durezza media di 0.49N ed una energia media richiesta per la rottura pari a 0.34 N.mm, valori significativamente superiori a quelli riscontrati sulle uve Nebbiolo provenienti dal sud Piemonte. Tale differenza è probabilmente imputabile ad uno spessore medio della buccia più elevato (270 µm). Se queste caratteristiche possono risultare favorevoli in vigneto determinando una maggiore resistenza alle avversità fitopatologiche, possono risultare problematiche nell'impostare una efficace macerazione.

Key words: Texture analysis, berry skin, seeds, Nebbiolo

Introduction

Nebbiolo grapevine variety is famous for producing noble red long aged wines from different Denominations of Origin like Barolo, Barbaresco, Carema, Gattinara, Ghemme, Bramaterra and Valtellina.

The clone choice, the technological ripeness level, the anthocyanins concentration, the distribution and evolution of tannins and the phenolic extraction properties, are important for the success of Nebbiolo winemaking planning (Cagnasso *et al.*, 2003; Gerbi *et al.*, 2002, Guidoni *et al.*, 2002; Mannini *et al.*, 2004).

The aim of this study was to compare two Nebbiolo production areas (Carema and Langhe) through the assess of grape (skin and seed) mechanical properties, using Texture Analysis techniques.

Since it's able to supply objective results, texture analysis is nowadays more and more applied in food sector as a surveying analytical technique for the definition and the control of aliments physical properties (Bourne, 2002).

The first Texture Analysis studies on grape have been made on table varieties (Bernstein e Lustig, 1981). The assessment of pulp compactness and berry skin consistency is important for the customer appreciation of the product (Sims e Halbrooks, 1986; Laszlo e Saayman, 1991; Mencarelli *et al.*, 1994; Sato *et al.*, 1997; Sato e Yamada, 2003).

Few experiences on Texture Analysis application on wine grapes have been made. The scientific contributions concerned principally the study of some mechanical properties modifications, like hardness evolution during ripening (Liang *et al.*, 1990; Abbal *et al.*, 1992; Robin *et al.*, 1996; Rolle *et al.*, 2006; Ruiz Hernandez, 1996).

The knowledge of texture indexes like berry skin thickness and hardness, as well as seed lignifications degree, can represent some fundamental qualitative information for the oenologist during the planning and management of pressing and maceration processes.

Materials and Methods

During the 2005 vintage, Nebbiolo grapes from six different vineyards have been analysed. Three of these vineyards were located in the mountainous production areas of Carema (TO) while the others were situated in the Langhe hills (La Morra, Serralunga d'Alba and Barolo (CN)).

At harvest, a randomised sampling of 400 berries from each vineyard, have been made carefully without detaching the pedicel. For each test 20 berries was analysed.

For the appraisal of grape mechanical properties, three different tests were made: berry skin hardness, berry skin thickness and seeds hardness.

The measurements were made using a Universal Testing Machine TAxT2i Texture Analyzer (Stable Micro System, Godalming, Surrey, UK) equipped with a HDP/90 platform and a 25 Kg load cell. All the acquisitions were made at 400 Hz and involving a Texture Expert Exceed software version 2.54. In according to Uys (1996) and Grotte et al. (2001), the operative conditions that were applied for the tests execution are resumed in Table 1.

Table 1 - Operational parameters for tests execution and assessed mechanical properties.

Tableau 1 - Paramètres opérationnels pour l'exécution des tests et proriétés mécaniques évaluées.

Test	Probe	Test speed	Compression	Mechanical properties
Berry skin hardness	needle	1 mms^{-1}	3mm	F_{sk} = berry skin break Force (N) W_{sk} = berry skin break Energy (mJ)
Berry skin thickness	P/2, Ø 2mm	0,2 mms^{-1}	_	Sp_{sk} = berry skin thickness (µm)
Seed hardness	P/35, Ø 35mm	1 mms^{-1}	50% deformation	F_s = seed break Force (N) W_s = seed break Energy (mJ) E_s = Young's Modulus (N/mm)

The analytical parameters of technological ripeness (sugars, total acidity, pH) were estimated with official methodologies CE.
The data elaboration was made using the Statistica ver. 6.0 Software (StatSoft Inc., Tulsa, OK, USA).

Results and Discussion

The Nebbiolo grapes cultivated in mountainous environment, as it could be expected, presented at harvest less sugar contents than those cultivated in hills environments (Table 2), however, sugar accumulation stood high. Although the harvest happened 15 days later, Carema grape total acidity was clearly higher.

Table 2 – Technological ripeness of Nebbiolo grapes at harvest. Mean of three vineyards.
X = mean value; δ = standard deviation; Sign = significance; **$p< 0.01$, *$p<0.05$, ns = not significant.

Tableau 2 – Maturité technologique des raisins Nebbiolo à la récolte. Moyenne trois vignobles.
X = moyenne; δ = Ecart type; Sign = significativité; **$p< 0.01$, *$p<0.05$, ns = pas significatif.

