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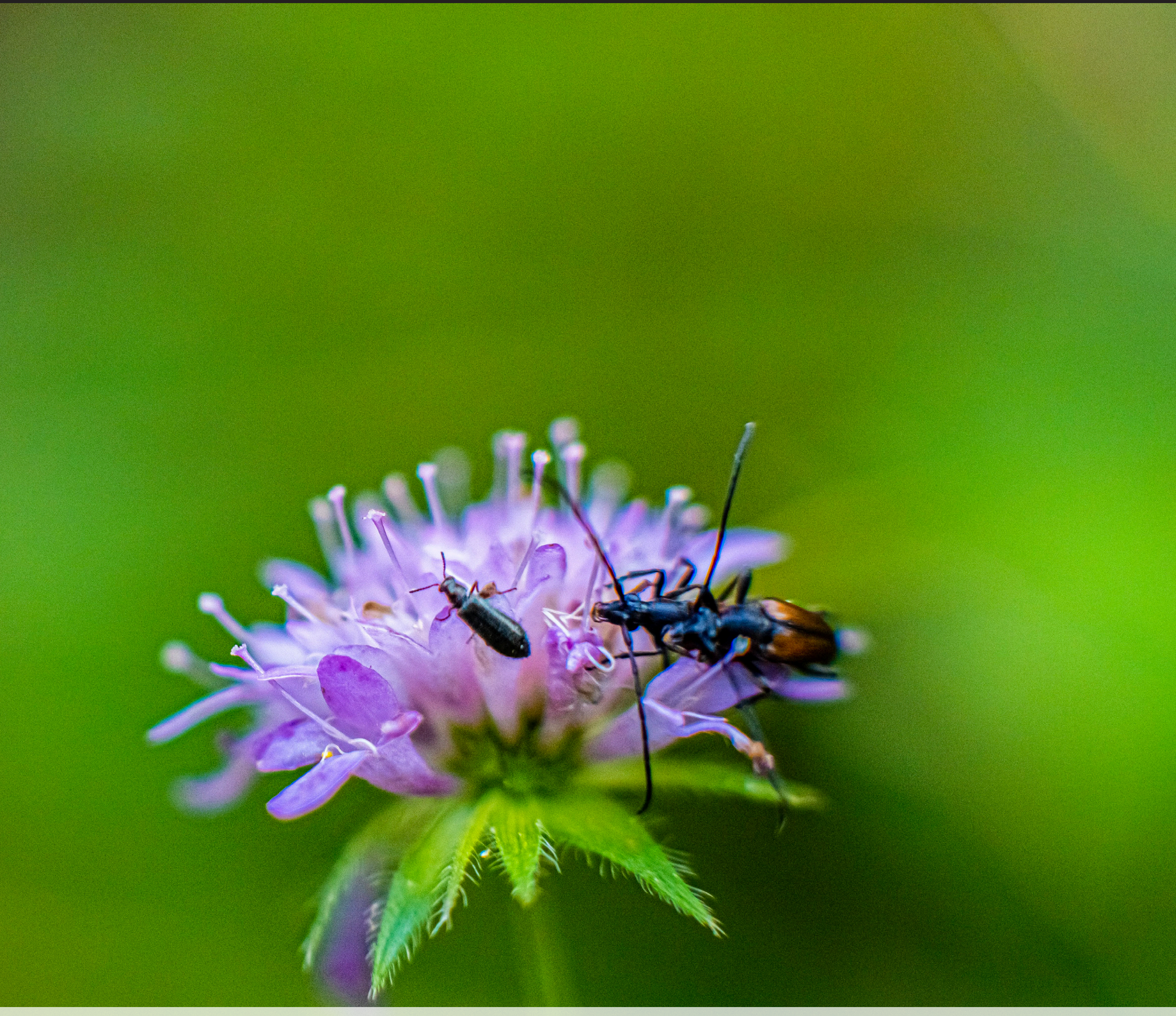
HUNGARIAN AGRICULTURAL RESEARCH

Summer 2022

Environmental management, land use, biodiversity



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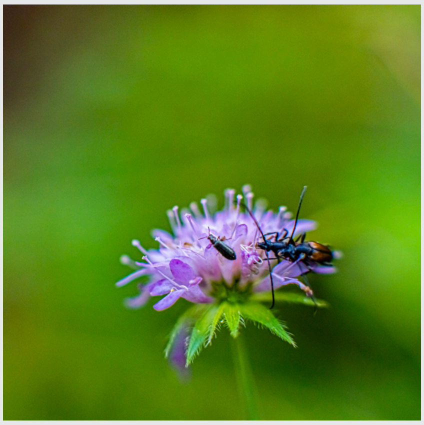

HUNGARIAN
AGRICULTURAL
RESEARCH
Environmental management, land use, biodiversity
Summer 2022 – Vol.32, No. 2.

Editor-in-chief:
András Béres (Hungarian University of Agriculture and Life Sciences)
Technical editor:
Nóra Koplányi (Herman Ottó Institute Nonprofit Ltd.)

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Cover photo:
Zoltán Szenek
Back cover:
Diána Arany

Published by
HERMAN OTTÓ INSTITUTE NONPROFIT LTD.

H-1223 Budapest, Park u. 2. Hungary
www.agrarlapok.hu/hungarian-agricultural-research l info@agrarlapok.hu
Publisher: Péter Bozzay
Owner
MINISTRY OF AGRICULTURE
Editorial Office
Herman Ottó Institute Nonprofit Ltd.
H-1223 Budapest, Park u. 2. Hungary

Subscription request should be placed with the Publisher (see above)
Subscription is HUF 3900 (only in Hungary) or
$16 early plus $5 (p & p) outside Hungary
HU ISSN 1216-4526

ENVIRONMENTAL FACTORS AND THE ROLE OF SENSORS IN CLIMATE MONITORING OF LIVESTOCK BUILDINGS

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ABSTRACT

Nowadays, the key factor of competitiveness is the method and extent of data collection, at what level they are analysed, evaluated, and what interventions are carried out. Furthermore, to achieve proper livestock farming, the aim is to ensure optimal climatic conditions for the animal buildings. The factors influencing the environment and their treatment are discussed in our work. Their effects help improve farmers' competitiveness based on animal welfare considerations, maintain a continuous good animal health status, and achieve more predictable production.

Keywords: livestock farming, environmental conditions, measurement methods, sensors

INTRODUCTION

Livestock farms should provide animals with an adequate microclimate in the enclosure, as environmental factors are crucial in livestock production's qualitative and quantitative characteristics (Tóth et al. 1998), (Fenyvesi et al. 2003). Furthermore, different animal species, breeds and age groups have different environmental needs. Therefore, it is necessary to create a microclimate in which the animal's comfort can be ensured, and its keeping is optimal and satisfies its biological needs (Figure 1). The microclimate is particularly important for livestock farms, especially poultry and pig farms (Herman Ottó Intézet 2020).


Figure 1: Cattle barn equipped with fans *(Source: NARIC MGI)*

The most important environmental factors include:

- the temperature of the stable air,
- the relative humidity,
- gas concentration and particulate matter,
- movement of air and the lighting (Tóth 2019).

These characteristics can be monitored with individual measuring systems or so-called multisensory systems.

MEASURING BACKGROUND FOR ENVIRONMENTAL FACTORS

Temperature measurement and control

The air temperature in the animal house is influenced by the outside air temperature, the building's thermal characteristics, and the heat production of the animals. Therefore, it is recommended to measure the barn's temperature at the animals' head height to meet the animals' heat demand. The desired temperature can be reached by appropriate control of the heating or ventilation. In animal husbandry systems, the typical temperature conditions are registered with electronic, gas and steam tension temperature sensors (Műszeroldal website).

One of the easiest ways to measure temperature is when an inside thermostat controls temperature. The thermostat detects the internal temperature of the building and activates the structural elements that help change the temperature according to the set value.

It can provide a more complex solution when the outside temperature is measured in addition to the inside. In this solution, a predetermined value is selected based on the signals of the sensors. Then, the external lower temperature air is introduced into the building while appropriate mixing is carried out (e.g., soil heat exchange tempering) (Tóth 2019).

Nowadays, computer control is mainly used. However, this solution also makes it possible to measure the humidity, temperature, and concentration of harmful gases in the outdoor and indoor air.

Depending on the animal species, inappropriate temperatures can cause heat stress in the individual and lead to the development of various diseases or even the animal's death.

Humidity measurement and control

The humidity of the outside air determines the humidity level in the livestock building, the phenomenon of evaporation in connection with feeding, watering and manure treatment, and the amount of moisture exhaled by the animals. Hygrometers, psychrometric or capacitive humidity sensors can determine the air humidity in livestock buildings (Tóth 1998).

The relative humidity value shows the relationship between the actual and maximum humidity in percentage terms. Another method that can be used for more accurate results is the simultaneous measurement of dry and wet temperatures. In this method, the measurement is conducted in the strongly flowing air with two thermometers, a dry and a water-moistened thermometer. A measuring device that can be used for this purpose is the psychrometer. In this case, the relative humidity is determined by the difference between the two types of measured temperatures (dry and wet), by calculation or by data table. In the case of a capacitive sensor, the change in the electrical permittivity of the dielectric material is measured to calculate the relative humidity values.

In a dust-contaminated environment, only the psychrometric sensor is recommended (due to the dust sensitivity of the sensors).

Maintaining relative humidity at the proper level avoids condensation on surfaces in contact with the external environment. Conversely, non-optimal humidity causes dehydration, dry cough, faster spread of pathogens, diseases, and death in severe cases.

Airspeed measurement and control

Besides the temperature and humidity characteristics described above, the comfort of the animals is ensured by the movement of the air. In closed livestock buildings, the desired air movement can be achieved by artificial ventilation, providing fresh air for the animals while removing excess vapour and gases in the atmosphere and particulate matter (Fenyvesi et al. 2003), (Herdovics et al. 2011), (Tóth 2018).

The air velocity can be measured by a rotating-cup anemometer, vane-anemometer, or thermal sensors. When measuring the air velocity with a rotating cup or vane-anemometer, the speed of the turbine wheel, which depends on the speed of the airflow, is converted into an electronically processable electrical signal using impulse transducers. The amperage varies according to the fourth power of the speed, so a low flow rate that other turbine devices cannot measure can be determined. In thermosensor air velocity meters, the sensor is heated to a significantly higher temperature than the flowing air (100-120 °C for semiconductors, 300 °C degrees or higher for metal filaments).

Platinum or tungsten fibers are used to prevent high-temperature corrosion. Improper air movement and drafts can cause colds and other concomitant illnesses.

Gas concentration measurement and control

The proportion of gases and particulate matter in the barn depends considerably on the size of the livestock, the feeding and manure treatment solutions used and the ventilation characteristics. The gases generated here can be measured using chemical reagents (hand-held air pollution meters) or more advanced electronic sensors (Figure 2). An example of such an advanced electronic sensor is the efficient and reliable gas monitoring system, the photoacoustic gas monitor. Additionally, a carbon monoxide probe can be used effectively at the maximum allowable concentration to monitor air quality.

Figure 2: Measurement of the gas content of the barn air *(Source: NARIC MGI)*

Table 1: Emissions to air from the intensive rearing of poultry or pigs

Air pollutant	Production system
Ammonia (NH_3)	Animal housing, manure storage, processing and landspreading
Odour	Animal housing, manure storage and landspreading
Dust (bioaerosols)	Animal housing, milling and grinding of feed, feed storage, solid manure storage and landspreading, heaters in buildings and small combustion installations
Methane (CH_4)	Animal housing, storage of manure and manure processing
Nitrous oxide (N_2O)	Animal housing, manure storage, processing and landspreading
NOX (NO + NO_2)	Animal housing, manure storage and landspreading, heaters in buildings and small combustion installations
Carbon dioxide (CO_2)	Animal housing, energy used for heating and transport on farm, and biogenic CO_2 that may be emitted in the field

Source: Santonja et al. 2017.

Also included are carbon dioxide sensors and gas probes for various gases, which measure ammonia, nitrogen dioxide, nitrogen oxide, chlorine gas, sulfur dioxide, hydrogen sulfide and ethylene oxide gases (Arany et al. 2018), (Senselectro website).

Ventilation in the livestock building is also important because the critical concentrations of carbon dioxide (CO_2), sulphur dioxide (SO_2), ammonia (NH_3) and dust pollution of gases hazardous to both animals and humans must be kept below the limit. Lack of proper regulation causes loss of appetite, somnolence and shortness of breath and can lead to other diseases.

The table below shows an example of emissions to air from intensive rearing of poultry or pigs production systems (Table 1).

