

# Assessment of result from quality control systems in the Sicilian winemaking industry through the use of multi-varied analysis<sup>1</sup>

VERA TERESA FOTI\*, MANUELA PILATO\*, GIUSEPPE TIMPANARO\*

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## 1. Introduction

Quality, in every facet, is of the utmost interest to companies due to the fact that it is a fundamental tool in optimizing the management and production process, while also increasing competitiveness in terms of image and production value, helping in breaking into new parts of the market, and facilitating trade and business in general. In the field of quality guarantees and standards, ISO norms (issued by the International Organization for Standardization in 1987 and absorbed by the Italian Unification Board, UNI) have been quite successful – in particular, “ISO 9001” regarding the “certification of quality management system” and “ISO 14001” on the “certification of environmental management systems”. Compliance with these norms and regulations, which can be voluntarily applied to all business sectors in contractual situations (in which the receiver of goods requests quality guarantee from the supplier), as well

## Abstract

The agrifood sector has started to pay attention to the ISO certification. This theme is important for the Sicilian wine market which is experiencing a crucial phase of market requalification and repositioning with the implementation of quality systems. The aim of this paper is to understand if the Sicilian wine industry, which has an ISO certification, takes into account the degree of satisfaction after reaching a period of application of the implementation of certification standards. With regard to this, certified businesses have been provided with a specially prepared questionnaire and value judgements have been collected on the business capacity of adaptability, operational problems etc.. After collecting considerable judgements and difficult analyses we suggest implementing a “Principal Components Analysis” in order to summarize and to consider ISO quality systems in the wine businesses of our study.

**Key words:** Wine Industry, Quality Management System, ISO Certification, Principal Components Analysis.

## Résumé

*L'industrie alimentaire a attaché une attention croissante à la certification ISO. Cette question revêt une importance particulière pour le secteur du vin en Sicile, qui vit maintenant une phase intense de mise à niveau de la production, de multiplication et de repositionnement sur le marché à travers l'adoption de systèmes de qualité. La recherche, visant à la détection des entreprises vinicoles siciliennes certifiées selon les normes ISO, vise à évaluer le degré de satisfaction après une période de mise en œuvre des normes imposées par la certification. À cet égard, les entreprises certifiées ont reçu un questionnaire spécialement conçu qui a été recueilli grâce à des examens et des évaluations de la capacité d'adaptation de la société sur les questions opérationnelles, etc.. Le sort des commentaires recueillis et les difficultés de l'analyse conjointe ont suggéré de mettre en œuvre une analyse en composantes principales pour résumer les différents attributs dans un nombre réduit de variables pour juger de l'ISO système qualité en vinification entreprises trouvées.*

**Mots-clés:** Industries du Vin, Systèmes de Qualité, Certification ISO, Analyse en Composantes Principales.

as non-contractual situations (in which company management decides to freely adopt the quality control system), in addition to promoting improvement in the organization's performance in terms of satisfying associated economic and company needs, also provides – or at least *should* provide – the guarantee, in some sectors such as that of food processing and production, that the company adheres to coactive norms regarding the hygiene and safety of the products, as well as traceability and environmental protection in the site where production takes place.

Since the 1990's, the food processing industry has shown an increasing amount of interest in certification based on ISO norms, underlining the understanding of the strategic importance that these regulations can have in order to work in a competi-

and global market. Among the number of food processing areas interested in ISO, winegrowing and wine-production are particularly important due to the intense requalification process of production centres that have recently been started, as well as the importance that quality has always had in this production sector. These aspects become even more fundamental in a specific region – Sicily – where in the last few years we have seen the consolidation of the leadership role in the production of high-quality wines produced by companies and businesses that have found that the adoption of ISO standards and norms is a tool capable of increasing competitiveness in domestic and international markets.

\* Dipartimento di Gestione dei Sistemi Agroalimentari ed Agroambientali (DIGESA), Sezione di Scienze Economico-Agrarie ed Estimative, Università degli Studi di Catania, Italy.

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The aim of this research is that of a direct study on a sample of Sicilian oenological enterprises and companies (winegrowers and wine-producers) that are certified in compliance with ISO norms (9001 and 14001), in order to understand the implementation process for quality control systems and assess the level of satisfaction reached by these companies after the initial period regarding certification. The information obtained through the use of *ad hoc* data gathering instruments, was applied to a multi-varied analysis drawing on the “Principal Component Analysis” (PCA) method (Pearson, 1901 and Hotelling, 1933), which is capable of summarizing the vast amount of opinions and data gathered in a reduced number of variables that are used to judge the ISO quality system in the wine-producing and wine-growing companies studied herein.

## 2. Spread of quality certification in the food processing sector, with particular interest placed on the oenological industry

In recent years, the food processing industry has shown an increasing amount of interest in certification based on ISO norms for Quality Management Systems (QMS) and Environmental Management Systems (EMS). The growth seen in the 1990’s shows how, albeit late when compared to other production sectors, the food processing industry understood the importance of adapting company structure to standards outlined by international standards, a fundamental choice in order to work in an increasingly globalized and competitive context<sup>2</sup>.

According to data provided by SINCERT (the Italian Board responsible for accrediting certification companies), the number of certified food processing companies in 2010<sup>3</sup> totalled 3,014, with 63% of these companies having headquarters in Central-Northern Italy, while the remaining 37% was located in Southern Italy (see table 1). From an in-depth analysis of this data, we find that the number of certified companies mirrored the general picture of domestic food processing production, where we find a strong presence of micro, very small, and small-sized enterprises, side by side with large and very large-sized enterprises that have multiple branches and with distribution centres all over the country. The regions with the greatest number of

Table 1 - *Certified Sicilian oenological enterprises based on ISO norms in the agrifood industry and oenological and incidence for region in Italy (2010) (\*)*.

