DEVELOPMENT OF GRAPE MICROFLORA DURING THE STORAGE PERIOD

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This research aimed to study the composition of epiphytic microflora on grape berries of certain varieties immediately after harvest and during long-term storage in the refrigerator and determine the effectiveness of using sulfur dioxide to prevent grape spoilage. Table grape varieties Agadai, Gara Shaani, Ag Shaani and Sary Gilya were chosen as the objects of microbiological studies. Microbiological contamination of berries determined by inoculation on a growth medium. Fumigations with sulfur dioxide were applied to suppress harmful microorganisms' activity. Found that the microbiology contamination of fresh grape berries differs sharply by grape variety: fungi of the genus *Alternaria* found in Agadai, *Aspergillus* in Gara Shaani, *Penicillium* in Ag Shaani, and *Fusarium* in Sary Gilya. Also, research results have shown the effectiveness of using sulfur dioxide which allows for a decrease in the fungi quantity by up to 87%.

Keywords: fumigation, fungi, grape microflora, storage technology, varieties

INTRODUCTION

The tendency of the increase in world fresh grape consumption (31.5 mln t in 2022, by 0.9% more than in 2021, OIV) leads to higher concurrency between grape producers that makes it inevitable to adapt to the market demands. Due to their initial nutritional and medicinal characteristics, grapes have a positive effect on human health and are an indispensable food product used in the treatment of nervous exhaustion, weakness and avitaminosis. Each kg of the grapes contains 150-200 g and more of sugar (glucose and fructose), up to 1.4% of organic acids (tartaric, malic, etc.), vitamins: A (carotin), B2 (riboflavin), C (ascorbic acid), P (citrin), up to 1.5% of mineral staffs (P, K, Fe, Ca, etc.), about 1% of proteins, and about 1% and more of pectic stuff [Cosme et al., 2018; Salimov, 2019; Sabra et al., 2021; Zhou et al., 2022; Dave et al., 2023]. At the same time, as a seasonal fruit, the consumption period of the grapes is limited to 3-4 months, depending on the variety. From this point of view, prolongation of the shelf life of the grapes is quite an important matter. Prevention of the loss of 20-30% of the perishable food products manufactured also is possible only by applying cold storage. In living organisms such as fruits and vegetables, including grapes, even after harvest, there continue the processes of respiration (breathing) and persist the transpiration function. The intensity of these processes depends on the variety of the grape, the growing location, the agrotechnics applied, the degree of ripeness, and, if stored, the storage technology. As the intensity of the biochemical processes increases, also are accelerated the unpreventable changes that point out at the aging of the berries. The storage ability decreases, and the appearance of the berries worsens. Gradually they become softer, lose their flavor and medicine values, and the various microorganisms start developing on the berries` surface. Resistance of the grapes to microbial damage heavily depends on the berry skin properties – thickness and presence of a vax layer. If the integrity of the skin is damaged, this paves the way for microbes to enter the internal layers of the tissue [Sharma et al., 2018; Gorlov et al., 2020; Kazimova and Nabiyev, 2022; Ahmadi Soleimani et al., 2023].

Grape rot causes significant damage to producers and traders both before and after harvest

During storage, losses of grapes occur mainly due to microorganisms representing epiphytic microflora. According to research, at different stages, losses of produced grapes can reach up to 53% [Aghayeva et al., 2010]. The permanent composition of the microflora of grapes is mainly composed of fungi belonging to the *Penicillium, Botrytis cinerea, Aspergillus, Alternaria, Fusarium, Mucor Fresen,* and *Cladosporum species* [Highet and Noir, 1995; Guzev et al., 2008; Kassemeyer and Berkelmann-Löhnertz, 2009; El-Samawaty et al., 2013; Kantor et al., 2017; Rajput et al., 2020; Salman et al., 2021]. Typically, rot begins with the development of mold fungi since the acidic environment of tissue sap is favorable for them. Later, bacteria can also take part in spoilage. Spoilage occurs extremely quickly at high temperatures. In an appropriate environment, the spores grow, forming reproduction tubules that infect the skin of healthy berries. If such conditions are absent, fungi create sclerotia - long-lasting small black, dense masses of mushroom mycelium. In high temperatures and in a humid environment, sclerotia begins to develop and form conidia. If it rains, especially at low temperatures, there is a sharp increase in grape disease. The denser the bunch and thinner the skin of the berries, and the denser the crown of the plant, the more dangerous the pathogen is [Rajabi et al., 2015; Armijo et al., 2016].