Attention to the effects of climate change has also focused on emissions from the livestock sector. Major health risks are small particulate matter, PM_{10} (10 μm or less) and $PM_{2,5}$ (2,5 μm or less). The group of air pollutants considered the most harmful by the World Health Organization (WHO), which, by binding various toxic substances, can also enter the bloodstream through the respiratory system due to its size (Sutton et al. 2011), (WHO 2013). In order to reduce air pollution, including particulate emissions, the new National Emission Limits (NEC) Directive (2016/2284 / EC) entered into force in the European Union on 31 December 2016. The new NEC Directive, which replaces previous legislation, sets emission reduction commitments for 2020 and 2030 for five primary air pollutants (sulfur dioxide, nitrogen oxides, volatile /non-methane/ organic compounds, ammonia, and particulate matter). In the past decades, ammonia emissions have been the focus of the analysis in animal husbandry. This is because ammonia in the atmosphere can be transported over long distances and then returned to the soil and surface waters by dry or wet deposition. In addition to individual solutions, we can use integrated measuring devices, which we present below.

An overview of the reported emissions (range) associated with poultry houses for ammonia, methane, nitrous oxide, dust and odour is presented in Table 2. Studies and research on odor measurement are also important areas,

Table 2: Range of reported air emission levels from poultry houses

Type of poultry	NH_3	CH_4	N_2O	PM_{10}	Odour (1)
	kg per bird place per year				ou_E/s per bird
Laying hens - Enriched cage systems	0,01-0,15	0,034-0,078	0,0017-0,023	0,01-0,04	0,102-0,68
Laying hens - Non-cage systems	0,019-0,36	0,078-0,2	0,002-0,180	0,02-0,15	0,102-1,53
Pullets (cage and not cage systems)	0,014-0,21	NI	NI	0,008-0,078	0,042-0,227
Broilers	0,004-0,18	0,004-0,006 (2)	0,009 (2)-0,032	0,004-0,025	0,032-0,7
Broiler breeders	0,025-0,58	NI	NI	0,016-0,049	0,11-0,93
Turkeys (female) Whole period	0,045-0,387	NI	0,015 (2)	0,09-0,5	0,4
Turkeys (male) Whole period	0,138-0,68	NI	NI	0,24-0,9	0,71
Ducks	0,05-0,29	NI	0,015 (2)	0,01-0,084	0,098-0,49
Guinea fowl (2)	0,80	NI	0,015	NI	NI

Source: Santonja et al. 2017

(1) Odour emissions have been derived from original data expressed in ouE/s per LU
(2) COM, Best Available Techniques (BAT) Reference Document for the Intensive Rearing of Poultry and Pigs (ILF BREF), 2003
NI: no information provided

which are also discussed in many Hungarian publications (Béres et al. 2020a), (Béres et al. 2020b).

Multisensors, the integrated solutions

The multisensor is an integrated measuring device that can be expanded modularly, examining animal welfare conditions, and building management aspects. Based on developments in livestock farms, sensors measuring physical quantities that provide information from animals' living spaces have been included. This allows us to measure air temperature, humidity, ammonia and carbon dioxide, draft and noise levels (Kövesdi 2018), (Okosfarm 2021).

With the integrated measuring solutions, farmers can continuously and in real-time monitor the climate conditions affecting the animals in the livestock building. The measured data can be displayed via an internet browser and a telephone application using a software package. The software analysed the data and stored it for later use for transparency. The device can support automatic regulation based on pre-set parameters to maintain ideal conditions. It alerts and provides information to users in an emergency, providing the opportunity for correction and immediate intervention. For more accurate results, the sensor's design allows it to work at the head height of the animals. It can also be used in poultry, pig and cattle farms. The system also has a so-called remote-control function, which allows to turn on the fans and evaporators or open the vents if the data shows an outlier during gas measurement (Figure 3).

The sensor data and its information can primarily inform medium and long-term decisions.

Figure 3: In case of outliers during gas measurement, the ventilation system is automatically activated (*Source: Okosfarm.hu*)

Figure 4: Livestock farm with solar photovoltaic systems system in Hungary *(Source:energiatakarek.hu)*

Sensors of the future

It still takes time for the sensors to become operational in the agricultural sector, but precision livestock farming (PLF) systems have already been introduced in some Hungarian farms. With the help of PLF systems, the maximum production level corresponding to the genetic abilities of the livestock can be maintained continuously during production (Tóth 2021). Therefore, solar systems would also become increasingly popular on livestock farms and for residential use. In addition to sustainable management and renewable energy, their importance is to meet all the farm's energy needs, thus supplying the sensors with electricity. A good example of this is Hungarian cattle farms, where in several cases, we can already find buildings with solar systems (Figure 4).

SUMMARY

In more developed countries, autonomous farms have emerged, where the ultimate form of intelligent agriculture and the highest level of agricultural production is realised. In these farms, modern sensor technologies are used for all work processes to monitor the condition of the environment, farm animals, plants and the operating status of various treatment equipment. Examples of such new technologies are IoT (Internet of Things), Big Data, AI (Artificial Intelligence - MI), fifth-generation (5G) technology and robots. With these technologies, all production operations on the farm can be carried out remotely. However, control and site management systems cannot be achieved without a high IT background. This will drive livestock farms towards automation and ensure sustainable development in the long term.

ACKNOWLEDGEMENTS

This study was based upon work that the National Research, Development and Innovation Office's Fund supports within the" 2019-1.1.1.-PIAC-KFI-2019-00222 "Automated mobile architectural solutions for agriculture based on local raw materials and by-products".

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NETWORK FOR THE COUNTRYSIDE – HUNGARIAN NATIONAL RURAL NETWORK

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ABSTRACT

Nowadays, the countryside has been appreciated as a habitat. More and more people are moving from cities to villages of various sizes, where fresh air, proximity to nature and public services are available or within easy reach. The traditional rural world, characterised by peasant culture and agricultural production, is now completely different. The task of the Hungarian National Rural Network (HNRN) is to help rural development by building links between rural actors, presenting them with national and international good practices as well as implemented good examples. Our staff has extensive professional experience and a wide network of contacts to support projects funded by grants.

Keywords: countryside, network, community, local product, local economic development, rural development

INTRODUCTION

„Each Member State shall set up a national rural network bringing together organisations and administrations involved in rural development.” (Regulation (EU) No 1305/2013)

The Hungarian National Rural Network is a key player in the social and economic development of the countryside. It is the connecting and retaining network of the Hungarian countryside which helps people living and farming in the smallest settlements of our country in almost all areas of life, and also provides support in the access and efficient use of development resources to make the countryside more liveable.
The HNRN effectively protects and represents the interests of people living in rural areas, both in Hungary and in Europe, by coordinating the activities of governmental, municipal, civil and business organisations, as well as professional organisations.

ORGANISATIONAL AND OPERATIONAL BACKGROUND

The maintenance and operation of a national rural network is mandatory in all EU Member States, but the conditions for doing so may be set up by the Member States themselves. The Council of Europe Regulation (EC) No 1698/2005 of 20 September 2005 obliged Member States to draw up a national rural development program in line with the development plans for the 2007-2013 budget period and to set up a European Network for Rural Development. In this context, it also made it compulsory for Member States to set up national rural development networks. In Hungary, the Hungarian National Rural Network was established at the end of 2008.

The reorganisation of the Hungarian National Rural Network in 2011 and the establishment of the county-level network of regional representatives was initiated by Dr Bálint Csatári.

As the institutional system of rural development has changed over the last 10 years, so has the place of the HNRN in the organisational system. Thus, after the NAKVI, the Permanent Secretariat and the network of regional representatives were under the supervision of the Prime Minister’s Office and then the Széchenyi Programme Office.
From April 2020, the Hungarian National Rural Network „returned” to its old place, the Herman Ottó Institute Nonprofit Ltd, the successor institution of the National Agricultural Advisory, Educational and Rural Development Institute (NAKVI).
Its operational framework is provided by the HNRN technical assistance framework of the Rural Development Programme.
The tasks of the Network are defined by the Managing Authority (Deputy State Secretary for Agricultural and Rural Development of the Ministry of Agriculture) and the Board of the HNRN in its Action Plan, and the implementation of the tasks is coordinated by the administrative staff of the Permanent Secretariat.

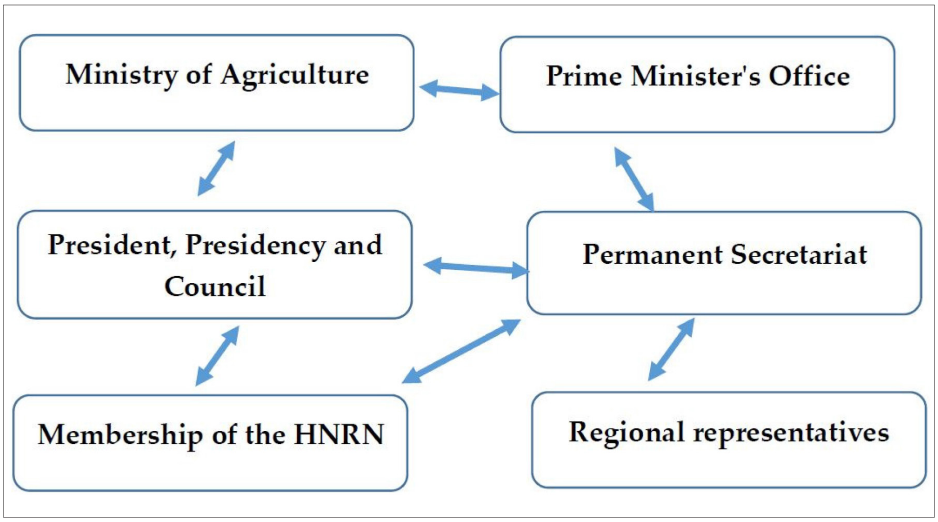

Figure 1: The professional management of the HNRN (*own editing*)

Permanent Secretariat

The professional and administrative background of the Hungarian National Rural Network is provided by the Permanent Secretariat (PS) which has been operating within the organizational system of the Herman Ottó Institute Nonprofit Ltd. since April 2020.

The Permanent Secretariat carries out the tasks underlying the operation of the Network and ensures the establishment of strong, direct links between government bodies and rural economic and civil organisations. In order to strengthen the regional and social cohesion, it promotes equal opportunities and unhindered access to information for registered members of the HNRN and other rural actors.

It is essential to organise events of national and regional significance, to hold professional exchanges, trainings, local planning, and development debates in order to bring together and inform rural developers, and the Permanent Secretariat is also involved in the organisation and implementation of these programmes.

The PS is responsible not only for national but also international relations, actively participates in the work of the European Network for Rural Development (ENRD) and the European LEADER Association (ELARD), promotes our domestic good practices abroad, and presents foreign good practices to the domestic rural development community.

The network of regional representatives

Based on the professional experience of former HNRN President, Dr Bálint Csatári thought it would result in more efficient networking if the HNRN became a link and a cohesive force between rural development actors with the help of “field experts” who were present in every county. The staff applying for the position of regional representative were expected to be versatile, mobile, willing to learn and to have a network of contacts in the counties. In practice, Bálint Csatári assigned a rural development manager role to the county colleagues, who were selected through a multi-stage recruitment process, with the agreement of the county LEADER action groups and other local rural development actors. The regional representatives started their work on 1 January 2013.

The tasks and the selection procedure of the regional representatives are not defined in the regulation governing the Hungarian National Rural Network, so they are always determined by the current organisation to which the Network belongs.

It is a huge challenge and experience to take part in the work of regional representatives, this profession means gaining experience and getting to know rural Hungary. They can attend conferences and study trips, both domestically and abroad, visiting their own counties and the country, collecting good examples. As the regions and counties of the country are different, the regional representatives have different interests, which makes their tasks even more interesting and valuable.

Bálint Csatári considered the local social capital to be a prerequisite for professional work and rural development, mapping of which is the mission of the regional representatives (Czibere 2016).

The regional representatives themselves initiate various rural development projects, help the professionals living in the area to meet and join forces, and strengthen the professional and civil communities of the given area. HNRN experts are key and indispensable actors of the countryside, working across the country on an expanding professional basis, with diverse knowledge and experience, in a spirit of trust and reciprocity.

MAIN ACTIVITIES, RESULTS

Due to the emergency caused by the coronavirus, the tasks of the Permanent Secretariat and the regional representatives had to be rescheduled. The regional representatives were able to attend fewer events in person, but were able to carry out their duties by working from home and through online consultations and conferences. They represented the HNRN at a number of events online and promoted the open tender opportunities and results of the Rural Development Programme.