Region	Agrifood enterprises (a)		Oenological enterprises (b)		Incidence% (b)/(a)
	n.	%	n.	%	
Emilia Romagna	472	15.7	36	8.7	7.6
Friuli Venezia Giulia	48	1.6	13	3.1	27.1
Lazio	110	3.6	8	1.9	7.3
Liguria	40	1.3	1	0.2	2.5
Lombardia	368	12.2	18	4.3	4.9
Piemonte	192	6.4	34	8.2	17.7
Toscana	164	5.4	41	9.9	25.0
Trentino Alto Adige	45	1.5	7	1.7	15.6
Umbria	77	2.6	11	2.7	14.3
Val d'Aosta	7	0.2	-	-	-
Veneto	371	12.3	88	21.3	23.7
<b>Central-Northern</b>	<b>1,894</b>	<b>62.8</b>	<b>257</b>	<b>62.0</b>	<b>13.6</b>
Abruzzo	87	2.9	16	3.9	18.4
Basilicata	35	1.2	4	1.0	11.4
Calabria	85	2.8	5	1.2	5.9
Campania	240	8.0	9	2.2	3.8
Marche	68	2.3	13	3.1	19.1
Molise	32	1.1	2	0.5	6.3
Puglia	238	7.9	46	11.1	19.3
Sardegna	118	3.9	14	3.4	11.9
Sicilia	217	7.2	48	11.6	22.1
<b>Southern</b>	<b>1,120</b>	<b>37.2</b>	<b>157</b>	<b>38.0</b>	<b>14.0</b>
<b>Total Italy</b>	<b>3,014</b>	<b>100.0</b>	<b>414</b>	<b>100.0</b>	<b>13.7</b>

(\*) Own calculation on SINCERT data.

certified food processing companies are, in order of importance: Emilia Romagna, Veneto, Lombardia, Campania, Puglia and Sicily, together making up more than 63% of all certified Italian companies.

In the beverage industry, there is a great deal of interest from wine-producers and winegrowers, which are the focus of this study. Moreover, the Italian wine industry, and in particular that of Sicily, appears to have taken on a sweeping process of production requalification in order to meet the needs of a consumer bracket that is increasingly attracted to high-quality products and the highest level of standards. In a certain sense, this trend seems to be confirmed by the growing attention towards more complex quality certification processes, seeing that a suitable number of oenological enterprises have already implemented an ISO system. From the analysis in table 1, we can see that the number of ISO-certified oenological companies in Italy total 414 (equal to roughly 13.7% of certified food processing companies), of which 62% are based in Central-Northern Italy and the remaining 38% in the Southern regions. For wine-producers and winegrowers, the analysis was also extended to certified local units (due to the high number of companies with multiple branches and sites) and the number of implemented certifications, pursuant to the fact that single production units, within their own sites, can clearly implement more than one quality systems (ISO 9001, 14001 and 18001) and obtain certification with different areas of application (multiple production activities carried out within the same company).

<sup>2</sup> There are a number of innovations regarding quality that were introduced by the Fischler reform in 2003 – among these, we should recall the Commission’s Report on policies regarding the quality of agricultural products (COM 2009, 234); new instruments introduced in the PSR (for the production of quality certified food as well as the spread and promotion of consumer awareness); OCM wine reform of 2008, which amended regulations and norms on the identification of quality for wines (from Italian rules on DOP and PGI to that of the European Community).

<sup>3</sup> Comparing this data to the overall consistency of food processing and production companies through the Industrial and Service Census from 2001, we find that 4.5% of Italian companies had implemented a quality control system and obtained the pertinent certification.

Table 2 - *Enterprises, Local units and Certifications based on ISO norms in the oenological industry in Italy at regional level (2010) (\*)*.

