The Impact of Various Grape Diseases on the Quality of Grapes and Wines

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Abstract: The relationship between grapevine diseases and wine quality is a significant concern in the global wine industry. In Georgia, recognized as the "Cradle of Wine," the production of high-quality wine is paramount for both local and international markets. This study investigates the effects of different grape diseases on key chemical and physical parameters of grapes and the resulting wines. It aims to provide insights into sustainable vineyard practices and adaptive strategies under the influence of global climate change.

Keywords: grape, grape diseases, grapes and wines quality, botrytis, downy mildew.

Introduction

Relevance of the Study:

Global wine consumers have become increasingly adept at identifying faults in wine quality. Georgian winemakers, bearing the "homeland of wine" distinction, face the responsibility of maintaining superior quality standards. Issues such as wine defects and faults often stem from errors during grape cultivation, wine production, or storage. These defects can significantly impact consumer perception, marketability, and economic returns for wine producers.

Impact of Climate Change:

Climate change poses a significant challenge to viticulture, altering the dynamics of grapevine diseases and their severity. Rising temperatures, increased precipitation variability, and extreme weather events have led to shifts in the geographic distribution and intensity of diseases like downy mildew, botrytis, and powdery mildew. These diseases compromise grape health, leading to diminished quality in phenolic compounds, organic acids, and aromatic profiles. This necessitates a deeper understanding of disease management in the context of evolving environmental conditions.

Global Perspective and Local Implications:

On a global scale, maintaining the consistency and quality of wine has become a competitive advantage. Georgian winemakers, with their unique varietals and traditional techniques, are uniquely positioned to appeal to niche markets. However, this opportunity can only be fully realized if grapevine diseases and their impacts are effectively managed. The interplay between local vineyard practices and global market demands underscores the importance of this research.

Research Objectives:

This study examines the effects of various diseases, including botrytis, downy mildew, and powdery mildew, on the chemical composition of grapes—such as phenolic compounds, organic acids, and trace elements—and tracks transformations during fermentation and aging. The study also evaluates the efficacy of technological interventions in mitigating the negative impacts of diseased grapes on wine quality.

By analyzing the influence of diseases on grape composition and subsequent wine quality, the research aims to provide actionable recommendations for sustainable vineyard management. These insights are intended to enhance the resilience of Georgian viticulture against environmental and market pressures, thereby ensuring the continued success of its wine industry.

Materials and Methods

Research Objects:

The study focused on healthy and diseased grapes of the Rkatsiteli, Khikhvi, and Budeshuri Saperavi varieties, sourced from the scientific collection plots of the Jighaura Research Center in Shida Kartli, Georgia. Diseases identified included botrytis, downy mildew, and mite infestations.

Identification:

The identification of grapevine diseases plays a crucial role in managing their impact on viticulture and ensuring the production of high-quality wines. Internationally recognized methods provide standardized approaches that enhance the accuracy and consistency of disease diagnosis. In this study, the identification of grape diseases was conducted under the supervision of Dr. Luda Tskhvedadze at the Plant Protection Laboratory. The use of OIV descriptors ensured adherence to international standards. Additionally, visual inspections were complemented with molecular diagnostics to confirm pathogen presence and evaluate their impact on grape and wine quality.

Experimental Design:

Grapes were harvested from control (healthy) and experimental (diseased) plots.

Classic winemaking techniques were applied to produce white and red wines.

Analyses included sugar, acidity, phenolic content, and fermentation dynamics.

Research Methods:

Visual Inspection and Documentation: Grapes were examined visually, and diseases were documented using high-resolution imaging.

Chemical Analysis of Grapes: Parameters such as sugar content, pH, total acidity, and phenolic compounds were analyzed using spectrophotometric and titration methods.

Winemaking Processes: Grapes were processed under three different conditions: destemmed, whole-cluster, and juice-only fermentations, using pure yeast cultures.

Fermentation Monitoring: Alcoholic fermentation dynamics were tracked through daily measurements of sugar levels, temperature, and alcohol content.

Microbial Analysis: Samples were cultured to identify dominant microbial populations in diseased and healthy grapes.

Statistical Analysis: Data were analyzed using ANOVA and multivariate statistics to assess the significance of observed differences.

Data Analysis:

Quantitative analyses were performed using established methodologies and international standards. Statistical processing employed variational statistics with three to five repetitions per sample.