Thanks to the Rural Development Programme tenders, more and more investments have been implemented,

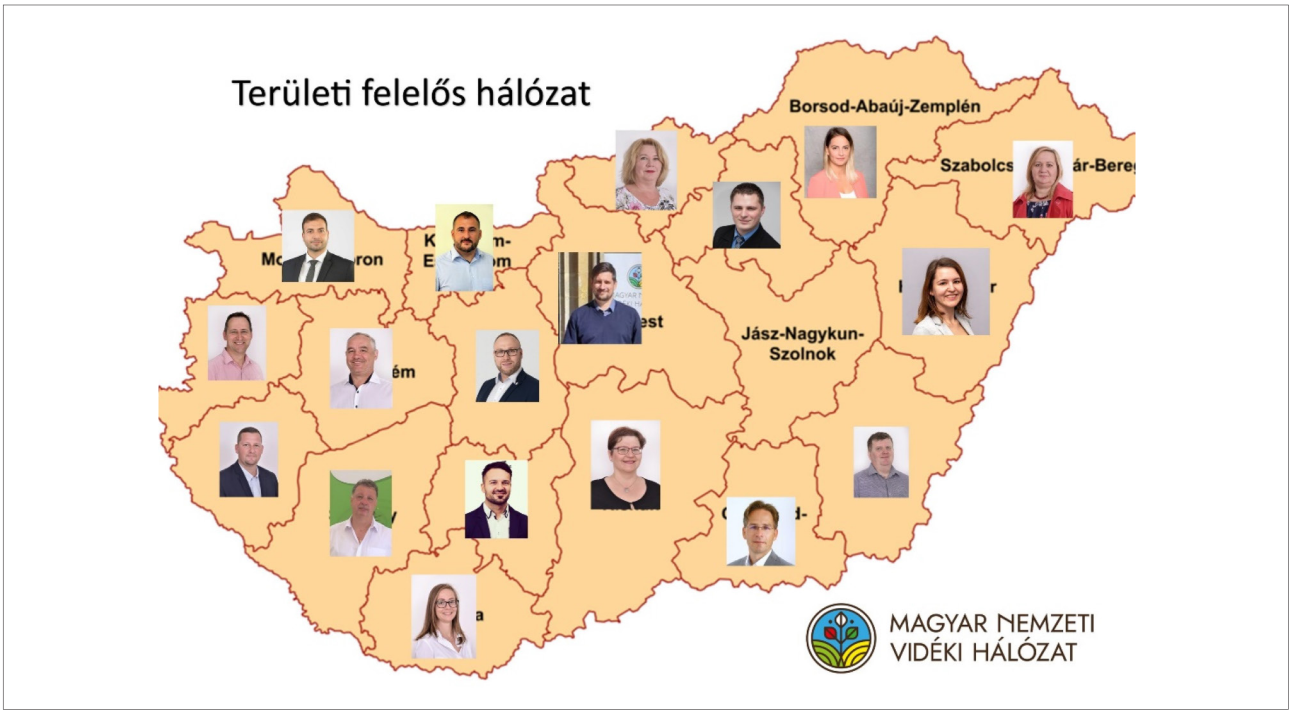

Figure 2: The network of regional representatives in April 2022 (*own editing*)

and the number of good practices that can be collected and communicated in several fields of action is constantly increasing. The number of national good practices in the ENRD collection is constantly growing.

Following the ease of the restrictions introduced during the pandemic, we had the opportunity to meet and build relationships with interested members of the public and the actors of the agricultural sector at regional and national agricultural fairs and conferences. For example, we participated in the Farmland Days in Mezőfalva, organised jointly with the National Chamber of Agriculture, the Duna-Tisza Agricultural Expo, the Great Plain Animal Husbandry Days, and the Bábolna Farmers' Days. Within the framework of EFOTT, we also addressed young people in Velence at our venue called Hungarikum Village and Island of Music where folk music concerts, dance houses and performances awaited the students.

In programmes, events and conferences organised in cooperation with the Hungarian National Rural Network, we provide opportunities for local craftspeople and producers to present and promote their work and products. We provide free registration for producers and craftspeople on our Producer Cart website. By presenting and promoting local products, we help to promote locally produced products, thereby also food security and local economic development.

We reach primary school children through the National School Garden Development Programme, and the educational films of the Foundation running the programme are available on our website.

Our Network is a partner of the Bread of Hungarians Programme, a year-round programme in which farmers from all over Hungary and Hungarian settlements in the Carpathian Basin offer wheat to organisations helping Hungarian children in need - both within and beyond our borders.

The Settlement Afforestation Programme has been a great success, giving local authorities and NGOs the opportunity to beautify their living environment through tenders, while at the same time creating a high-quality, diverse and long-term sustainable tree population, using tree species from the place of production. This activity contributes to the Ministry of Agriculture's coordinated afforestation and reforestation programme which aims to cover 27% of the country's territory with forests and wooded areas by 2030.

Since its establishment in 2016, the HNRN has been part of the Nature Park professional coordination network, in which, alongside the Hungarian Nature Park Association, the Ministry of Agriculture and the Herman Ottó Institute Nonprofit Ltd, it promotes the activities of national nature parks and supports their professional tasks. Within the framework of this cooperation, a 12-part film series was recently shot in 12 Hungarian nature parks, and joint events were organised.

The Network is also committed to the preservation of Hungarian gastronomy and traditions, therefore, we promote these national values and Hungaricums through our flagship programmes. We take part in pálinka and wine festivals and traditional events related to folk culture (e.g.

St. Andrew's Day pig slaughter, cattle drive in Szigetköz). We help people living on farms in their daily lives by providing advice on how to participate in farm development projects funded by the Rural Development Programme and national budgets, and by cooperating with village and farm caretakers.

Our events offer an opportunity to taste dishes prepared by popular Hungarian chefs, thus promoting, for example, the ‚Soaring Farm' National Meat Pigeon Programme, the consumption of cheese and goose liver, and the School Honey Programme.

We maintain close relations with universities offering agricultural and rural development courses (MATE, SZE), and we organise joint projects and conferences in cooperation with regional and national professional organisations (Doctoral Student Association, Digital Welfare Nonprofit Ltd, Hungarian Society for Urban Planning).

SUMMARY

The aim of the Hungarian National Rural Network is to improve the quality of life of those living in rural areas, and to achieve this goal, the knowledge of their opportunities and needs as well as the performance of the local economy is essential. Recent years have been dominated by the pandemic, which has highlighted the importance of self-sufficiency and the role of local cooperation and local communities in our lives. Although the traditional rural world is now disappearing, the sense of rural life, silence, tranquillity, and fresh air are increasingly attracting those who want to move out of big cities. The only way to preserve rural traditions and an undisturbed yet liveable living environment is to work for the development of the countryside by applying innovative farming solutions and passing on the acquired knowledge to young people.

You can find out more about our activities and current programmes at www.mnvh.hu.

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AIR PROTECTION IMPACTS OF THE APPLICATION OF PRECISION FARMING METHODS

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ABSTRACT

In the early 1980s, in some countries with advanced agriculture - especially in the United States - began that research and development work, which aim was creating and applying new technological advances of cultivation systems, technologies and machinery at agricultural corporate level, adapted to the spatial and temporal variability of agricultural areas (e. g. satellite positioning systems). Research and development has served two basic purposes: to increase the economic efficiency of agricultural production and, at the same time, to develop eco-friendly cultivation technologies. The developed cultivation systems or rather some of their elements appeared in Hungary at the end of the 1990s, then the precision research tenders launched in 2000 gave a big boost to research and development.

In our article, we examine in more detail the air protection and climate protection issues of the use of precision agriculture, including precision cultivation, and its role in the field of adaptation to climate change.

Keywords: precision farming, particulate matter, emission, HUNGAIRY LIFE integrated project

AIR POLLUTANT EMISSIONS OF AGRICULTURE

During agricultural production, sometimes we have to reckon with significant emissions of air pollutants. Typical sources of emissions and significant amounts of air pollutants are the followings:

- emissions of air pollutants from internal-combustion engines, machinery and transport vehicles (e. g. carbon monoxide, nitrogen oxides, solid particles, hydrocarbons);
- emissions from equipment (e. g. heating, drying) related to thermal energy generation (e. g. carbon monoxide, nitrogen oxides, solid particles);
- emissions related to livestock-farming, manure management (e. g. ammonia, methane, hydrogen sulphide, solid particles, other odorous substances);
- dust emissions from the soil surface, agricultural areas, paved and unpaved agricultural roads (it is important to note that most of the solid particles leaving the soil surface due to deflation - because of the lower density of the particles - are organic matter, humus (Stefanovits et al. 1999)).

In addition to the above, of course other local emissions of air pollutants may also occur in large numbers depending on the purpose of production or technology, such as drift of applied plant-protecting agents in environmental air or emissions from the burning of leftovers of fruits pruning for plant-sanitary reasons.

Examining the air protection situation of Hungary, it can be concluded that currently the condition is the worst for small-sized aerosol particles (commonly known as atmospheric aerosol particles) in terms of environmental air pollution, the high concentration of this air pollutant causes the greatest environmental health risk at present. Looking at the share of each sector in terms of particulate matter emissions (PM_{10} - a fraction of particulate matter in the particle size range of less than 10 micrometres), the most significant source of this air pollutant is the residential sector (supplying of heat energy to households), but in terms of significance immediately followed by agricultural emissions *(Figure 1)*.
As written above, almost all agricultural sectors contribute to these emissions - solid particles - so it is practical to examine the ways to reduce emissions in each area.

PARTICULATES POLLUTION, HEALTH EFFECTS

With regard to the pollution of ambient airborne dust can be said, that the extent of this is a global problem;

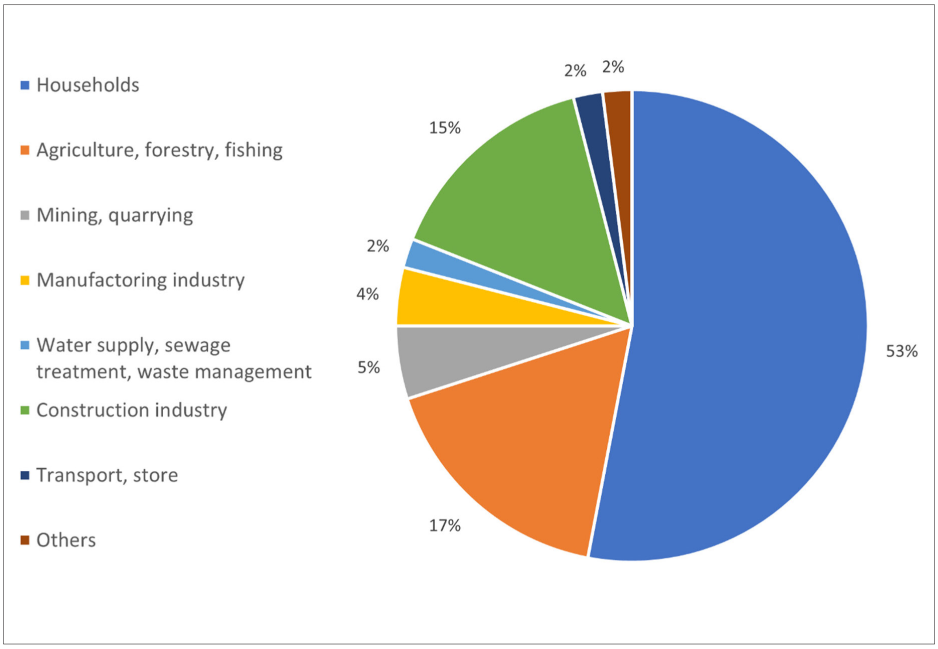

Figure 1: Emissions of particulate matter (PM$_{10}$) of national economic and residential sectors, 2018 (*KSH 2020*)

in line with this, in Europe and Hungary daily air quality limit values are exceeded in connection with the nature of winter weather occasionally with significant frequency, although in recent years a declining trend has been observed in Hungary in this respect.

The effects of particulates on health have been studied by many people around the world (e. g. WHO - World Health Organization) and in Hungary (OKI - National Institute of Public Health, NNK - National Public Health Centre) for a long time. This air pollutant basically exerts its harmful effects on the respiratory and the circulatory system, but when it enters the organism, it can also damage some other organs and it plays a significant role in the development of malignant tumours. Based on the results of the researches, furthermore the analysis of environmental health risks and mortality data, the following, sometimes shocking conclusions were drawn (Dobi 2016; PM$_{10}$ csökkentési program):

- 92 percent of the world's population lives in areas, where the particulates (PM$_{10}$) contamination is above the World Health Organisation's recommended air pollution value;
- exposure to particulates from man-made sources shortens a person's life by an average of 8,6 months in Europe; this value varies from country to country, three months in Finland, thirteen months in Belgium;
- air pollution plays a role in the early deaths of more than 3 million people worldwide, approximately 600 000 in Europe and 8 000-14 000 in Hungary;
- the costs of air pollution caused diseases account for approximately 10% of average GDP in the EU.

SOME ELEMENTS OF PRECISION CULTIVATION - REDUCTION OF SOLID PARTICLES (DUST) EMISSIONS

The basic technological elements and technical solutions of precision cultivation - or rather using a term that better describes the actual purpose: site-specific farming - without the need for completeness are the followings:

- high precision positioning system;
- CTF (Controlled Traffic Farming);
- local measurements, sensors and remote sensing (e.g. soil and plant health assessment), personal data collection at the location;
- geo-mapping (e. g. collection and use of data on soil type, nutrient levels, yields, etc. in farming), using GIS systems.