Region	Enterprises		Local units		Certifications									
	n.	%	n.	%	9001:2000		9001:2008		14001:2004		18001:2007		Total	
					n.	%	n.	%	n.	%	n.	%	n.	%
Emilia Romagna	36	8.7	66	12.3	10	5.7	26	12.6	6	6.0	2	40.0	44	9.1
Friuli Venezia Giulia	13	3.1	14	2.6	3	1.7	8	3.9	2	2.0	-	-	13	2.7
Lazio	8	1.9	10	1.9	4	2.3	4	2.0	-	-	-	-	8	1.6
Liguria	1	0.2	1	0.2	-	-	1	0.5	-	-	-	-	1	0.2
Lombardia	18	4.3	22	4.1	8	4.5	7	3.4	2	2.0	-	-	17	3.5
Piemonte	34	8.2	48	9.0	15	8.5	15	7.3	8	8.0	-	-	38	7.8
Toscana	41	9.9	61	11.4	24	13.6	16	7.8	5	5.0	1	20.0	46	9.5
Trentino Alto Adige	7	1.7	7	1.3	3	1.7	4	2.0	1	1.0	-	-	8	1.6
Umbria	11	2.7	11	2.1	3	1.7	4	2.0	3	3.0	2	40.0	12	2.5
Val d'Aosta	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Veneto	88	21.3	119	22.3	33	18.8	55	26.8	14	14.0	-	-	102	21.0
<b>Central-Northern</b>	<b>257</b>	<b>62.0</b>	<b>359</b>	<b>67.2</b>	<b>103</b>	<b>58.5</b>	<b>140</b>	<b>68.3</b>	<b>41</b>	<b>41.0</b>	<b>5</b>	<b>100.0</b>	<b>289</b>	<b>59.5</b>
Abruzzo	16	3.9	17	3.2	9	5.1	7	3.4	1	1.0	-	-	17	3.5
Basilicata	4	1.0	6	1.1	1	0.6	1	0.5	3	3.0	-	-	5	1.0
Calabria	5	1.2	5	0.9	5	2.9	-	0	-	-	-	-	5	1.0
Campania	9	2.2	9	1.7	3	1.7	5	2.4	2	2.0	-	-	10	2.1
Marche	13	3.1	14	2.6	5	2.8	8	3.9	1	1.0	-	-	14	2.9
Molise	2	0.5	2	0.4	-	-	2	1.0	-	-	-	-	2	0.4
Puglia	46	11.1	50	9.4	19	10.8	19	9.3	16	16.0	-	-	54	11.1
Sardegna	14	3.4	14	2.6	9	5.1	5	2.4	1	1.0	-	-	15	3.1
Sicilia	48	11.6	58	10.9	22	12.5	18	8.8	35	35.0	-	-	75	15.4
<b>Southern</b>	<b>157</b>	<b>38.0</b>	<b>175</b>	<b>32.8</b>	<b>73</b>	<b>41.5</b>	<b>65</b>	<b>31.7</b>	<b>59</b>	<b>59.0</b>	<b>-</b>	<b>-</b>	<b>197</b>	<b>40.5</b>
<b>Total Italy</b>	<b>414</b>	<b>100.0</b>	<b>534</b>	<b>100.0</b>	<b>176</b>	<b>100.0</b>	<b>205</b>	<b>100.0</b>	<b>100</b>	<b>100.0</b>	<b>5</b>	<b>100.0</b>	<b>486</b>	<b>100.0</b>

(\*) Own calculation on SINCERT data.

Table 3 - *Enterprises, Local units and Certifications based on ISO norms in the oenological industry in Sicily at provincial level (2010) (\*)*.

Province	Enterprises		Local units		Certifications							
	n.	%	n.	%	9001:2000		9001:2008		14001:2004		Total	
					n.	%	n.	%	n.	%	n.	%
Agrigento	7	14.6	7	21.1	2	9.1	3	16.7	5	14.3	10	13.3
Caltanissetta	1	2.1	1	1.7	1	4.5	-	-	1	2.9	2	2.7
Catania	-	-	-	-	-	-	-	-	-	-	-	-
Enna	-	-	-	-	-	-	-	-	-	-	-	-
Messina	1	2.1	1	1.7	1	4.5	-	-	1	2.9	2	2.7
Palermo	9	18.8	10	17.2	5	22.8	2	11.1	6	17.1	13	17.4
Ragusa	1	2.1	1	1.7	-	-	1	5.5	-	-	1	1.3
Siracusa	1	2.1	1	1.7	1	4.5	-	-	-	-	1	1.3
Trapani	28	58.2	37	63.9	12	54.6	12	66.7	22	62.8	46	61.3
<b>Total Sicily</b>	<b>48</b>	<b>100.0</b>	<b>58</b>	<b>100.0</b>	<b>22</b>	<b>100.0</b>	<b>18</b>	<b>100.0</b>	<b>35</b>	<b>100.0</b>	<b>75</b>	<b>100.0</b>

(\*) Own calculation on SINCERT data.

Just as we can see for food processing industry on a whole, there is also a great divide between the number of companies (legal entities) and local units (plants, production centres, or administration and management), caused by the presence of a certain number of businesses with multiple locations generally located in Central-Northern Italy with 67.2% of the domestic total compared to 32.8% from the South (see table 2). This trend is in part supported by the ISO certifications held, which come to a total of 486 (with 59.5% for Central-Northern Italy and 40.5% for the South), and regarding the ISO 9001 standards (split between 9001:2000 and 9001:2008) with 78% of the certifications and 14001:2007 with 21% of the certifications. There was only a small number, however, of certifications regarding 18001:2007 (Occupational health and safety management systems). Among regions in Italy,

Veneto, Sicily, Puglia and Tuscany together make up 54% of Italy's winemaking and producing companies that are certified.

Moving this analysis to a regional level in Sicily, where our research has been focused, referred to 2010, there were a total of 48 certified oenological enterprises, located in the provinces with greatest number of wine-makers and wine-producers: Trapani (58.2%),

Palermo (18.8%) and Agrigento (14.6%) (see table 3). It is rather surprising, however, that there is a complete lack of certified oenological companies in the province of Catania, an area famous for high-quality wine production from the vineyards around Mt. Etna. Certified local units/branches total 58 (+20.8% when compared to company data), while certified companies total 75 (+45.8% compared to the number of companies), divided between ISO 9001 (53.3%) and 14001 (46.7%). Regarding provincial distribution,

we can see the same trends as for companies, with a strong polarization of local units and certifications in the province of Trapani (with 63.9% and 61.3%, respectively), followed by Palermo (17.2% and 17.4%) and Agrigento (12.1% and 13.3%). From the close examination of the data, we find that there is a growing number of certified companies on a regional level, thus a strong attention has been placed by companies on the theme of quality, likely due to the fact that they are currently seeing a great deal of programmed initiatives for the rural development policies regarding modernization, restructuring and production diversification – all aspects that foresee to conditions that are necessary in order to obtain planned incentives, the adoption of company quality and/or environmental systems in the food processing business.