Results

Monitoring of Chemical Components During Ripening:

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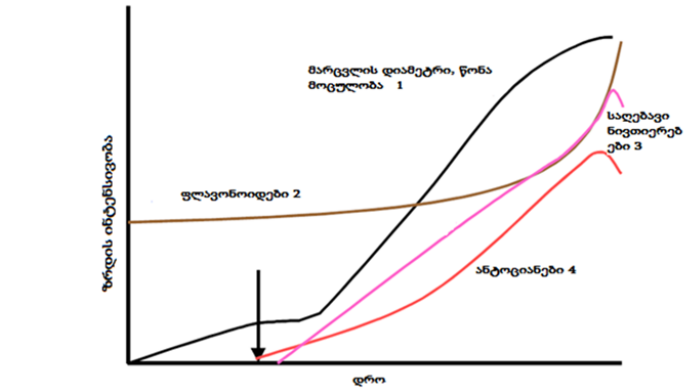

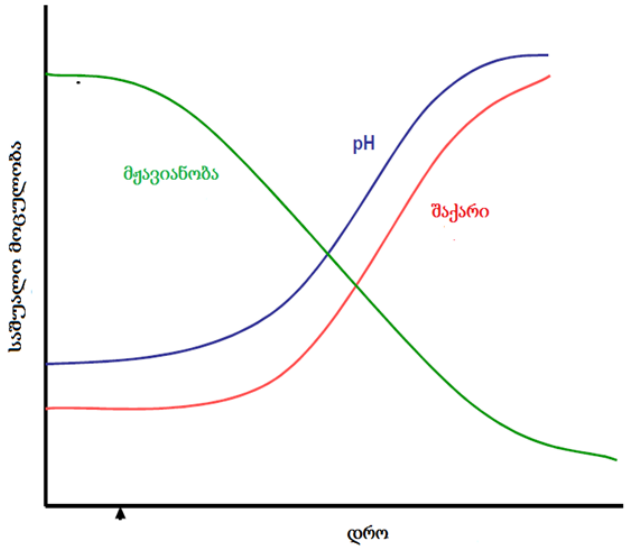

Figures 3.1.1 and 3.1.2 illustrate the dynamics of sugar accumulation, acidity reduction, and pH changes in healthy grapes during ripening. Diseased grapes showed deviations, including increased sugar concentration and altered acidity due to skin damage and evaporation.

Grape Cluster Characteristics:

Grape Variety	Cluster Length (mm)			Cluster Diameter (D1/D2, mm)		Cluster Weight (g)			**Cluster Volume (cm³)**
	in	id	ax	in	ax	in	id	ax	

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Budeshuri Saperavi (Healthy)	50	60	65	D_1-11.0	I_2-5.5	92	05	18	350
Rkatsiteli (Healthy)	45	50	63	D_1-8.0	I_2-5.0	78	90	04	290
Khikhvi(Healthy)	62	68	75	D_1-9.0	I_2-6.0	65	87	99	320
Budeshuri Saperavi (Mites)	35	40	45	D_1-7.5	I_2-5.5	00	20	45	180
Rkatsiteli(Downy and Powdery Mildew)	23	37	43	D_1-9.0	I_2-5.5	30	48	83	145
Khikhvi (Botrytis)	42	55	65	D_1-7.5	I_2-5.0	78	05	3	195

Table 1 highlights differences in cluster geometry and weight between healthy and diseased grapes. Diseased clusters exhibited reduced length, diameter, weight, and volume due to tissue damage and dehydration.

Must and Wine Analyses:

Sample	Sugars (%)	Total Acidity (g/L)	PH	Total Nitrogen (%)	Proteins (%)
Rkatsiteli (Healthy)	21,3	4,75	4,2	0.090	0,563
Rkatsiteli (Diseased)	23,4	7,27	3,5	0,092	0,575
Khikhvi (Healthy)	22,4	5,1	3,8	0,080	0,225
Khikhvi (Botrytis)	25,5	5,25	3,4	0,081	0,250
Budeshuri Saperavi (Healthy)	25	4,95	4,1	0,088	0,550
Budeshuri Saperavi (Mites)	26	5,4	3,8	0,090	0,563

Table 3.2 shows increased levels of sugars, acids, phenolics, and proteins in must from diseased grapes. These changes are attributed to the metabolic activities of microorganisms affecting respiration and assimilation processes in grapes.

Fermentation Dynamics:

Alcoholic fermentation lasted 15 days, monitored through sugar degradation and alcohol accumulation. Diseased grapes produced wines with higher volatile acidity and reduced stability, often accompanied by undesirable sensory characteristics.

Conclusions

In Kartli, common grape diseases include downy mildew (Plasopara viticola), powdery mildew (Erysiphe sp.), mites (Phytoseiulus sp.), and botrytis (Botrytis cinerea).

Diseased grapes demonstrate significant alterations in chemical composition, leading to wines with higher acidity, phenolics, and proteins but reduced sensory appeal.

Sustainable vineyard practices and targeted technological interventions can mitigate the negative impacts of diseased grapes on wine quality.

Practical Implications:

Understanding the influence of grapevine diseases on wine quality is essential for developing adaptive strategies to combat the challenges posed by climate change. This knowledge benefits farmers, producers, and the broader wine industry by enhancing product quality and market competitiveness.

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