By applying the above technological elements and the cultivation system based on them, the emission of air pollutants and the environmental load of the cultivation process can be significantly reduced:

- the number of operating hours can be reduced by reducing the number of turns, overlaps and the number of errors due to operator fatigue, which naturally reduces the emissions of air pollutants from the internal combustion engines of power engines, machines and transport vehicles;
- also due to the above reasons, the reduction in distance run, in the number of certain passing and in the extent of cultivation processes causes also a reduction in the emission of solid particles (dust) from the soil surface;
- the knowledge of site-specific characteristics makes it possible to reduce losses, for example, during fertilization and plant protection work, parallel to this the environmental impacts of cultivation can be reduced, of course.

USA, THE RELATIONSHIP BETWEEN BEST AGRICULTURAL PRACTICE AND EMISSION OF SOLID PARTICULATES

The potential of best agricultural practice to reduce particulates pollution is increasingly being recognized in more and more places worldwide. An example of this is the *"Guide to Agricultural PM$_{10}$ Best Management Prac-*

tices" issued by the Governor's Agricultural Best Management Practices Committee in the State of Arizona (USA), which is mandatory in the particulate matter polluted areas and zones of the state (e. g. Maricopa County) (Guide to Agricultural PM_{10} Best Management Practices 2008). The regulation applies to all farmers who cultivate at least 10 acres (approximately 4 ha) in the affected area. Farmers must apply at least 2-2 technological solutions from the recommended best practices in each of the following three categories: tillage and harvesting, arable and non-arable lands. Here are some examples of best practice by this guide:

- tillage and harvesting: interconnection of cultivation steps, abandonment of night cultivation, integrated plant protection, prohibition of working in strong winds, *using precision agricultural elements*, etc.
- arable lands: cultivation perpendicular to the wind direction, application of mulching technology, cultivation taking into account soil moisture, application of agroforestry, etc.
- non-arable lands: restricting traffic on agricultural roads, speed limits, setting up artificial windbreaks, planting in critical areas, preventing application of dust to the roads, etc.

The fact that best practices have been carried out must be documented and certified by the farmer (by keeping a logbook, photo documentation, invoices, a personalised management strategy document, etc.). If Arizona Department of Environmental Quality cannot determine compliance with the above regulations, the farmer may be required for example to prepare a plan for the application of best farming practices, or even have his/her general air protection permit revoked.

AN IMPORTANT CONNECTION LINK - CLIMATE CHANGE, ADAPTATION

In 2019, 11% of the summarized carbon dioxide emissions of the national economic sectors came from agriculture *(Figure 2)*. By the way, compared to the base year (1990), emissions in the energy sector (-42%), in the industrial sector (-49%) and in the agricultural sector (-41%) decreased significantly (OMSZ 2022).

Of course, in connection with the previously mentioned emissions of air pollutants from engines, machinery and transport vehicles, emissions from heat production for heating and drying and other emissions from manure management, significant amounts of greenhouse gases are also released into the environment, contributing to the increase in atmospheric concentrations that cause climate change. The application of site-specific farming, in addition to the previously mentioned reduction of air pollutant emissions, naturally - for example in the context of reduced fuel consumption - will also result in a reduction of greenhouse gas emissions, contributing to the achievement of mitigation goals.

The year 2015 is a good example of what climate change can be expected in the future. 2015 became one of the hottest years, breaking numerous previous records: the 6th warmest winter and the 4th warmest summer since the

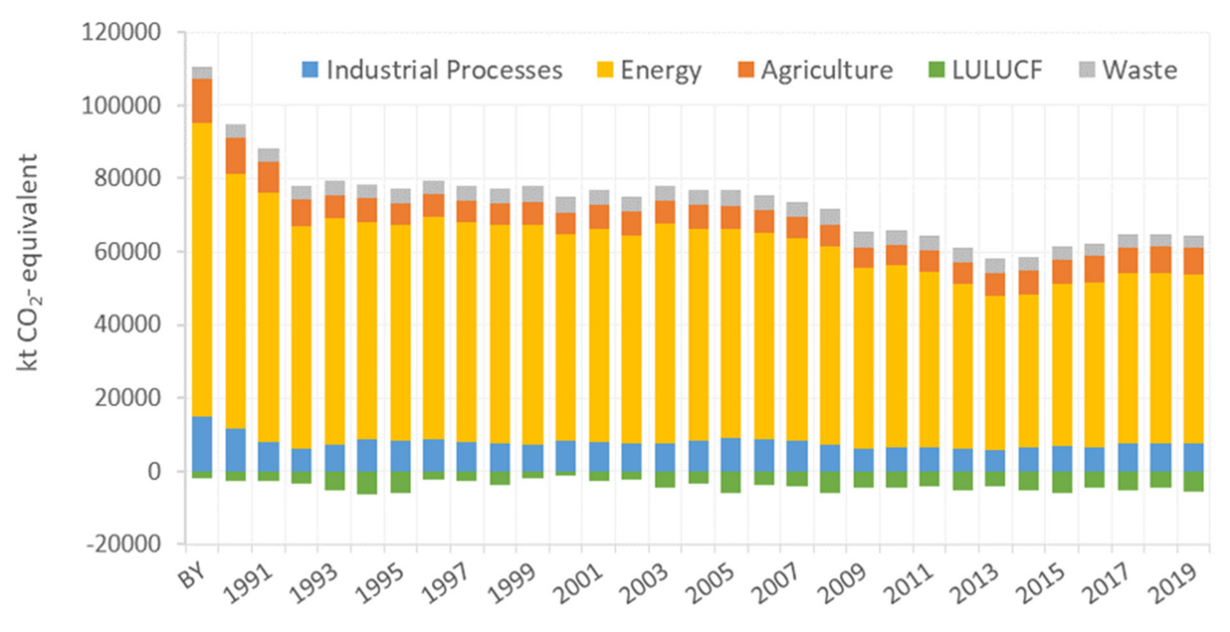

Figure 2: Total national emission by main sectors between the base year (1990) and 2019 (*OMSZ 2022*)

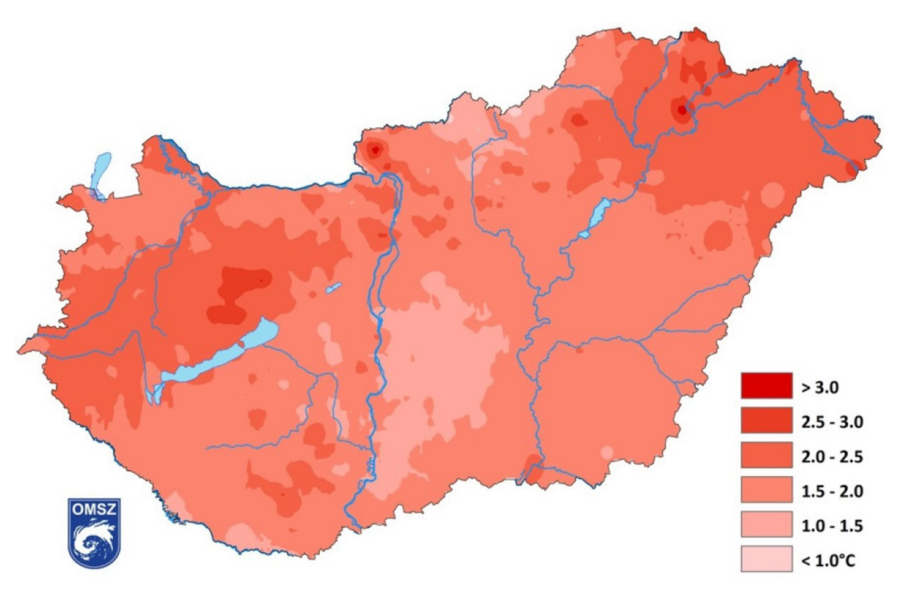

Figure 3: Deviation of the mean temperature of the summer of 2015 from the 1981-2010 norm (*OMSZ 2016*)

beginning of the data series in 1901 can be linked to this year, and based on these data, it proved to be the third warmest year (*Figure 3*).
In addition to the temperature data, precipitation conditions also showed significant fluctuations: seven, drier-than-usual months took place in the year (February-April, June, July, November and December), in two months the national average rainfall tend to normal (August and September), and three months passed with a significant plus (January 186%, May 132%, October 269%).

These two data series also highlight an important feature of climate change, the increase in the incidence of extreme weather events. Furthermore, as is well known in the field of cultivation, these extreme meteorological conditions are expected to reinforce the difference between divergent production conditions (e. g. physical, chemical, biological condition, water absorption and water retention capacity of soils). That is, accurate consideration of site-specific characteristics in farming (e. g. nutrient supply, soil condition, soil structure, water supply) can significantly increase the resistance of soil to climate change. Based on this, it can be concluded that site-specific farming also has a significant role in adapting to climate change.

THE HUNGAIRY LIFE INTEGRATED PROJECT, REDUCTION OF EMISSIONS FROM AGRICULTURAL SOURCES

The 8-year long HUNGAIRY LIFE integrated project, titled "Improving air quality in 8 regions by facilitating the implementation of air quality plans" was launched on 1 January, 2019. The main goal of the project is to improve air quality not only in the participating settlements (Békéscsaba, Budapest, Debrecen, Eger, Kaposvár, Karcag, Miskolc, Pécs, Szolnok, Tatabánya), but also in the surrounding agglomerations and regions. In addition, the development and demonstration of good practices can help to improve air quality in the rest of the country, even by reducing emissions of air pollutants from agriculture.

Within the frame of the project, the project beneficiary *"Mindennapi Kultúráért Egyesület" ("For Everyday Culture Society")*, is engaged in the dissemination of the application of agricultural emission reduction technologies and the collection of experiences related to the application. During the implementation of the project, the Society compiled a collection of agricultural emission reduction technologies and good practices (Tölli and Béres 2022), which of course deals in detail with the air protection and emission reduction effects of the application of precision agricultural methods. Based on this document, the Society held trainings for agricultural entrepreneurs and for agricultural advisers in 2020-2022 and further trainings will be held in the period of 2022-2026. To gather experience in the application of agricultural emission reduction technologies from farmers who already use such technologies, take place with a so-called semi-structured questionnaire. One of the goals of collecting experiences is to share them in further trainings, but the main goal object is to develop a study for professionals, decision-preparatories and decision-makers in 2023 entitled *"Repeatability and transferability plan of low-emission agricultural technologies to Hungary"*.

SUMMARY

As we have seen, the air pollutant that poses the greatest environmental risk nowadays, 17% of all national emissions of particulate matter (PM_{10}), comes from agriculture, forestry and fishing. The use of precision cultivation - or rather using a term that better describes the actual purpose: site-specific farming - can significantly reduce the emissions of this air pollutant, among others. In addition, the use of precision farming technology has a role to play in decreasing the degree of climate change, helps to achieve mitigation goals, furthermore helps to adapt to the effects of climate change.

ACKNOWLEDGEMENTS

This manuscript made in the frame of the implementation of LIFE IP HUNGAIRY project. LIFE IP HUNGAIRY project (LIFE17 IPE / HU / 000017) has realized by the support of the European Union's LIFE program. The contents of this publication are the sole responsibility of *For Everyday Culture Society* and do not necessarily reflect the opinion of the European Union.

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ANALYSIS OF THE DISSOLVED OXYGEN AND CARBON DIOXIDE CONTENT OF CARBONATED WINES IN AN OPERATIONAL BOTTLING LINE WITH DIFFERENT SETTINGS

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ABSTRACT

The research was carried out to answer practical questions that are relevant to large-scale production (winemaking). We were looking for answers to the question of how the saturator and the counter-pressure filling machine control the amount of dissolved oxygen and carbon dioxide in the wine during continuous operation and after evening shutdown. Our measurements were carried out at different settings of the machine line, so that we could also investigate possible differences when using two different span gases. The analytical measurements were supplemented by sensory judgements to answer the question of how different machine settings affect the amount of dissolved oxygen in the bottled product before release.