The process of grape storage characterizes by the indicator named "storage ability of the variety", which refers to sustainability to diseases and physiological disorders, mechanical damages, and stress factors of the environment. In other words, the storage ability of grapes means maintaining freshness for several months without significant losses, infection with phytopathogenic and physiological diseases, and maintaining high organoleptic characteristics. From this point of view, cold storage is the most used method during the post-harvest period. For example, microbiological contamination is affected by the chemical composition of the berries, the presence of pectic, coloring, and other stuff belonging to the polyphenol group. Storageability also depends on the structure of the berries` tissue and skin, and the availability of the vax layer. The thicker the skin and tissue of the berries, the more difficult it is for pathogens and pests to penetrate the tissue and cause harm. To prevent losses during the storage period, carrying out all necessary agrotechnical operations, permanent phytosanitary and toxicological control of the soil and the yield, creating an optimal gas environment in the storage capacity, and other measures are needed. Such techniques as formation canopy, correct determination of buds, and productive shoot load also significantly affect successful grape storage. All the mentioned factors could be applied to influence the grape quality and increase its storage ability [Asadullayev et al., 2014; Rajabi et al., 2015; Gorlov et al., 2020; Romero et al., 2020].

During storage, the fruits continue to "live" at the expense of the plastic and energetic nutritional stuff accumulated in the vegetation period. In this connection, the main principle of yield storage is the slowing of spending of the nutrition stuff for respiration by the object of storage itself. Being an objective indicator of the ripening speed of the yield of different kinds and varieties, aging, and storage ability in general, the intensity of respiration could change significantly. The traditional storage at a temperature of about 0°C is based on the possibility of minimizing the respiration intensity. In such conditions, besides overripening of the product, the activity of the pathogen microflora is also suppressed [Szegedi, Civerolo, 2011; Ageyeva et al., 2015; Gorlov et al., 2020; Habib et al., 2021; Kazimova, Nabiyev, 2022].

Botrytis cinerea is the primary cause of post-harvest rot of grapes; however, depending on storage conditions, damage may be caused by other pathogens. To prevent the risks of the rottings, an integrated approach is needed. Preharvest control is based on prevention of the infection risks and is not limited only to the use of fungicides. Careful harvesting and packaging minimize damages and infections; this is one of the crucial requirements for preventing rots during storage [Szegedi et Civerolo, 2011; Rajabi et al., 2015; Wei et al., 2022].

After packaging and during storage, special attention should be paid to minimizing the infection risks and preventing the molds from spreading. Here, the right choice of storage temperature is a decisive factor. To suppress the activity of the pathogens, sulfur dioxide in various application ways is widely used: pads, layers, fumigation, etc. SO_2 pads are very effective for rot prevention during medium and long-term storage. In the case of applying fumigations, weekly treatments at the rate of 0.5-1.5 g per m³ of the storage camera carried out. Before fumigation, it is necessary to check the current state of the grapes stored. Effectiveness of application of the sulfur dioxid for prevention of grape damages during storage, is frequently noticed at in the relevant references [Ageyeva et al., 2015; Rajabi et al. 2015; Sortino et al., 2017, 2018; Ahmed et al., 2018; Roberto et al., 2019; Habib et al., 2021; Li et al., 2022; de Aguiar et al., 2023].

MATERIALS AND METHODS

As the objects of study there were chosen three local (Ag shaani, Gara shaani, and Sary gilya) and one introduced (Agadai) table grape varieties grown in the Ampelographic Collection of the Scientific Research Institute of Viticulture and Wine-making. Descriptions of the above-mentioned varieties can be found in the database of the Vitis International Variety Catalogue (VIVC). The Ampelographic Collection is located on the Absheron peninsula, in the eastern part of the country, on the coast of the Caspian Sea. The climate type of the peninsula is dry and subtropical. The mean annual air temperature is 13.5-14.4°C, the sum of active temperatures is 4192-4461°, mean annual precipitation is 202-311 mm. This is a traditional region of table viticulture. The yield of the above-mentioned varieties was put in a cold store for four months. For suppressing the activity of the pathogenic microflora during the storage period, weekly fumigations with sulfur anhydride (2 g per each m³ of the refrigeration camera) were used. The type of microflora on the berry's surface was determined by plantation on the growth media. The number and change dynamics of the microflora and the effect of the fumigations applied were assessed before and during the storage period.

RESULTS AND DISCUSSIONS

We found that the microbiological contamination differs sharply between the varieties studied. So, in the Ag shaani variety, the fungi were represented by the *Penicillium* species, in Gara shaani – by *Aspergillus*, in Sary gilya – by *Fusarium*, and in Agadai – by *Alternaria*. Also, there were heavy variations concerning the quantity of the microorganisms found on the surfaces of different grape varieties (Table). Fumigation realized immediately after putting on store significantly decreased the contamination by the fungal pathogenes by 37-87%, depending on grape variety. Application of SO_2 led to furthed decrease in pathogenic microflora, and by the end of storage, the amount of fungi made 1,6-41,9% of the initial quantity.