### 3. Materials and methods

The study on the assessment of company quality control systems in the Sicilian winemaking and wine-producing industries was preceded by the acquisition of documentation on the consistency and location of SINCERT-certified food processing enterprises. This fundamental statistical data clearly signals a changing situation, showing useful indications regarding certified businesses, their location, ISO certifications held by companies, the issue date of these certificates, the certification board or organization that handles the issuing of the aforesaid certificates, as well as the trade name and/or business that underwent the certification process. The extent to which this information is available, however, diminishes as we move from an analysis of the food processing industry on a whole to the oenological industry, including the production of wine and grape harvesting, as well as the fermentation process of musts and concentrated products – a sector that is particularly important for Sicily.

Once we have defined the robustness of certified oenological businesses on a national and regional level, we can move forward to a direct study within Sicilian businesses and enterprises (50 in all), through the distribution of a tailored questionnaire by face-to-face interview.

The questionnaire sheet was completed by only 38 companies representing approximately 66% of the universe finally, the companies under production have been reduced to 35, ruling out the cases for which incomplete data and information collected did not allow an accurate analysis. Overall it came out of a simple causal probability sampling, supported by some knowledge of structural information available on population (degree of presence of different types of enterprises, organizational level, volume of processed products, quantity of wine produced, the degree of attachment upstream and downstream of the primary production).

The gathering of statistical data took place from January to April 2010. More specifically, the type of studied companies with an ISO quality system regarded those businesses that produce and bottle AOC and IGT wines, fortified wines and table wines, as well as those made with concentrated and rectified musts, products used in the winemaking industry and as natural sweeteners in the food processing industry.

The questionnaire was divided into three parts – the first dealt with the gathering of data on principal structural characteristics of the oenological industry (type of company, corporate or company formation, legal structure, founding date, turnover, employees, products, business and sales organization, etc.). The second part dealt with the quality control system held by the company (type of certification, first year, reasons for requesting certification and company goals). Lastly,

the third part was aimed at gathering opinions and assessments (expressed through the Likert 5 step scale, according to which 1 = very positive assessment and 5 = insufficient) regarding the quality system adopted by the company (regarding company adaptation, operational issues, and production results, etc.).

Data on assessment and judgement were the subject of Principal Component multi-varied statistical Analysis (PCA) in order to summarize the different attributes gathered in a reduced number of variables, also offering an assessment of results products by the ISO quality system implemented in the winemaking and wine-producing companies that were the subject of this study.

This type of analysis transforms the original variables into new variables in a linear way, so that the *i*-th Principal component ( $Y_i$ ) is written with the following equation:

$$Y_i = w_{i1}X_1 + w_{i2}X_2 + \dots + w_{ip}X_p$$

where  $X_1, X_2, \dots, X_p$  are the original standardized P variables and  $w_{i1}, w_{i2}, \dots, w_{ip}$  are the weighted values (pattern coefficients) associated with them.

Therefore, the amount of data is reduced through the matrix calculation and the components are drawn out in such a way that the first one reproduces the majority of the examined matrix variance, the second expresses the second level of majority variance and so on.

The pattern coefficients represent the eigenvalues  $\lambda_i$  that correspond to the *i*-th principal component and are obtained from the following matrix calculation:

$$(R - \lambda_i I) a_i = 0$$

where R = correlation matrix among original variables; I = identity matrix (that is, which returns the original matrix) and  $a_i$  = eigenvector made up of coefficients that determine the *i*-th principal component, just as with the linear combination of original variables.

Eigenvalues and eigenvectors are extracted in an iterative manner through an array of steps that determine a vector and are then tested with respect to a value taken as a reference (the sum of the difference squared between the pairs of elements in the two vectors must be less than 0.0001); if there is a difference with regard to the value-criteria, the vector is modified in order to produce a second vector, and so on until the first principal component has been extracted. The process moves forward through the following extractions of coefficients (weighted values) until factors able to reproduce the original variance are obtained, even if distributed in a different manner.

After having planned the number of variables based on the sample of business enterprises to be studied, data analysis was carried out using SPSS ver. 12.0 software for Windows. With this work in mind, a first edition of the questionnaire included an overall set of 36 variables, relevant to the organizational sphere and management of human resources, as well as upstream and downstream contractual relationships of winemakers – these variables were then reduced after an initial validation of the questionnaire, as seen in table 4<sup>4</sup>.

<sup>4</sup> This process was necessary because during the validation of the first questionnaire, the detector was made of the fact that respondents often attributed to the questions the same semantic meaning by suggesting, therefore, the opportunity to simplify the questionnaire sheet macro-variables in the main index suitable to grasp the organizational and management aspects of the oenological industry with ISO certification.

Table 4 - List and description of the variables in the sicilian oenological business with ISO systems (2010).

Variable	Description
ORGEST	Rationalization of the organization and management of production processes
COSCA	Advantages in reduction of costs and/or production waste
COPRO	Monitoring of process conformity and problem solving
CORE	Personnel involvement and responsibility
VEEFF	Check efficiently human resource
ACQSTRU	Acquisition of goods and service
TRACC	Traceability and possibility to resolve future disputes
RAPACQ	Business to business relations with different buyers
PERFME	Enterprise performance of the reference market
IMPROVA	Exploitation of company and brand image

Table 5 - Determinant of the variables, factorability of the correlation matrix of surveyed variables in the sicilian oenological business with ISO systems (2010).