Keywords: carbonic acid, dissolved oxygen, carbon dioxide, bottling, saturation, Hungary

INTRODUCTION

Dissolved oxygen and dissolved carbon dioxide play an important role in the quality of wine. Oxygen is a molecule (chemical symbol: O_2) that plays a major role in all aspects of winemaking. The extent to which oxygen is absorbed and dissolved has a significant influence on the character of the wine. Oxygen is essentially the 'enemy' of white wines, as it spoils the primary fresh, fruity, floral aromas from the grapes and oxidizes the colouring agents, thus deepening the colour of the wine. Unwanted oxidation processes can be triggered by contact with air during wine making. The effect of oxygen on wine may be important for ageing and ageing, but it is also true that in the absence of dissolved oxygen, transformations and changes can occur in wines that are also beneficial for the development of wine and its aroma (Kállay, 2010). The amount of oxygen dissolved in wine and the time it takes for this oxygen to dissolve in wine depend significantly on the temperature of the wine. If the wine is in free contact with air, it can dissolve into the wine over a larger surface area and in greater quantities (Vidal, 2006). It is important to note that alcoholic fermentation is a reducing process, as yeasts use the oxygen present in the first stage of fermentation in their metabolism and then produce carbon dioxide later in the process, which protects the fermenting wine from oxygen (Du Toit, 2006)

Fixation of dissolved oxygen. After the physical process of dissolution, dissolved oxygen is bound to the oxidizable substances in the wine: phenolic components, sulfurous acid, Fe II compounds, etc., at a variable rate depending on the conditions. The resulting changes (e.g., precipitation of Fe III compounds) are not immediate but only noticeable after a few hours or days (Kállay, 2010).

The gases involved in oenology can basically be divided into two groups. One is the group of inert gases (nitrogen, argon), which do not react with the constituents of wine. The other group consists of gases that react with the constituents of wine (oxygen, carbon dioxide) (Toussaint, 2014).

In large plants, wine may remain in a single container in pieces during transport and bottling. In such cases, protective gases (carbon dioxide, nitrogen, argon) can be temporarily used to displace the air. Oxidation effects can be counteracted by using e.g., nitrogen (Eperjesi et al., 2010).

The degree of saturation of carbon dioxide is highly dependent on the temperature of the wine. As the temperature decreases, its ability to absorb carbon dioxide increases and vice versa. For a given carbon dioxide content, if you lower the temperature of the drink, the pressure decreases. Lower saturation pressure increases the life of the equipment and reduces the losses of the operation (Devatine, 2011). It is advisable to cool the carbonated beverage to 2-6°C. This is an essential requirement for higher carbonated beverages (>5g/l CO_2).

By pressure is meant the partial pressure of the gas above the liquid. Henry's law states that the amount of gas absorbed is directly proportional to the increase in pressure. This law is not fully valid above 2 bars for various beverages because the dissolved compounds in beverages other than water (wine, fruit juices, etc.) absorb some of the carbon dioxide (Bacskay, 1998), (Castellari, 2004)

The filling of sparkling wines is carried out using back-pressure filling machines. In back-pressure fillers, the pressure in the wine tank and in the bottle under filling is higher than atmospheric pressure. Its structural parts are the tank, the filling device, the bottle lifter, the drive, the regulating equipment, and other accessories. The back pressure gas is usually CO_2 or Nitrogen. The tank is annular, made of stainless steel, of pressure-resistant design. The constant level in the tank is ensured by a valve introducing the pressure gas and a bleed valve. The tank is fitted with a level indicator, a thermometer, and a pressure indicator. To avoid accidents, the tank is surrounded by a steel plate (Bacskay, 1998), (Gawel, 2020).

During the filling machine operation, the filling head fills the cylinders in six steps. First, the bottle is placed on the bottle lifter and then lifted to the correct position, at which point the filling head seals the bottle airtight. In the second step, the compressed gas flows from the container into the cylinder, creating the same pressure in the cylinder as in the container. Then, by displacing the gas, the filling of the wine begins. The wine rises until it reaches the end of the air tube. This air tube is selected according to the dimensions of the bottle. It is then decoupled from the filling head after the pressure is released and continues the conveyor to the next machine (Walls, 2022), (Nevares, 2009)

When carbonated wine is bottled, it is the task of the expansion gas to prevent the release of carbon dioxide. The pressure of the expansion gas (filling pressure) exceeds the pressure of the carbon dioxide (saturation pressure) measured at the filling temperature of the wine by 1,5 to 2,0 bar (Bacskay, 1998), (Filipe-Ribeiro, 2021).

Once the bottle has passed the final washing phase, the counter-pressure filling machine is next in line. Before bottling begins, the finished, filtered wine is placed in one of the tanks in the bottling plant. From the tank it flows directly into the saturator, which adds a pre-set amount of carbon dioxide.

It is then passed through two 5-candle candle filters, first through a 2 µm filter and then through a 0,65 µm filter. The whole process is a closed system, thus eliminating the possibility of oxidation and ensuring microbiological stability. After filtration, the liquid is directly fed into the back-pressure filling machine. The filling machine in the plant is one of the largest in the winery in terms of capacity compared to the domestic conditions. Its capacity allows for the bottling of large quantities of wine in a short time. The machine has fifty filling heads and its own tank with a maximum wine storage buffer capacity of 342 litres. The maximum filling speed is up to 12000 bottles per hour. The bottle is connected to the filling head before filling starts. A pressure test is carried out on the bottle with a sudden injection of gas, so that it will not be filled in the event of a seal failure or if the bottle is damaged.

The bottling of sparkling wines is technically complicated by the high gas content. For sparkling wines, carbon dioxide must be preserved throughout the treatment process, and for aerated and semi-sparkling wines, carbon dioxide must be absorbed during bottling and perfectly blended in the chilled wine to minimize losses during the filling process. For carbonation, the most suitable equipment is a continuous saturator with adjustable dosing.

Sparkling wines are bottled exclusively by the cold sterile process. The modern technology for bottling carbonated wine was developed for large-scale production in Hungary by Mercz (1971).

The technological applications of the saturation equipment are the freshening of wine by adding 0-2 g/l of carbon dioxide and the production of semi-sparkling wine (according to the wine law), with the addition of larger quantities of carbon dioxide and taking account of temperature and pressure conditions. The saturation machine can be used to achieve diffusion of two media by dissolving a gas in a liquid, according to the laws of gas in and gas out of the liquids.

The technical conditions required for optimum operation of the device are keeping the product temperature as low as possible for gas dissolution (wine refreshment), continuous supply of carbon dioxide without risk of freezing of the dosing system, use of a product pump to ensure continuous operation in the case of saturation wine treatment on the bottling machine and continuous level control of the wine tank of the filling machine. For wines with a CO_2 content above 1-1,5 g/l, the use of a low counter-pressure or counter-pressure filling machine is recommended.

The two fills are made from the same tank, so that all the parameters of the wines are identical. The initial base wine is considered homogeneous. A complete analysis was carried out on the sample taken from the tank. The starting material used for the analysis is a dry white wine of the Irsai Olivér grape variety from the 2015 vintage, which is commercially available.

MATERIAL AND METHODS

We investigated the possibilities of different charging settings for an in-service back-pressure filling machine. The total analysis of the samples of wine to be filled, plus the amount of dissolved oxygen in the wine, was measured using two different span gases. The number of bottles removed, and the amount of wine removed were a function of the buffer capacity of the filling machine. The amount of dissolved oxygen in each cylinder removed was measured in mg/l. The instrument used for our measurements was a Fibos 3 LCD from Nomasense - Presens. Dissolved carbon dioxide in wine was measured with the NomaSense CO_2 P2000 carbon dioxide instrument from Nomacorc. Based on the measurements, it can be determined whether the use of CO_2 or N_2 filler gas influences the analytical values and sensory qualities of saturated wine.

In the case where the filling process must be stopped, it does not refill immediately, but starts filling the cylinders at start-up and refills the tank when the required level is reached.

The complete analysis was carried out in the initial state when the tank was in the tank before bottling. The complete analysis consisted of the measurement and calculation of 9 parameters. They were classified according to the amount of sugar, total sulphur, free sulphur, volatile, extract, sugar free, acid, alcohol, and specific gravity in the wine. The parameters were measured in the winery's laboratory using OIV methods. In addition to the above, the dissolved oxygen and carbon dioxide content of the wine were measured.

RESULTS

The values obtained from the measurement of the basic analysis correspond to the parameters of quality winemaking found in the literature. The results measured in the baseline analysis are the same for both operating settings (N_2 and CO_2 span gases). No difference was found between the results of the baseline analysis of the wine stored in the tank and the wine in the bottles after filling.

In-use measurements

1. Operating condition (O.C. 1.): average of the carbon dioxide and dissolved oxygen of the bottles after filling, which was started after 10 minutes of continuous standstill, when the filling process of the filling machine was stopped due to operating conditions. Two settings were considered, where the filling machine span gas was varied. The gases used are nitrogen and carbon dioxide.

2. Operational condition (O. C. 2.): The bottling process ran smoothly without any problems. Our measurements were also carried out in this operating situation. The value is the average of the carbon dioxide and oxygen measured in the cylinders taken during the operation. In this case, measurements were also carried out under both operating conditions.

Dissolved oxygen in wine was also measured during the two operating conditions (Figure 1). The amount of oxygen measured in the bottles after a stop (358,3 ppb) during CO_2 pressurization is less (by 6,7 ppb) than when the filling is continuous without interruption and the amount of dissolved oxygen measured in the bottles taken randomly during the filling (365 ppb).

The other operational setting when nitrogen span gas was used. In this case, the amount of oxygen measured during the interruption of the filling process (358,8 ppb) is less (by 107,6 ppb) than the amount of oxygen

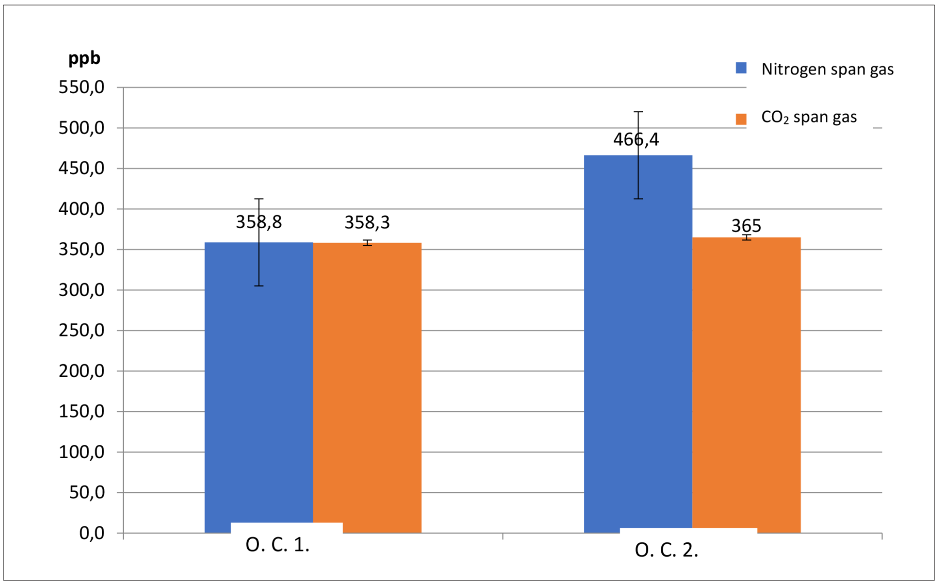

Figure 1: Dissolved oxygen content in wine at different operating conditions

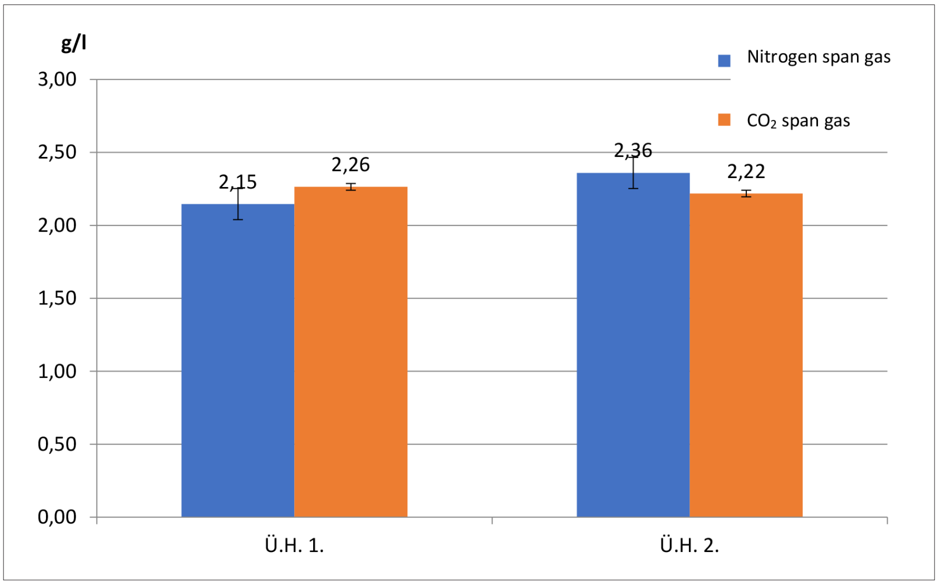

Figure 2: Carbon dioxide content in wine at different operating conditions

measured in the samples taken during continuous filling (466,4 ppb).

It can be said that the amount of dissolved oxygen measured in wine charged with different span gases differs, but in this case, it is not significant.