	Nebbiolo Mountain		Nebbiolo Hill		Sign.
	X	δ	X	δ	
Harvest date	11-ott		28-set		
Sugars g/L	221	6	236	8	*
Total acidity (g/L tartaric acid)	12,8	1,4	6,7	0,2	**
pH	3,05	0,04	3,02	0,01	ns

The Force-time (or deformation) curve obtained with this test is reported in figure 1. The berry skin hardness is assessed whether with the maximum break force (Fsk) or with the break energy (W_{sk}). The first parameter corresponds to the skin resistance to the probe penetration while the second parameter is represented by area under the curve, which is limited between the 0 point and F_{sk}, whereas the curve related to berry skin thickness determination is reported in figure 2. The berry skin thickness (Sp_{sk}) is given by the distance between the point corresponding to the probe contact with the berry skin (*trigger*) and the platform base HDP/90.
The Nebbiolo berry skin hardness and break energy results are reported in Table 3.

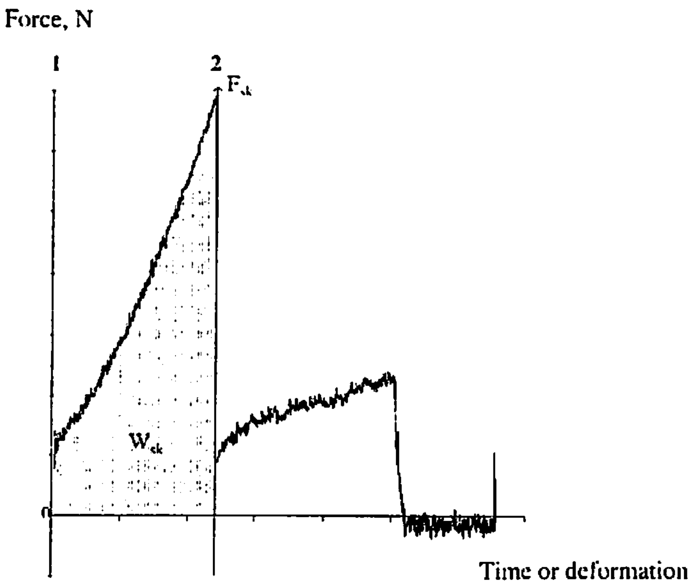

Figure 1 – Force-time Curve corresponding to the berry skin penetration test.

Figure 1 – Courbe Force-temps relative au test de pénétration de la pellicue de la baie.

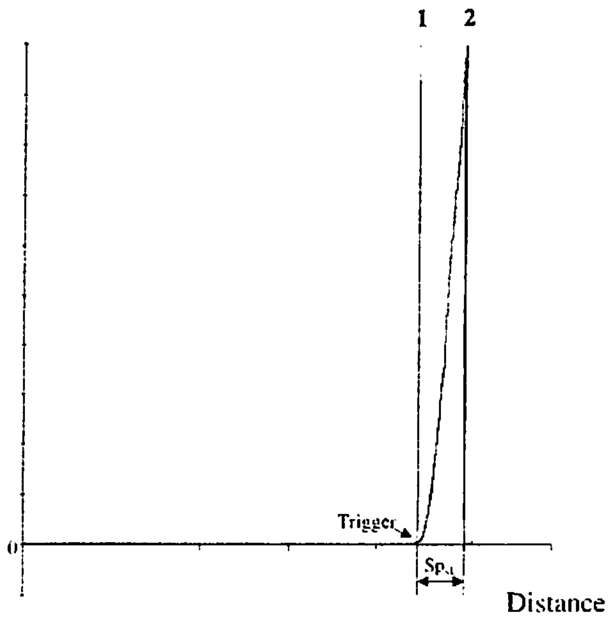

Figure 2 – Force-distance curve corresponding to the berry skin thickness determination test.

Figure 2 – Courbe Force-distance relative au test de détérmination de l'épaisseur de la pellicule de la baie.

Even with a high data dispersion, which is typical of vegetable products (Roudot, 2001), mountainous Nebbiolo is characterized by a higher berry skin consistence. The Carema Nebbiolo has the highest break force (0.498 N) and energy (0.346 mJ) mean values, that could be due to a reduced level of maturity. The berry skin hardness decreases indeed when sugars increase (Lee e Bourne, 1980).
This higher berry skin resistance to rupture (splitting) is nevertheless important from the agronomical and phytopatholpgical point of view (Considine, 1981; Lang e During, 1990; Bišof *et al.*, 1994), and could likewise be the consequence of a higher berry skin thickness in mountainous Nebbiolo grapes (table 4). From the technological point of view, this characteristic could be penalizing since it could reduce cell permeability (Cagnasso *et al.*, 2005).

Table 3 – Textural characteristics of Nebbiolo berry skin cultivated in different environments.
X = mean value; δ = standard deviation; Sign = significance; **p< 0.01, *p<0.05, ns not significant.

