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HUNGARIAN AGRICULTURAL RESEARCH

Autumn 2022

Environmental management, land use, biodiversity

FROM CONTENTS

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HUNGAIRY

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A LIFE IP HUNGAIRY (LIFE17 IPE/HU/000017) projekt az Európai Unió LIFE programjának támogatásával valósul meg.

HERMAN OTTÓ INTÉZET NONPROFIT KFT.

HUNGARIAN
AGRICULTURAL
RESEARCH
Environmental management, land use, biodiversity
Autumn 2022 – Vol.32, No. 3.

Editor-in-chief:
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Cover photo:
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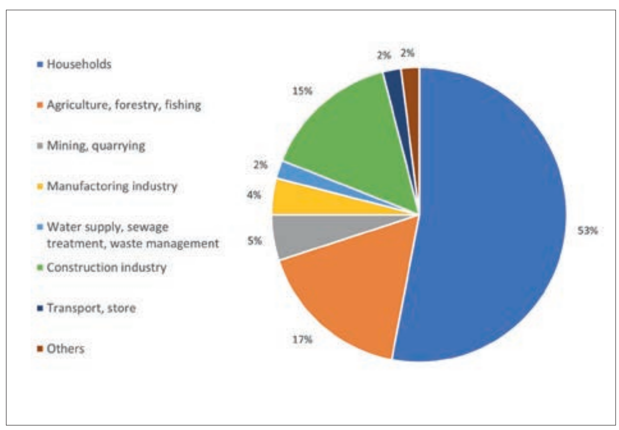
Back cover:
Nóra Koplányi

Published by
HERMAN OTTÓ INSTITUTE NONPROFIT LTD.

H-1223 Budapest, Park u. 2. Hungary
www.agrarlapok.hu/hungarian-agricultural-research I 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



HOPE BEYOND THE COVID-19: ANTIVIRAL EFFECTS OF WINES AND WINE COMPOUNDS

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ABSTRACT

It is well known even from the ancient times, that wines have beneficial health effects. In this article, the antiviral effects of wines and the most efficient wine compounds (resveratrol, quercetin, other polyphenols and shikimic acid) are reviewed. It is concluded that the moderate consumption of wine could have beneficial health effects in the respect of viral infection.

Keywords: wine; health; antiviral effects

„Where wine appears, the doctor disappears." (French proverb)

INTRODUCTION

The wine is maybe the oldest, most loved drink of the human culture. Even apostle Paul suggest his son Timothy to drink some wine to cure his frequent sicknesses (Anon n.d.). The Greeks ascribed more effects to the wine in the antiquity already, and its main characteristics were depicted with the peaks of a triangle. One of the peaks had denoted food, the other medicine, the third – with a certain magical effect – poison (Eperjesi et al. 2010). Homer, Plato, Aristotle, and Hippocrates all wrote of wine's beneficial effects on health (MacNeil 2015).
On the other hand, most of the references enhance the antioxidant and antibiotic effects of wines, some other references mention the antiviral effects as well.
All viruses share the same basic replication cycle:

- Virus receptor recognition, attachment, and entry into the cell.
- Viral gene expression and genome replication.
- Viral capsid formation and virion assembly (Wagner et al. 2008).

Different wine compounds act different way as an antiviral agent. The most frequently studied antiviral compounds of wines are the resveratrol, quercetin, several other polyphenols and the shikimic acid.

RESVERATROL

The resveratrol accumulates in the grape berry during ripening primarily in the skin, but also detectable in the seed of the fully-ripen berries. Concluding from this, the resveratrol content of wines primary is the function of the applied grape processing technology. According to the results of French and Italian researchers, the concentration of resveratrol in red wines (0.44-4.71 mg/l, average: 2.24 mg/l) are higher, than in white wines (Kállay 2010). Resveratrol was found to have many beneficial effects, including antiviral effects for human health.
It has therapeutic effects on HBV (hepatitis B virus)-associated HCC (hepatocellular carcinoma). However, the mechanisms by which they act are not fully understood (Huang et al. 2014).