Determinant		0.015
KMO test (Keiser Meyer Olkin)		0.808
Bartlett roundness test	Chi-quadrato appross.	180.431
	df	15
	Sig.	0.000

In following, we carried out the application of the multi-varied analysis with the customary procedures, through the succession of steps such as the evaluation of the suitability of the variables, factorability of the correlation matrix, the selection methods and the number of factors to be extracted, as well as the pertaining rotation, interpretation and evaluation of the results.

Moreover, descriptive principal statistics were determined (variance, average, asymmetry, kurtosis, frequency distribution, etc.), in order to then verify the possibility of applying the analysis of principal components (on-scale surveyed variables with equivalent intervals; non-null variance; valid relationship between subject and variables; non-excessive polarization of answers, etc.) and sample adequacy carried out through the use of the Kaiser Meyer Olkin (K-MO) test and the Bartlett roundness test. The evaluation of the suitability of the variables led to the exclusion of some chosen variables due to the fact that, despite an attempt at re-codification, we were unable to adequately reduce the level of asymmetry and kurtosis.

With regard to wine-cellars with ISO systems (see table 5), the value of the determinant did not result as zero (therefore, there are no liner-dependent variables), while the KMO test (from the relationship between observed and partial correlations) of 0.808 confirms that the relationship between pairs of variables can be explained by the relationship with the remaining variables and that multi-varied technique was suitable. Furthermore, the high value (180.4) of the

Bartlett test is significant ( $p < 0.0001$ ) and allows for the affirmation that the initial correlation matrix is significantly different from the identity matrix (null hypothesis was thrown out), in which each variable is correlated to itself and only itself and independent from the others. At this point, we moved on with the other sequence of operations contained in the software used for this study.

## 4. Results and discussion

### 4.1 Economic-structural characteristics and aspects of the oenological businesses surveyed

The technical-economic characteristics of the 35 surveyed units are outlined in table 6. Of these businesses, 55% are located in the province of Trapani, 25% in the province of Palermo, and the remaining 20% in Agrigento. With reference to company formation and types of companies, half of the businesses are limited companies, 25% are cooperatives and the remaining companies are limited liability (incorporated) companies.

As far as the introduction of ISO is concerned, long-standing as well as newly founded business were interested

Table 6 - Principal technical-economic characteristics of the Sicilian oenological enterprises surveyed (2010)(\*)

Indications	Value	Indications	Value
<b>Location, n.</b>		<b>Vineyards Area, ha</b>	
- Agrigento	7	- minimum	400
- Palermo	9	- maximum	5,500
- Trapani	19	- average	2,600
<b>Legal structure, n.</b>		<b>Bottles, n. (000)</b>	
- Limited companies	18	- minimum	100
- Limited liability companies	9	- maximum	14,500
- Cooperatives	9		
<b>Founding date, n.</b>		<b>Employees n.</b>	
- before 1960	18	- Full time workers	
- between 1960 and 2000	14	- minimum	4
- after 2000	4	- maximum	73
		- medium	30
<b>Certifications implemented, n.</b>		- Seasonal workers	
- company quality system	21	- minimum	5
- company quality system and environmental	14	- maximum	150
		- medium	70
<b>Certifications held by companies, n.</b>		<b>Final markets concerned production (%)</b>	
- DNV Italia srl	18	- domestic	46
- Certiquality	9	- international markets	54
- CSQA s.r.l.	9		
<b>The issue date of quality system, n.</b>		<b>Buyers of certified products (%)</b>	
- before 2000	16	- wholesalers and/or exporters	22
- between 2001 and 2005	12	- G.D.O.	24
- after 2005	7	- specialized stores	10
		- H.O.R.E.C.A.	44

(\*) Own calculation on direct data (face-to-face interviews) at the enterprises surveyed.

Table 7 - Matrix of the values of sample suitability measurement regarding each variable surveyed in the sicilian oenological business with ISO systems (2010).

		ORGEST	COSCA	CORE	ACQSTRU	TRACC	RAPACQ	IMPROVA
Correlation	ORGEST	0.834 *	-0.435	0.119	-0.070	0.277	0.212	0.018
	COSCA	-0.435	0.776 *	-0.182	-0.074	-0.231	0.123	-0.596
	CORE	0.119	-0.182	0.869 *	-0.127	0.235	0.136	-0.031
	ACQSTRU	-0.070	-0.074	-0.127	0.803 *	0.085	0.677	-0.141
	TRACC	0.277	-0.231	0.235	0.085	0.511 *	0.283	-0.201
	RAPACQ	0.212	0.123	0.136	0.677	0.283	0.753 *	-0.204
	IMPROVA	0.018	-0.596	-0.031	-0.141	-0.021	-0.204	0.772 *

(a) Sample suitability measurement (MSA).

in certification. As a matter of fact, about 50% of the examined cases had started wine production before 1960, while 40% between 1960 and 2000, and just 10% in the last decade. These businesses, in 60% of the cases, had implemented a company quality system, to which 40% of them also added environmental certification. With reference to the Boards or Agencies that issued ISO certification to the industries pertaining to the study herein, half were checked by DNV Italia s.r.l., while the other companies are divided among other agencies or boards, such as Certiquality (roughly 25%) and CSQA s.r.l. (25%). Regarding the time period of certification, 45% of the companies had implemented these systems before 2000, while the remaining 55% between 2001 and 2005 or in the following years.

There appears to be a great deal of interest in the direct connection with production (grapes), mainly from the region itself. As a matter of fact, all certified companies and businesses directly control a rather large area of vineyards, which varies in our study from 400 to 5,500 hectares, with an average area of 2,600 hectares. This confirms the current trend that sees companies working towards greater vertical integration aimed at improving qualifications and increasing production values, while keeping close at hand the market for grape supply, which is fundamental in order to meet production needs.