During the filling of the wine, the filling process was observed throughout. It went smoothly, no problems were encountered, and the wine flowed almost continuously, and the bottles were filled.

During bottling, when a bottling line is blocked for some reason (labeller saturation, jamming) and the filling process must stop, the CO_2 expansion gas in the buffer tank is in contact with the wine for a longer time, so the measured CO_2 dissolution rate (2. In contrast, when the filling process is continuous and uninterrupted, the amount of CO_2 measured in the randomly drawn bottles is less (2,22 g/l). The difference (0,04 g/l) is detectable but negligible from an oenological point of view.

For the other operational setting, nitrogen span gas was used. The amount of CO_2 measured during the steady state of the filling process is less (2,15 g/l) than the amount of CO_2 measured in the samples taken during the continuous filling process (2,36 g/l). The difference in this case is higher (0,21 g/l) than in the previous application of the expansion gas.

The CO_2 content of the wine charged with the different span gases differs, but this difference is not significant from a technological point of view.

Organoleptic assessment results

The samples were sensorially rated by a professional tasting panel of 7 people in the following groups:

- Sample 1: O. C. 2. nitrogen pressure filling (inlet)
- Sample 2: O. C. 1. nitrogen filling with compressed gas
- Sample 3: O. C. 1. charging with carbon dioxide pressure gas
- Sample 4: O. C. 2. repetition of first sample, charging with nitrogen CNG
- Sample 5: O. C. 2. charging with carbon dioxide span gas

The sensory evaluation was carried out by profile analysis. The criteria for the profile analysis were as follows: colour within the profile green and yellow; aroma profile: varietal, floral, fruity, foreign, scent intensity; flavour profile: acidity, fullness, freshness (CO_2), varietal, flavour; flavour intensity, harmony, and finally overall impression (Figure 3).

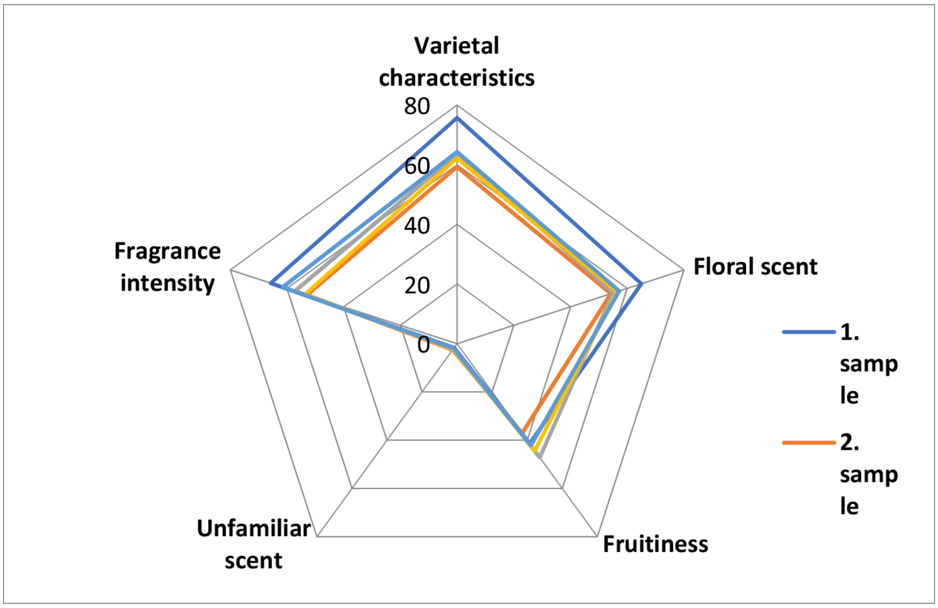

Figure 3: Profile analysis: scent profile

The tasting results showed that there were differences between all 5 samples. No significant difference in the colour profile could be detected.

Within the aroma profile, variety 1 (O. C. 2. nitrogen pressurization (inhaler)) has a prominent value, while the other 4 samples have a minimal difference around 60%. For the floral scent, it can also be said that sample one (O. C. 2. nitrogen pressure filling (inhaler)) stands out compared to the other four samples, which are between 55-60% with a few percent difference. For the fruitiness, it is observed that sample three (O. C. 1. carbon dioxide pressure gas filling) has the highest value, while the lowest is for the C.H.1. nitrogen pressure gas filling sample. There is no foreign scent in the wine. Also, in terms of scent intensity, sample 1 (O. C. 2. nitrogen blasting (inlet)) stands out, while the others are between 50-65%. Overall, based on the aroma profile analysis, sample one (O. C. 2. nitrogen blasting (injection)) and sample five (O. C. 2. carbon dioxide blasting) scored the highest, while sample two (O. C. 1. nitrogen blasting) scored the lowest.

Within the flavour profile analysis, the acid sense was higher (62,1%) in sample three (O. C. 1. carbon dioxide pressurization) and lower (55%) in sample four (O. C. 2. replicate of first sample, nitrogen pressurization). The five samples were scored between 50-65%. For saturation, it can be observed that samples four (replicate of the first sample of O. C. 2, nitrogen pressurization) and five (O. C. 2, carbon dioxide pressurization) were scored in the highest percentage (50%). Sample two (O. C. 1. nitrogen pressure filling) and sample one (O. C. 2. nitrogen pressure filling (inlet)) scored the lowest.

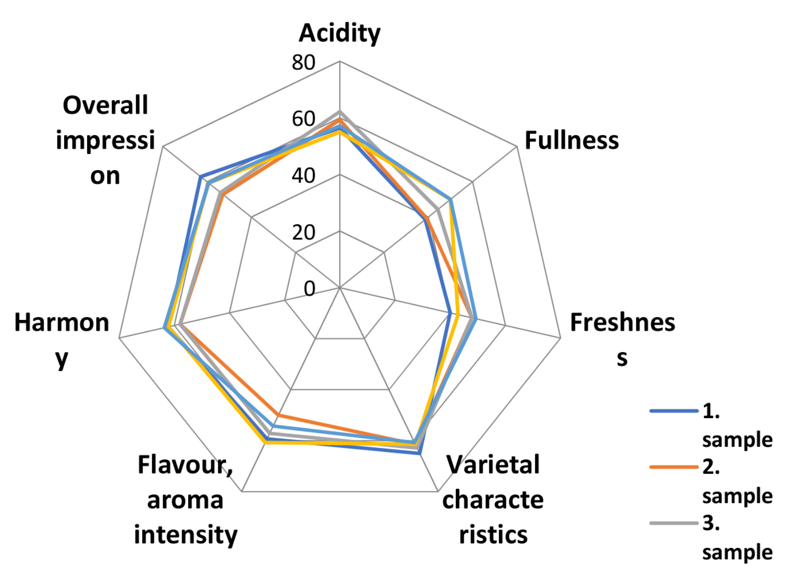

Figure 4: Profile analysis, Taste analysis

Freshness was the most important criterion for a complete profile analysis. Before starting the tasting, everyone was asked to focus on the amount and pleasantness of the carbon dioxide in the freshness aspect. Three different evaluations were observed, with the wine with the least carbon dioxide (40%) being the first sample (O. C. 2. nitrogen pressure filling (inlet)). Sample four (O. C. 2. repeat of first sample, nitrogen pressure charging) was in the middle (45%) in terms of carbonation. Samples two (O. C. 1. nitrogen pressure charging), three (O. C. 1. carbon dioxide pressure charging) and five (O. C. 2. carbon dioxide pressure charging) were all the most carbonated (50%) on tasting.

The varietal character of Irsai Olivér shows outstanding results for all samples. Uniformly, they all scored above 61%. Flavour and aroma intensity were least pronounced in sample two (50%) and best in sample four (60,7%) (repetition of the first sample of O. C. 2, nitrogenous expansion). The harmony of the wine is good and the difference between samples is minimal.

On a composite basis, wines five and four scored the highest percentages. Samples two and three scored less. Also, in terms of the scores obtained, sample five scored the highest, while sample two scored the lowest.

CONCLUSION

Our observations were carried out at different settings of a large-scale bottling line. We focused on measuring the amount of carbon dioxide added to the wine by the saturator and its appearance in the bottle. We wanted to find out how the saturator and the back-pressure filler control the amount of dissolved oxygen and carbon dioxide in the wine during continuous operation and in case of shutdown.

The filling heads fill at the same rate, both in terms of CO_2 content, pressure, temperature, and flow rate.
Using two different span gases, the machine line produced measurable differences in both CO_2 and O_2 content, but it is important to note that these differences are negligible from a wine-making technology point of view.
In the two operating situations of the bottling machine

(congestion, continuous operation), the parameters tested showed differences that confirm our assumptions, but these differences do not represent a technological risk for the bottled wines.

In addition to the analytical tests, the sensory evaluations showed that most of the professional evaluators specifically preferred the wine from bottles with continuous CO_2 expansion.

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CHEMICAL AND ORGANOLEPTIC COMPARISON OF WINES FROM GRAPE VARIETIES OF BADACSONY

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ABSTRACT

The Badacsony wine region has a unique soil and climate. Thanks to the closeness of Lake Balaton, both temperature and precipitation are special and favourable for the vines. The wines from the Badacsony wine region are among the outstanding wines of the country.

In our research, we examined 2 years of vintage, during which we investigated the differences and similarities within the vintages, what similarities or differences can be found between the vintages in terms of varieties.

In addition to the basic analysis, the acid composition and metal ion composition of the wines were measured. 5 to 5 wines of each vintage were judged using a 100-point scoring system.

Keywords*:* Badacsony, Hungary, Zeus, Vulcanus, Zervin, Zefír, Rózsakő, organoleptic test

INTRODUCTION

The grape varieties bred in the wine region play a key role in our country and worldwide, because they are locally bred varieties and can be used to produce high quality wines.

The total area of the wine region is 5200 ha, of which only about 1620 ha (2011) are planted with vines. The typical soils of the wine-growing area are Pannonian clay, basalt, loess, and Pannonian sand. Brown forest soils are found on these layers. The microclimate is very favourable due to the proximity of Lake Balaton. It is also protected from the north by the Bakony mountain range. The weather is more even than in other continental parts of the country. 640 mm average precipitation, 11,2 °C average annual mean temperature. 1934 hours/year average sunshine. The grape varieties grown are mainly Kéknyelű, Olasz rizling and Szürkebarát (Bányai, et. al., 2012.)

The organoleptic properties of wines are strongly influenced by the acid composition. The organic acids in wines are also technologically important.

Malic acid (acidum-malicum) Formula: COOH-CHOH-CH2-COOH, can be understood as mono-oxy-borostyric acid. L(-)-malic acid occurs in must and grapes. It is highly soluble in water and alcohol, giving a pleasant acid taste. Found in many fruits and in all parts of the grape. Its quantity is highly variable, depending on weather conditions (Kállay, 2014). The concentration of malic acid is 25g/l in green grapes before colouring, after which it can be reduced by up to half as its use increases during berry growth. During ripening, the must malic acid content is 4-5 g/l in cooler areas and 1-2 g/l further south (Ribéreau-Gayon et. al., 2006). The malic acid content in wine can be given as 0-8 g/l (Eperjesi et. al., 1998), (Robles et al., 2019).

Tartaric acid (acidum-tartaricum). Formula: CCOOH-CHOH-CHOH-CHOH-COOH, corresponding to dioxi-borostearic acid. Of oenological importance among the salts of tartaric acid are its semi-bound potassium salt, its bound tartaric acid (potassium hydrogen tartrate) and its neutral calcium salt. It is less soluble in alcohol and water, so it leaches out during fermentation and reduces the total amount of tartaric acid. The precipitation of tartaric acid depends on the amount of bound tartaric acid (Kállay, 2014). The predominant acid in must and grapes is tartaric acid, which is present as L(+)-tartaric acid (Figure 2). Its concentration can exceed 6 g/l in northern regions, but with higher temperatures in more southerly areas it is only around 2-4 g/l (Ribéreau-Gayon et. al., 2006). In wine, tartaric acid is present in concentrations of 1-5 g/l but can vary widely (Eperjesi et. al., 1998), (Robles et al., 2019).

Citric acid (acidum-citricum) Freely soluble in alcohol and water. It is present in small amounts in must and grapes (Kállay, 2014). It slows down but does not block the activity of yeasts (Kalathenos et. al., 1995). It is present in must and grapes in amounts of 0,5-1 g/l (Ribéreau-Gayon et.

al., 2006). White wines contain more citric acid than red wines. It may inhibit iron fracture because of its strong complexing properties. It binds the Fe+++ ion to form a complex anion (Kállay, 2014), (Robles et al., 2019).

Lactic acid formula: CH3-CHOH-COOH is formed in small amounts during the fermentation of monosaccharides. It is formed enzymatically and has a concentration of about 400 mg/l. Two lactic acid dehydrogenase enzymes are known, D(-)-lactic acid and L(+)-lactic acid. D(-)-lactic acid is produced from sugar by yeasts during alcoholic fermentation. Lactic acid is converted from L(-)-lactic acid to L(+)-lactic acid by lactic acid bacteria during biological malic acid degradation (Kállay, 2014).