Tableau 3 – Caractéristiques structurales de la pellicule dela baie du Nebbiolo cultivé dans divers environnements.
X = moyenne: δ = Ecart type: Sign = significativité; **p< 0.01, *p<0.05, ns pas significatif.

	Nebbiolo Mountain		Nebbiolo Hill		
	X	δ	X	δ	Sign.
F_{sk} (N)	0.498	0.100	0.355	0.062	**
W_{sk} (mJ)	0.346	0.143	0.182	0.050	**

Table 4 – Berry skin thickness of Nebbiolo berries cultivated in different environments.
X = mean value; δ = standard deviation; Sign = significance; **p< 0.01, *p<0.05, ns not significant.

Tableau 4 – Epaisseur de la pellicule de la baie du Nebbiolo cultivé dans divers environnements.
X = moyenne: δ = Ecart type; Sign = significativité; **p< 0.01, *p<0.05, ns pas significatif.

	Nebbiolo Mountain		Nebbiolo Hill		
	X	δ	X	δ	Sign.
Sp_{sk} (μ)	274	6	218	3	**

The Force-time curve, related to the seeds hardness test, is reported in figure 3. Break Force (Fs) corresponds to the first pick, while break energy (W_s) corresponds to the area under the curve and which is limited by the 0 point and the break point. Dl represent the break distance. E_s is a measure of material's resistance to axial deformation. It represent the stiffness of the material to an applied load. The larger the stiffness, the higher the force or stress needed to cause a given deformation or strain. Its value is calculated as the slope of the stress-strain curve in the linear section (Vargas *et al.*, 2001).

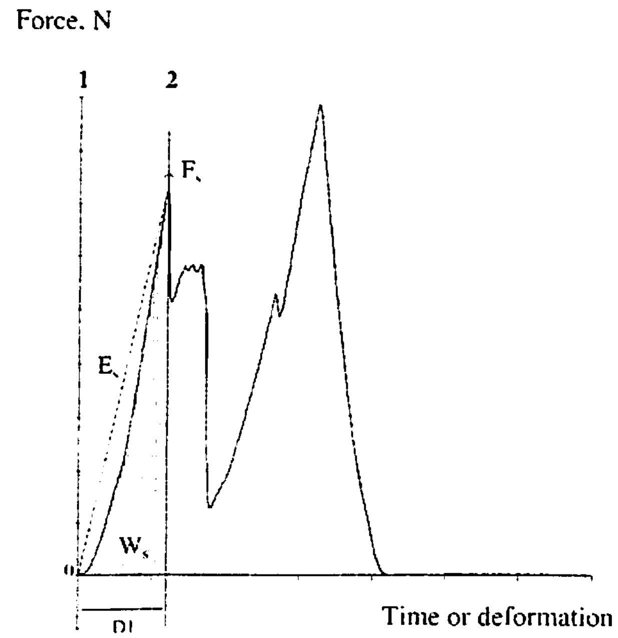

Figure 3 – Force-distance curve related to the test for seed hardness determination.

Figure 3 – Courbe Force-distance relative au test de détermination de la dureté des pépins de la baie.

Even if seeds elasticity is the same in both environments, mean seeds hardness in Nebbiolo cultivated in Langhe is higher than in Carema (Table 5). We could consequently suppose that the reached seeds maturity degree is homogenous, but coat characteristics, for example thickness, are different. Therefore such aspect needs to be subsequently deepened .

Table 5 – Textural characteristics of Nebbiolo seeds cultivated in different environments
X = mean value; δ = standard deviation; Sign = significance; **p< 0.01. *p<0.05. ns not significant.

Tableau 5 – Caractéristiques structurales des pépins du Nebbiolo cultivé dans divers environnements.
X = moyenne; δ = Ecart type; Sign = significativité; **p< 0.01. *p<0.05. ns pas significatif.

	Nebbiolo Mountain		Nebbiolo Hill		
	X	δ	X	δ	Sign.
F_s (N)	48,66	15,64	59.09	10.32	*
W_s (mJ)	12,89	6.11	16.28	4.34	*
E_s (N/mm)	76,64	22,56	76.76	20.78	ns

Conclusions

Texture analysis resulted to be an efficient instrument for the assess of wine grape mechanical behavior. Even if the experience is referred to a unique vintage and results are not generalizable, it showed a high discrimination between the studied Nebbiolo grapes. The different vineyards had an homogenous behavior. The knowledge of texture indexes could provide important qualitative information for the oenologist when he plans and manage the pressing and maceration processes.

In order to acquire a wider information it becomes necessary to extend the study to other grape varieties, coming from areas that have different pedoclimatic characteristics.

Moreover, it is essential to check the possible correlations between data obtained by texture analysis and grape chemical parameters, with a particular interest to those related to phenolic maturity, that used to involve long and expensive methodologies.

It is finally interesting to establish some texture analysis tests able to integrate human sensorial capacities and to furnish objective evaluations of the mechanical parameters required in some grape sensory analysis cards.

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