A fundamental indicator of the production capacities of winemaking companies is represented by the annual bottle production, fluctuating in our study from a minimum of 100,000 to a max of 14,500,000, to which we must also add other types of products. This number seems to be growing rapidly, in connection with certification and quality control of production and the production concentration of must and table wines, demonstrated by the fact that a large part of the production of these companies is aimed at making wines with a specific quality range (DOC, IGT, etc.), to the detriment of house wines and wines from casks. Regarding the number of employees working in the sector in 2009, full-time workers varied from 4 to a maximum of 73, with an average of 30, while seasonal workers varied from 5 to 150, with an average of 70 workers (during harvesting and the

first steps of winemaking).

As far as the markets of these companies were concerned, the Italian (domestic, including regional and national) market absorbed on average 46% of overall production, while foreign markets received 54% of the products, with the majority (in Europe) going towards Germany, Belgium, Scandi-

navia, the U.K., etc., and non-European markets such as Canada, the U.S., Japan, etc. The biggest buyers of certified products are wholesalers and/or exporters (on average about 22%), followed by the G.D.O. (roughly 24%), specialized stores (around 10%) and HORECA direct sales channels (around 44%), and others.

#### 4.2 First results of multi-varied analysis

The variables that registered the importance that these companies attributed to the benefits of the ISO quality system implementation were reduced to an overall number of 7, filtering out cases that were not suitable to the normal multi-varied distribution. By examining the values of sample suitability measurement regarding each variable (see table 7), we can find high correlations with the exception of the TRACC variable, which comes to a little over 0.511.

Following this, the resulting matrix was created (see table 7), where we reported the correlation coefficient values observed in pairs to pairs, all with significant probability, in order to identify the presence of possible correlation (relative) relationships among the variables. Moreover, we find different degrees of correlation – more marked for the pairs of variables ORGEST and COSCA (with values exceeding 0.7) on one hand, while on the other, between ACQSTRU and RAPACQ (with absolute values greater than 0.8), respectively markers of “company organizational structure” (context variables within the business system) and “relationships with market environments” (variables outside with production system)<sup>5</sup>.

For each group of variables that was identified, we moved forward to create the additive index (weighted), which could provide the position of the person interviewed with respect to the four value constellations, taking into consideration a relative synthesis of the original information and data. This was all made possible thanks to “Principal Component Analysis” (PCA), which allows for the transformation of initial variables into new variables (or principal components), derived from the linear combination of original data and built in such way that they are not correlated, even if they condense the greatest possible amount of original data.

Eigenvalues extracted from the analysis were listed in table 8, where there is clear evidence that only the first two components show eigenvalues (and therefore variance)

<sup>5</sup> This regards important information due to the fact that it immediately supports a decision based on two principal factors.

Table 8 - Eigenvalues matrix and reduced and variance of the principal components and of original factors (2010) (\*).

Component	Initial eigenvalues			Weighted values		
	Total	% variance	% cumulative	Total	% variance	% cumulative
1	3.9278	56.114	56.114	3.928	56.114	56.114
2	1.034	14.773	70.886	1.034	14.773	70.886
3	0.751	10.731	81.617	0.751	10.731	81.617
4	0.634	9.063	90.680	0.634	9.063	90.680
5	0.350	5.005	95.685	0.350	5.005	95.685
6	0.163	2.330	98.016			
7	0.139	1.984	100.000			

(\*). Extraction method: Principal Component Analysis (PCA).

Table 9 - Reproduced and residual correlations among variables surveyed of sicilian oenological business with ISO systems (2010) (\*).

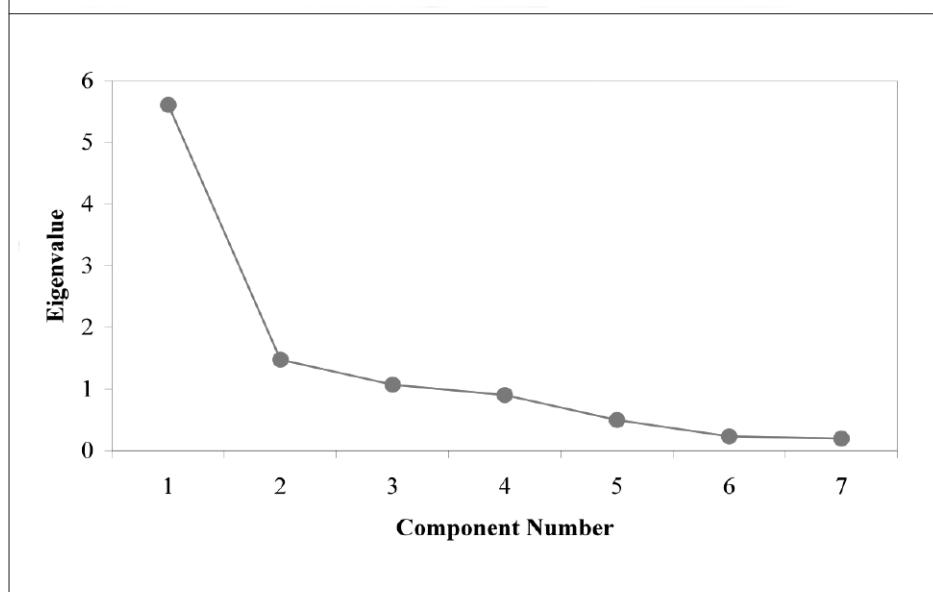
	ORGEST	COSCA	CORE	ACQSTRU	TRACC	RAPACQ	IMPROVA
Reproduced correlation							
ORGEST	0.979 <sup>b</sup>	0.759	0.343	0.606	0.066	-0.631	0.489
COSCA	0.759	0.891 <sup>b</sup>	0.476	0.680	0.311	-0.652	0.809
CORE	0.343	0.476	0.998 <sup>b</sup>	0.489	-0.015	-0.466	0.349
ACQSTRU	0.606	0.680	0.489	0.938 <sup>b</sup>	0.209	-0.909	0.508
TRACC	0.066	0.311	-0.015	0.209	0.995 <sup>b</sup>	-0.333	0.197
RAPACQ	-0.631	-0.652	-0.466	-0.909	-0.333	0.928 <sup>b</sup>	-0.399
IMPROVA	0.489	0.809	0.349	0.508	0.197	-0.399	0.970 <sup>b</sup>
Residual							
ORGEST		-0.046	0.006	0.013	0.010	0.010	0.021
COSCA	-0.046		-0.013	-0.008	-0.019	0.000	-0.055
CORE	0.006	-0.013		0.003	0.003	0.002	0.006
ACQSTRU	0.013	-0.008	0.003		0.013	0.067	-0.009
TRACC	0.010	-0.019	0.003	0.013		0.012	0.007
RAPACQ	0.010	0.000	0.002	0.067	0.012		-0.014
IMPROVA	0.021	-0.055	0.006	-0.009	0.007	-0.014	