We can see that the scale of microbiological contamination of different varieties strictly

Table. Quantity of microorganisms on grape berries` surface during storage period (thousands per 1 g of berries)

Variety	Fungi	Non-fumigated, before storage	Fumigated		Losses after storage, %
			On putting on storage	After storage	
Ag shaani	*Penicillium*	1.2	0.8	0.6	27.3
Gara shaani	*Aspergillus*	2.4	0.5	0.05	0.7
Sary gilya	*Fusarium*	2.9	1.5	1.2	21.12
Agadai	*Alternaria*	1.7	0.2	0.06	1.7

corresponds to the size of losses after the storage period. The Ag shaani variety demonstrated considerable stem browning; in the Gara shaani and Sary gilya varieties, this process was going less intensively. Also, while most of the losses in the Gara shaani and Agadai varieties consisted mainly of detached berries, in the Ag shaani and Sary gilya varieties, the microbiological rot made the general part of the losses. Moreover, the slight browning of the berries observed in the white-coloured Ag shaani and Sary gilya varieties, which corresponds with literature data available [El-Samawati et al., 2013, Rajput et al., 2020, Salman et al., 2021]. Weekly fumigations during storage period led to further decrease in fungal load, and by the end of storage period, the quantity of the fungi was 1.1-6.2% from their initial number.

Thus, we can draw a conclusion that the storage ability of the grapes is affected both by the variety and the kind of fungi developing during the storage period; the Agadai and Gara shaani demonstrated high resistance to the fungal diseases, while there were considerable losses in the Ag shaani and Sary gilya varieties caused by *Penicillium* and *Fusarium,* respectively. So, the Agadai and Gara shaani varieties recommended for prolonged cold storage in the conditions of the Absheron peninsula. The studies also confirmed the effectiveness of applying sulfur dioxide for suppressing the activity of epiphytic microflora during grape storage.

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Saxlama zamanı üzümün mikroflorasının inkişafı

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Tədqiqatın məqsədi ayrı-ayrı üzüm sortların gilələrinin məhsul yığımından dərhal sonra və soyuducuda uzun müddət saxlandıqda epifitik mikroflorasının tərkibinin öyrənilməsi və üzümdə itkilərin qarşısının alınması üçün kükürd dioksidindən istifadənin effektivlik dərəcəsini müəyyən etməkdən ibarət olmuşdur. Tədqiqat obyekti kimi süfrə üzüm sortları Ağaday, Qara Şanı, Ağ Şanı və Sarı Gilə seçilmişdir. Gilələrin mikrobioloji yoluxması, qida mühitində aşılama yolu ilə təyin edilmişdir. Müəyyən olunmuşdur ki, təzə üzüm gilələrinin mikrobioloji çirklənməsi, üzüm sortundan asılı olaraq kəskin şəkildə dəyişir: Ağadayı sortunda *Alternaria*, Qara Şanıda *Aspergillus*, Ağ Şanıda *Penicillium*, Sarıgilədə *Fusarium* cinsinə aid göbələklər aşkar edilmişdir. Həmçinin, tədqiqatın nəticələri göbələklərin sayını 87% -ə qədər azalmağa imkan verən kükürd dioksidin istifadəsinin effektivliyini göstərdi.

Açar sözlər: fumiqasiya, göbələklər, üzümün mikroflorası, saxlama texnologiyası, sortlar

Развитие микрофлоры винограда во время хранения

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Целью исследований было изучение состава эпифитной микрофлоры ягод винограда отдельных сортов сразу после сбора и при длительном хранении в холодильнике и определение степени эффективности использования сернистого ангидрида для предотвращения порчи винограда. В качестве объектов микробиологических исследований были выбраны столовые сорта винограда Агадаи, Гара Шаани, Аг Шаани и Сары Гиля. Микробиологическую обсемененность ягод определяли путем посева на питательную среду. Для подавления деятельности вредных микроорганизмов применялась фумигация сернистым газом. Установлено, что микробиологическая обсемененность свежих ягод винограда резко различается в зависимости от сорта винограда: в Агадаи обнаружены грибы рода *Alternaria*, в Гара Шаани - *Aspergillus*, в Аг Шани - *Penicillium*, в Сары-Гиля - *Fusarium*. Также, результаты исследований показали эффективность использования сернистого ангидрида, что позволило снизить количество грибов до 87%.

Ключевые слова: фумигация, грибы, микрофлора винограда, технология хранения, сорта