Fumaric acid is present in minor or trace amounts (1-2mg/l) (Kállay, 2014).

Formula of **succinic acid**: COOH-CH2-CH2-COOH, soluble in alcohol and water. It has an unpleasant, slightly acidic taste (Kállay, 2014). It is produced as a secondary product of alcoholic fermentation during the metabolic activity of yeasts. It is responsible for the development of the aroma of wines. It is found in wines at concentrations of 1 g/l (Peynaud, Blouin, 1996).

Acetic acid formula: CH3-COOH, volatile acid content more than 95% acetic acid in healthy wines. Traces of acetic acid are detectable in healthy musts, but it may be present in higher concentrations in rotten, mouldy musts. The higher the sugar content of must, the more acetic acid can be formed. The amount of acetic acid produced during fermentation does not normally exceed 0,6-0,8 g/l, depending on the fermentation conditions. Acetic acid is formed during the decomposition of citric acid in malolactic fermentation. If the acetic acid content of the wine is below 1 g/l, it is considered healthy. Other volatile acids may also be present in small amounts in wine, such as formic acid, propionic acid, and butyric acid (Kállay, 2014).

In addition to the main acids, several organic acids can be found, such as glycolic acid, mesoxalic acid, glyoxylic acid, glyceric acid and saccharic acid, etc. Their quantity is negligible because they are not of major oenological importance. Glucuconic acid and glycolic acid are also present in the wine in minor amounts (Kállay, 2014). Sicimic acid may be present in varying amounts, depending on the cultivation technique, and has a positive physiological effect in white wines, together with quercetin (Bertelli et al., 2008), (Robles et al., 2019).

MATERIALS AND METHODS

For our research we selected five grape varieties bred in Badacsony. These varieties are Vulcanus, Zervin, Zefír, Zeus and Rózsakő. The dry white wines are Vulcanus, Zervin and Zefír. Zeus is semi-dry and Rózsakő is sweet. We have analysed wines from the 2018 and 2019 vintages.

Vulcanus is a grape variety, also known as Badacsony 38. It is a hybrid resulting from the crossing of two varieties, these are the Szürkebarát and Budai varieties. Produced in 1957 in Badacsony by Dr. Ferenc Király. The seedlings were planted in 1959. Ervin Kiss and Ervinné Kiss studied the selection, propagation, evaluation of parent stock, evaluation of reproduction and cultivation of candidate varieties from 1961. János Májer and his colleagues continued the studies from 1995 (Májer, 2004). Named after the god of volcanoes and fire, it was granted state recognition as a variety in 2003.

Zervin, also known as Badacsony 15 was bred by Ferenc Király from a cross between Ezerjó and Bouvier. Its siblings are the Zengő, Zenit and Zeusz varieties. Ervin Kiss continued the breeding work at the Badacsony Research Institute. In 1986 he established the plantation in Badacsony, selecting the most promising hybrids from the stock. Continuous changes in maintenance made research difficult, but small experimental plots were established in 2001 to supplement further research. In 2003, the variety was registered for state recognition as Badacsony 15 (Györffyné, et. al., 2013). The variety was granted state recognition as Zervin in 2012.

Zefir grape variety is called Badacsony 2. It was produced in 1951 from a cross between Hárslevelű and Leányka. It was bred by Ferenc Király. Several collaborators took part in the experiment, Ervin Kiss, Ottokár Luntz and Gyula Gábor. The seedlings were produced and crossed in Pécs, then the hybrid material was evaluated in Badacsony and finally the evaluation took place in Eger. The state certification was awarded in 1983. The variety has the phenological characteristics of early flowering, and of earlier budding and ripening. The breeding period is short. Its biological characteristic is that the ripened berries have a high sugar content. From the point of view of resistance, the vines are well tolerant of drought, although the buds are sensitive to frost. It is therefore recommended to grow it in frost-free areas (Hajdu, 2003).

The hybrid from the cross between Ezerjó and Bouvier, called **Zeus**, hybrid Badacsony 10, was bred by Ferenc Király in 1956. Ervin Kiss, Erviné Kiss and Mrs. Imréné Bakonyi highlighted the hybrids on which further evaluations were carried out. János Lázár and Gézáné Farkas performed the de-viralisation. The crossing combination was produced at the Research Institute for Viticulture and Oenology in Pécs and the experiments were carried out in Badacsony. The variety was granted state certification in 1994. It has a loose canopy like the Ezerjó variety. Its flowers are prolific and its buds fertile.

Rózsakő is also known as Badacsony 36. It is named after the Rose Stone (Rózsakő) on Badacsony Hill. Another excellent pollinating variety of Kéknyelű. It is a hybrid resulting from the crossing of the Buda and Kéknyelű varieties. It was produced in 1957 by Dr. Ferenc Király in Badacsony. The seedlings were transplanted in 1959. From 1961, Ervin Kiss and Ervinné Kiss carried out the tests, including the natural value of the candidate varieties, selection of candidate varieties, evaluation of mother plants, propagation of candidate varieties and evaluation of the reproduction. Subsequently, János Májer and his colleagues continued the studies from 1995 (Májer, 2004). In 2003 it received the state recognition.

Characterisation of the cultivation techniques of the plantations

The cultivation technology is the same for all 5 varieties. The spacing of the vines in the plantations is 2x1 m. Medium-height cordon cultivation is used, with 14 light buds on pruning elements of different lengths, using alternate pruning with pots. The Research Institute applies an environmentally friendly technology for plant protection, combining the coordination of different plant protection methods with pest and pathogen forecasting. When cultivating the vineyards, the aim is to keep the soil weed-free so that it is tended and cultivated mechanically. The greenwork is carried out with a view to the establishment of a thin and airy canopy.

Processing of the vines

The selected grape varieties Vulcanus, Zervin, Zefír, Zeus and Rózsakő are produced using the same technology. The wines were made using a rapid processing method: after crushing and destemming, a pneumatic press was used to extract the must. The must was then decanted into a settling tank. After settling, the must was racked off and then transferred to a cork-steel tank for fermentation by inoculation with a yeast at 16-18°C. The must was then pressed into a pneumatic fermentation tank and the must was then racked into a fermentation tank. During fermentation, medium was added 3 times. After a basic sulphurization (free sulphurous acid content 40 mg/l), a bentonitic fermentation was carried out. After cold treatment, filtration and bottling were carried out.

The finished wines were also analysed organoleptically. With a score of 100 points. The basic analysis was then carried out. In parallel with the measurements, the acid composition was measured using HPLC. The next day, the elements were measured using the AAS instrument.

Measurement methods:

Basic analysis

Basic analysis was performed after the sensory evaluation, consisting of the measurement and calculation of 9 parameters. Analysis and evaluation were performed simultaneously on bottled samples. These analyses were pH, alcohol content, titratable acidity, free sulphurous acid content, total sulphurous acid content, volatile acid content, sugar content, specific gravity, and extract content. In the laboratory, measurements were carried out according to OIV methods. Methods used.

Determination of acid composition by HPLC technique

In addition to the above, the total acid composition of the wine was measured by HPLC. The acid composition includes Tartaric acid, Citric acid, Malic acid, Succinic acid, Lactic acid, Acetic acid and Fumaric acid. During HPLC measurements, the liquid flowed in the instrument at 0,5 mL/min, the nominal pressure was 35 bar, the wavelength was 210 nm and the set temperature was 50 °C.

Determination of metal ions by AAS technique

The Atomic Absorption Spectrophotometer iCE 3000 was used. The elements measured in wine were measured according to OIV methods.

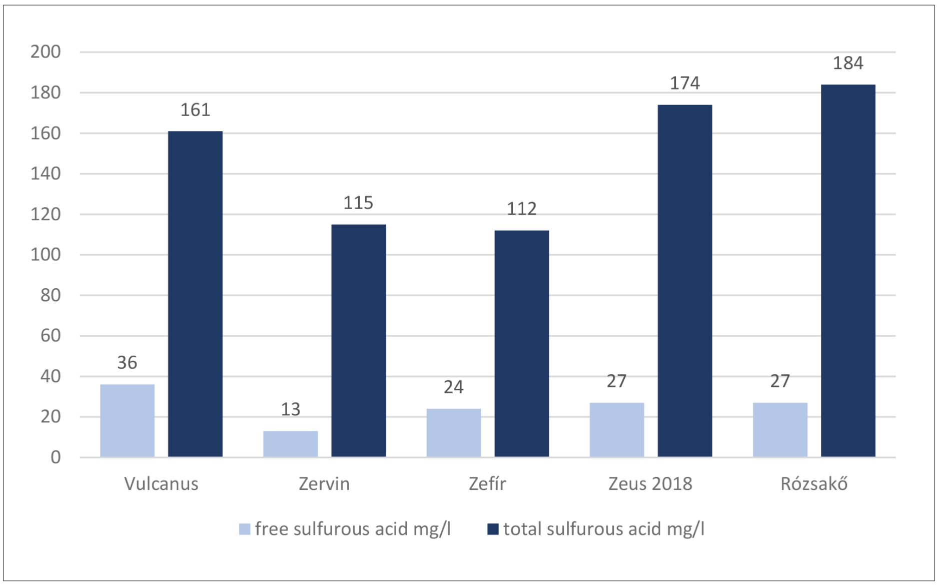

Figure 1: Free sulfurous acid and total sulfurous acid in 2018 vintage wines

Table 1: Alcohol, Sugar, Volatile Acidity, Titratable Acidity, Specific Gravity, and Total Extract Values of the 2018 vintage wines

Variety Examination	Vulcanus	Zervin	Zefír	Zeus	Rózsakő
pH	3,42	3,15	3,70	3,93	3,74
alcohol content (v/v%)	11,86	11,74	12,58	14,71	10,95
titratable acid content (g/l)	7,2	6,8	5,0	6,5	6,6
volatile acid content (g/l)	0,60	0,47	0,45	0,94	1,14
sugar content (g/l)	3,8	0,9	1,2	13,3	38,6
total extract (g/l)	24,7	20,1	20,6	48,1	68,6

RESULTS

Overall analysis results

The sulphurisation values show clearly that equal sulphurisation rates were used and that the amount of free sulfurous acid depends on the pH and acidity of the wine and its other components.
For all varieties the free and total sulfurous acid are below the permitted levels.
The analytical results measured in the 2018 vintage wines are shown in Table 1., which includes the Alcohol, Sugar, Volatile Acid, and Titratable Acidity, as well as the Total Extract results.

There is no significant difference between the measured pH results in the wines. All five wines have good values.

In terms of alcohol, the Zeus variety obtained an outstanding result of 14,71 v/v%. The alcohol content is influenced by the amount of initial sugar, so the alcohol content obtained is a function of this. Compared to other wines, this is a high value. The titratable acidity of the wines ranges from 5,0 to 7,2 g/l. The highest value was measured in Vulcanus and the lowest in Zefír. The volatile acidity was below 1 g/l in four of the five wines, but 1,14 g/l in the Rózsakő. The sugar content measured is low in the three dry wines, ranging from 0,9 g/l to 3,8 g/l. An outstanding result was obtained for the sweet Rózsakő, with a sugar content of 38,6 g/l. In addition, the sugar content of the semi-dry Zeus is also higher. In terms of specific gravity, all 5 wines gave the correct values. The total extract content of the wines is good.
The values of free and total sulfurous acid in the wines of the 2019 vintage are shown in Figure 2. The free sulfurous acid content in the varieties ranges from 25 to 61 mg/l. The highest result was obtained in the Zefír variety (61 mg/l), while the lowest was obtained in the Rózsakő variety (25 mg/l). For total sulfurous acid values, the lowest was measured in the Zefír variety, while the highest was measured in the Rózsakő variety. The results obtained show that the sulphur levels adjusted in the wines were adequate.
The results of the pH measurements in the wines show that there is no significant difference between the varieties. The same can be said for the volatile acidity, as all wines have a value below 1 g/l. The alcohol content of the wines ranges between 11,73 and 12,23 v/v%, except for Zeus, because the measured value (14,31 v/v%) is higher than the others. Among the results of the titratable acidity measured in the wines, we would like to highlight one variety, and this is Rózsakő, because it has a higher acidity compared to the values measured in the other wines. The sugar content of the three dry varieties ranges between 1,0 and 1,8 g/l. The semi-dry Zeus and the sweet Rózsakő have higher values. The specific gravity of all the wines shows a good value. The total extract content is similar in wines with a low sugar content. The results obtained for Zeus and Rózsakő are higher than in the other three cases.