(\*). Extraction method: Principal Component Analysis (PCA).

(a) Residuals are elaborated among correlations observed and reproduced. There are no redundant residuals 2 (9,0%) which have absolute values larger than 0,05.

(b) Communality reproduced

Figure 1 - Graphic representation of the eigenvalue (2010).



greater than 1. On the other hand, all other components have a variance less than that of a single original variable. Moreover, the first two principal components are able to reproduce nearly 3/4 (about 71%) of and total variance. Furthermore, they can be considered representative of the set of information contained in the original variables (therefore, the rest has a marginal role in assessing the ISO quality system). In this way, 2 of the 3 heuristic criteria have been respected for the choice of the number of components (components that describe 70-80% of overall variability; components that of an eigenvalue  $\geq 1$  with variance  $>$  average variance). Moreover, the eigenvalue graph, or "screen plot" (figure 1) also suggests the use of 2-3 components, falling with the break. By definition, it would be enough to gather an overall variability of 70% and, therefore, the two-factor solution, taking into account the fact that even the inspection of the reproduced and residual correlations (table 9) suggest avoiding the extraction of further additional factors.

In order to interpret the principal components, the factor pattern matrix and structure matrix were developed (table 10). Respectively, these matrixes represent the correlations between original variables and the first two principal components. Furthermore, in order to compensate for widely-known inconveniences pertaining to the extraction method (certainly not the independence among latent factors – there is a high complexity of the structure of extracted factors, etc.), and in order to obtain a factorial model that can be easily interpreted, we carried out the oblique axis rotation with the Kaiser PROMAX technique, holding a fixed number of factors and communality (explained variance) of each observed variable<sup>6</sup>. In this manner, the first component, which explains only about 56% of the total variability and is therefore the source of greater

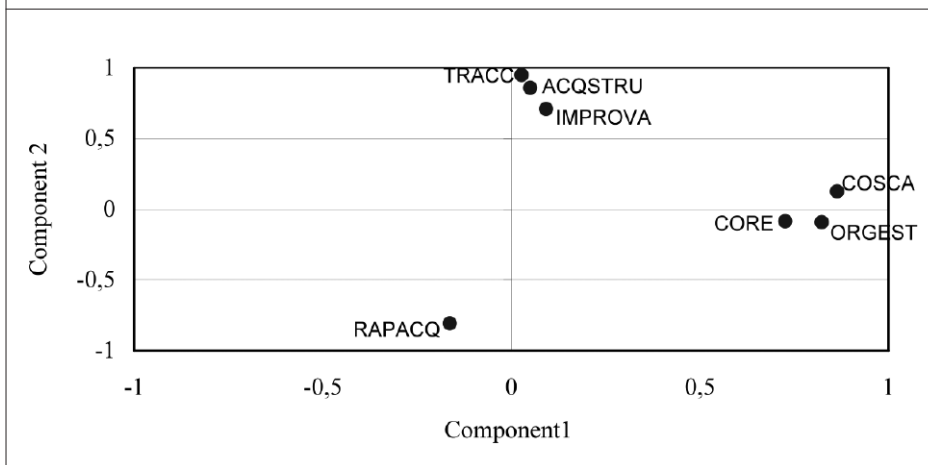
<sup>6</sup> "Communality" values (the total variability that each single variable shares with all the others) after the extraction carried significant results for almost all "environmental" and "contextual" aspects taken into consideration.

Table 10 - The factor and structure matrix and correlations among components extracted by variables surveyed in the sample of sicilian oenological business with ISO systems (2010) (\*).

Factor pattern matrix (a)			Structure matrix			Correlations matrix of components		
	Component			Component		Component	Component	
	1	2		1	2		1	2
COSCA	0.864	0.127	COSCA	0.931	0.582	1	1.000	0.527
ACQSTRU	0.050	0.859	ACQSTRU	0.503	0.885	2	0.527	1.000
ORGEST	0.823	-0.092	RAPACQ	0.775	0.342			
RAPACQ	-0.163	-0.806	ORGEST	-0.588	-0.892			
CORE	0.726	-0.084	IMPROVA	0.682	0.299			
IMPROVA	0.092	0.709	CORE	0.466	0.757			
TRACC	0.027	0.950	TRACC	0.528	0.964			

(\*) Extraction method: Principal Component Analysis (PCA). Rotation method: Promax with Kaiser technique.  
(a) Rotation has reached convergence criterias in 3 reiterations.

Figure 2 - Graphic representation of the saturation in the selected principal components (2010).



variability among the advantages brought forward by the ISO system in Sicilian wine producers, emerges clearly characterized by the connection with the variables linked to the sphere of “advantages in reduction of costs and/or production waste” (COSCA), “rationalization of the organization and management of production processes” (ORGEST) and “personnel involvement and responsibility” (CORE), while the second component (which involves roughly 15% of the total variability) results positively connected with the advantages pertaining to “traceability and possibility to resolve future disputes” (TRACC), to “business to business relations with different buyers” (RAPACQ) and/or in the “acquisition of goods and services” (ACQSTRU), in addition to “exploitation of company and brand image” (IMPROVA) on the market. These linking relationships prove to be valid when considering the non-rotated matrix as well as the matrix pro-

<sup>7</sup> Holding of ISO certification in the oenological industry cannot be directly detected on the label of each bottle of wine and, therefore, does not, in fact, represent added information that is an advantage to the end consumer, but rather it is set as a required instrument for the wine cellar's access to sales orders or business opportunities where they can show a “warrantee” or “guarantee” of their ability to respect contractual agreements.

duced by axis rotation. The importance of the correlation between two components also arises from the differences among the secondary saturations in the two matrixes. As a matter of fact, while the secondary saturations in model matrixes have an absolute value which is nearly always less than 0.1, in the structure matrix they are generally 0.5.

Moreover, the factorial pattern shown in the graph (figure 2) clearly shows the simple structure created after axis and saturation rotation compared to the selected principal components.

Through the implementation of the quality system, the oenological firm is required to qualify wine suppliers, discriminates against them in accordance with the degree of specialization and sub-contracting activities required and commits them to follow the progress of the final product quality.

From an organizational perspective, the various operators of the winery are also assigned functions of scrutiny and accountability with the aim of reducing the random variability of several factors (for instance due to the different abilities of the operators, to fluctuations in working conditions in cellars, often as a result of the peculiarities of wine and seasonal trends and characteristics of the territory

of origin) or special (for instance, abnormalities of regulation of bottling machines, causing non-compliance in the volume of liquid in the bottle).

The wine quality system is involved in relationship management in the commercial sector and in response to that the production system is called upon to give the competitive market, in terms of standard of services (including communication), trading, etc. . .

In conclusion, the simplification of the variables based on the statements given by the ISO-certified companies and the study of their relationships created by PCA allow for a greater understanding of the importance placed on the continuous improvement of the production process, the reduction of production costs, in addition to the chance to implement a system of traceability that guarantees product quality and reduce possible disputes. Ensuring and guaranteeing quality to the consumer, made possible by certification systems, facilitates *business to business*<sup>7</sup> relationships, while also simplifying possible issues regarding order compliance, and ultimately improve company image, competitiveness and reference market credibility. Initial problems (formulating the production process, training and updating of personnel, etc.) counterpoint other immediate substantial “advantages” within, among other things, the respect of



current legal limitations regarding company and business liabilities and responsibilities (worker safety, consumer protection and environmental awareness and protection).

## 5. Conclusions

The noteworthy recent increase in certification is clearly shown by the growing number of winemakers and winegrowers that have implemented quality systems and standards. This subject proves to be particularly important to the Sicilian winegrowing and wine-producing sector, which has been going through an intense period of requalification of their products, improvement of market competitiveness, along with the rapid increase in the number of quality systems adopted by these companies. The extent to which this phenomenon has influenced this sector was the push behind this study, based on a sample set of certified Sicilian oenological businesses. Our research shed light on exactly how certification system can represent a key element for small and medium-sized wine-making and wine-producing enterprises in order to improve organizational efficiency, productivity, and company image, as well as favour sales relationships with buyers.

The importance of the aforesaid is further supported by results from Principal Component Analysis (PCA), used to assess the data regarding the opinions and judgements of the businesses that participated in this study – data which was based on the level of satisfaction reached after a certain period of system certification application. This technique, which allowed for the composition of new “artificial” variables starting from original variables and thus guaranteeing a minimum of information loss, highlighted at least two sets of motivations that favour the introduction of a certification system for production processes or environmental protection, be it external or internal.

As far as internal motivations were concerned, the advantages that the quality system can offer a company translate, above all, into the continuous improvement of production processes, greater involvement of personnel, and cost reduction. These motivations show, as a matter of fact, that within the area of their group membership (general market goals and economic-financial goals) there are high values in terms of frequency as well as convergence of their answers. With reference to external motivation, the companies generally undertake the road towards certification, above all, pushed by the somewhat binding demand from public and private buyers that require their suppliers to adopt quality control systems that offer a greater degree of guarantee on supply results, including the reduction of objective responsibility risks and a simplification of control methods. For those businesses that took part in the study, quality certification was a fundamental prerogative in order to penetrate the market and create sound business relationships with those buyers (above all foreign buyers) that have a preference for the implementation of “common” production terms represented by ISO standards, without overlooking the appealing advantages stemming from the possibili-

ty to have access to public or state financing, a situations that has led a great deal of companies to choose and/or maintain quality system certification and/or implementation of environmental management systems.

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