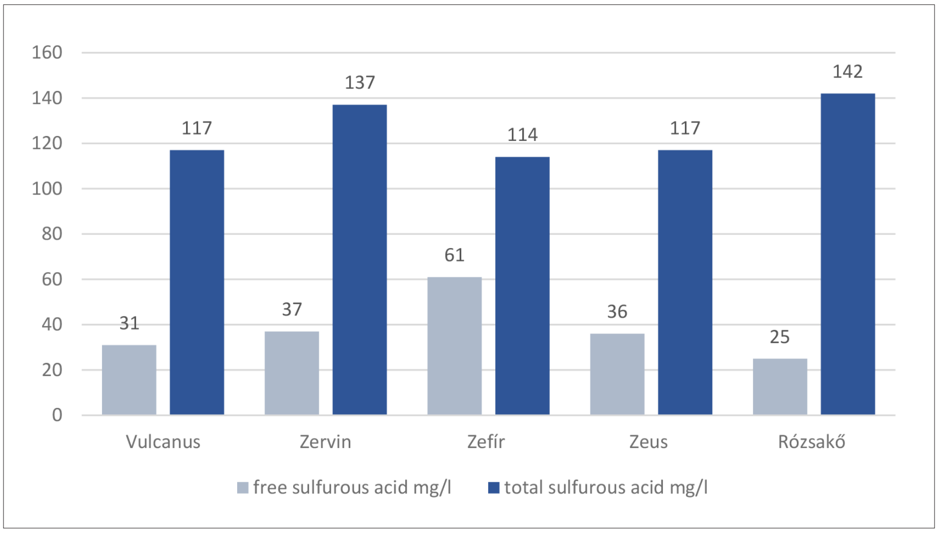

Figure 2: Free sulfurous acid and total sulfurous acid in 2019 vintage wines

Comparison of the 2018 and 2019 vintages

Comparing the results of the basic analysis of the two vintages, we can say that the

Table 2: Alcohol, Sugar, Volatile Acid, Titratable Acidity, Specific Gravity, and Total Extract Values for 2019 vintage wines

Variety Examination	Vulcanus	Zervin	Zefír	Zeus	Rózsakő
pH	3,43	3,52	3,35	3,60	3,71
alcohol content (v/v%)	11,73	12,23	12,20	14,31	12,14
titratable acid content (g/l)	7,7	6,7	6,2	7,0	8,3
volatile acid content (g/l)	0,40	0,56	0,47	0,80	0,67
sugar content (g/l)	1,0	1,8	0,9	16,1	42,4
specific gravity (N/m³)	0,9941	0,9931	0,9921	0,9969	1,0142
total extract (g/l)	25,0	23,9	21,2	39,7	78,5

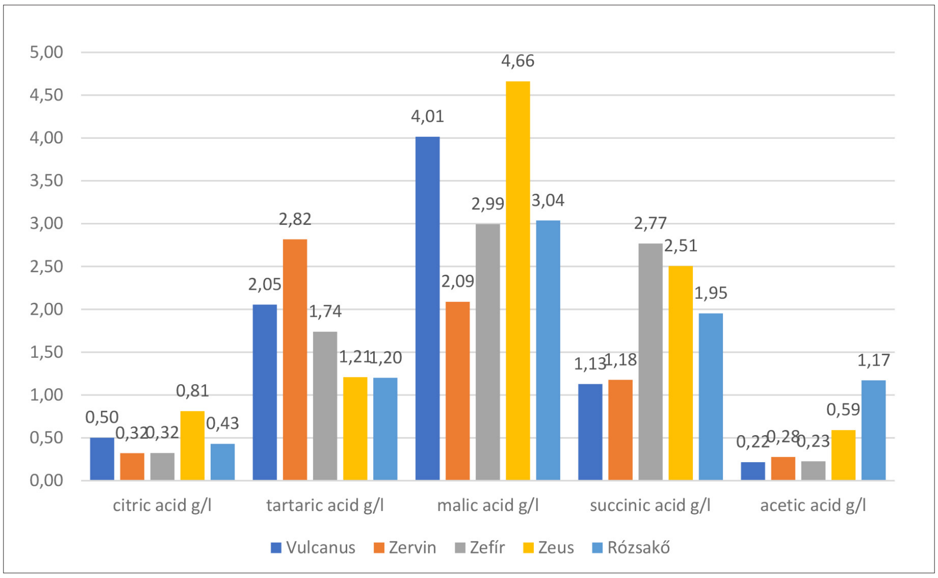

Figure 3: Acid composition of Vulcanus, Zervin, Zefír, Zeus and Rózsakő in 2018

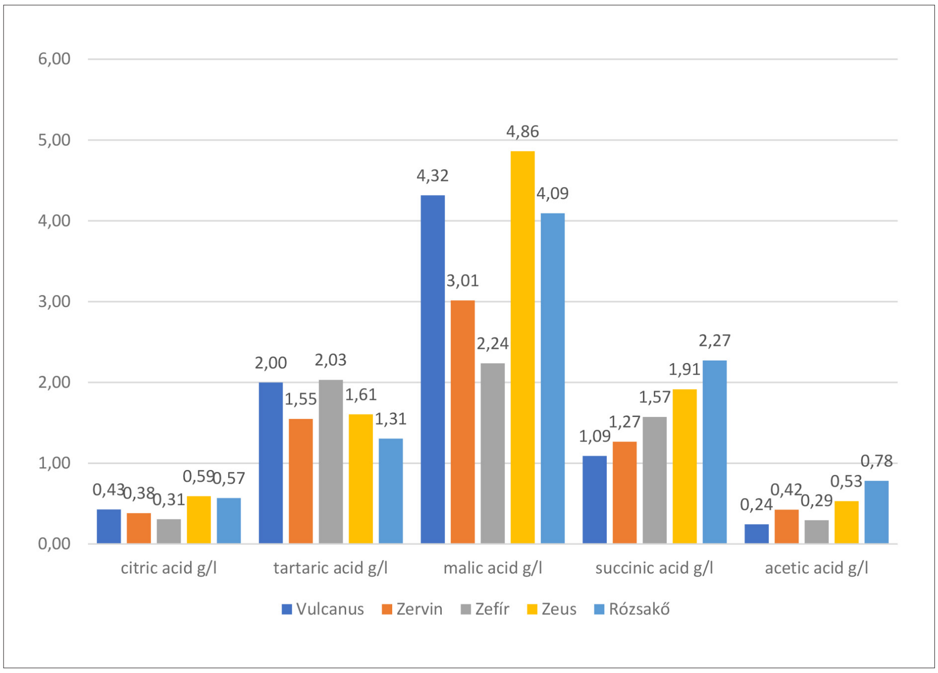

Figure 4: Acid composition of Vulcanus, Zervin, Zefír, Zeus and Rózsakő in 2019

results of alcohol content, titratable acidity, volatile acidity, extract content and specific gravity of the wine from the Vulcanus grape variety are almost identical for both vintages. The most significant difference was the sugar content, which was 3,8 g/l in the 2018 vintage and 1,0 g/l in the 2019 vintage.

Comparing the data from the Zervin grape variety wine, we found that there is a minimal difference of 0,9 g/l in the sugar content values, which is almost negligible, and a difference of 3,8 g/l in the extract content results. In both cases the 2019 vintage showed a higher value.

In the case of Zefír, no major difference can be detected when comparing the two vintages.

Two differences are highlighted in the Zeus data. The sugar content is different, with 2,8 g/l more in the 2019 vintage than in the 2018 vintage. However, the extract content was 8,4 g/l higher in the 2018 vintage. The other values tested are not significant for comparison.

The most significant difference between the two vintages can be seen in the case

Table 3: 2018 and 2019 Vulcanus, Zervin, Zefír, Zeus and Rózsakő wines Potassium, Calcium, Iron and Copper

Vintage year	Element / Variety	Potassium (mg/l)	Calcium (mg/l)	Iron (mg/l)	Copper (mg/l)
2018	**Vulcanus**	1063	99,1	0,711	0,125
	Zervin	610	73,8	0,747	0,399
	Zefír	1024	77,0	0,622	0,148
	Zeus	1664	117	0,424	0,533
	Rózsakő	1396	134	0,452	0,026
2019	**Vulcanus**	1086	104	0,724	0,028
	Zervin	1016	107	1,091	2,081
	Zefír	710	89,6	0,440	0,028
	Zeus	1148	107	0,352	0,023
	Rózsakő	1686	139	0,591	0,072

of the Rózsakő variety. In all cases the 2019 vintage was the one with the higher value. The difference was 1,19 v/v% for alcohol, 1,7 g/l for titratable acidity, 3,8 g/l for sugar and 9,9 g/l for extract.

The results of the acid composition measured in the 2018 vintage wines are illustrated in Figure 3. From the point of view of tartaric acid, Zervin had the highest content (2,82 g/l) among the wines measured. Two varieties had the lowest content, Zeus (1,21 g/l) and Rózsakő (1,20 g/l). Among the citric acid results obtained, Zeus had the highest maturity (0,81 g/l). The lowest levels were measured in Zervin and Zefír. The amount of malic acid in the wines ranged from 2,09 to 4,66 g/l. Zeus had the highest amount, while Zervin had the lowest. In addition, the value measured in Vulcanus is also higher than average.

The succinic acid content ranges from 1,13 to 2,77 g/l. The lowest value is in Vulcanus and the highest in Zefir. The acetic acid values show that the highest value is for Rózsakő. Higher acetic acid levels indicate that the wine also has a higher volatile acid content. Lactic acid and Fumaric acid are present in very small amounts in the wines. There are no outliers in the results.

The acid composition of the 2019 vintage wines is illustrated in Figure 4. No major differences in tartaric acid content were detected between the wines. The lowest amount measured (1,31 g/l) was in the Rózsakő, while the highest (2,03 g/l) was in the Zefír. There is no great variation in citric acid between the five different varietal wines. For malic acid content, the highest result was obtained with Zeus and the lowest with Zefír, but all 5 varieties have different results. In addition to Zeus, we measured a value of over 4,0 g/l in Rózsakő and Vulcanus. Succinic acid ranges from 1,09 to 2,27 g/l in the wines and the lowest is in Vulcanus, then the value rises in the order of measurement, so the highest is in Rózsakő. In terms of acetic acid, there are no outstanding values, all results are below 1 g/l. Lactic acid and Fumaric acid are minimal in the wines and there are no outliers between varieties.

The mineral content of the wines is on average adequate, based on the data measured in Hungary. Overall, the highest values of Potassium and Calcium in both vintages were found in the Rózsakő. The wine with the highest iron content in both vintages was Zervin. For copper, Zeus had the highest in the 2018 vintage, while Zervin had more in the 2019 vintage.

The results of the organoleptic evaluation showed that the wines made from the five grape varieties cultivated in Badacsony performed well in front of the judging panel

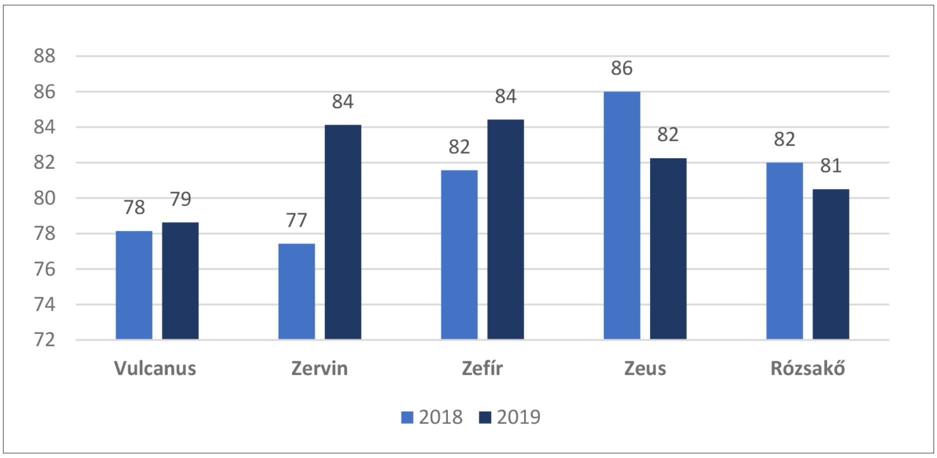

Figure 5: Average score of the 2019 and 2018 Vulcanus, Zervin, Zefír, Zeus and Rózsakő sensory evaluation results

and received an outstanding evaluation. The 2018 Zeus stood out among all the wines in the Taste, Flavour and Quality category.

CONCLUSIONS

Based on our tests, we can say that we have discovered differences in the chemical composition between varieties both within a given vintage and when comparing vintages.

By monitoring and evaluating the free and total sulphurous acid content, we found that the values are appropriate based on the winemaking technology and the processing of the grapes.

The results of the organoleptic evaluation allowed us to map the appearance, aroma and flavour intensity of wines made from the Vulcanus, Zervin, Zefír, Zeus and Rózsakő grape varieties. We intend to continue our research in the future, with a particular focus on the development of optimum winemaking technology for each variety.

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