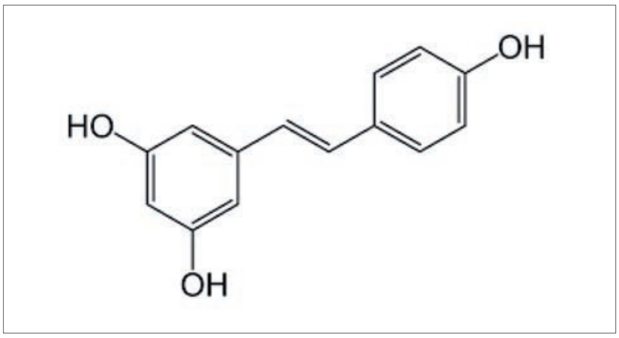

Figure 1: The chemical structure of resveratrol

Both red wine and resveratrol reduced the level of viral RNA in a dose-dependent manner, but resveratrol had no effect on MNV-1 (murine norovirus-1) polymerase. These findings suggest that red wine and resveratrol can affect the foodborne viral surrogates very effectively at an early stage of infection (Oh et al. 2015).

Italian researchers find that the inhibitory effect of resveratrol on the production of several HRV (Human rhinoviruses) - induced inflammatory mediators in nasal epithelia likely depending on the ability of resveratrol to suppress viral replication (Mastromarino et al. 2015).

In the experiments of Leo et al. (2012) (De Leo et al. 2012) resveratrol inhibited EBV lytic genes expression and the production of viral particles of Epstein Barr Virus (EBV). Researchers demonstrated that resveratrol inhibited protein synthesis, decreased reactive oxygen species (ROS) levels, and suppressed the EBV-induced activation of the redox-sensitive transcription factors NF–kB and AP-1.

Resveratrol was found to inhibit human cytomegalovirus replication, and likely operated during attachment and entry. Researchers hypothesize that "the primary molecular target for resveratrol may be blockage of epidermal growth factor receptor activation and its downstream effectors." (Evers et al. 2004)

Resveratrol was found to "strongly inhibit the replication of influenza virus, but that this activity was not directly related to glutathione-mediated antioxidant activity. Rather, it involved the blockade of the nuclear-cytoplasmic translocation of viral ribonucleoproteins and reduced expression of late viral proteins seemingly related to the inhibition of protein kinase C activity and its dependent pathways." (Palamara et al. 2005)

Fioravanti et al. (2012) (Fioravanti et al. 2012) also found resveratrol and its analogs to inhibit influenza A virus replication in a dose-dependent manner.

In the study of Clouser et al. (2012) (Clouser et al. 2012) resveratrol acted in synergy with a cytosine analog, decitabine to inhibit HIV-1 infectivity.

Resveratrol was reported to be efficient antiviral agent in ducks as well, as it was confirmed to significantly reduce the mortality of ducklings which infected with a virulent strain of DEV (Duck enteritis virus) (Zhao et al. 2016).

This polyphenol was found to have antiviral effect on African swine fever virus in vitro. Resveratrol and oxyresveratrol showed a 98–100% reduction in viral titers. "Both compounds allowed early protein synthesis but inhibited viral DNA replication, late viral protein synthesis and viral factory formation." (Galindo et al. 2011) Stilbene derivatives, (such as resveratrol), showed totally inhibitory effect against SARS coronavirus-1 in vitro (Li et al. 2006).

As resveratrol has the potential to mitigate many risk factors associated with cardiovascular disease, it has the potential as a functional supplement to reduce the severity of COVID-19 disease in cardiovascular patients. Resveratrol has been shown to inhibit key metabolic pathways involved in the pathogenesis of SARS-CoV-2, including regulation of the renin-angiotensin system and expression of angiotensin-converting enzyme 2, stimulation of the immune system and regulation of pro-inflammatory cytokine release. Therefore, several studies have already suggested the potential use of resveratrol in the treatment of COVID-19 (Gligorijević et al. 2021).

Several studies have demonstrated the antiviral efficacy of chloroquine and hydroxychloroquine against SARS-CoV-2 in vitro and in vivo. However, the cardiovascular toxicity of chloroquine and hydroxychloroquine limits their general use and therefore there is a need to find an adjuvant that could be used in combination with these treatments to minimise adverse effects. The cardioprotective properties of resveratrol may reduce the cardiovascular toxicity of chloroquine and hydroxychloroquine, and its synergistic use may be recommended (Emmanuel, Lawrence, and Oluyomi 2021).

QUERCETIN

Bioflavonoids were first discovered by the Hungarian Nobel Prize laureate Albert Szent-Gyorgyi in the year 1930 (Muthukala, Sivakumari, and Ashok 2015). Quercetin is a unique bioflavonoid that has been extensively studied by researchers.

Quercetin accumulates in the grape berry in its glucoside form, and it is partly decaying during fermentation. Its concentration in red wines is about 10 mg/l in red wines, below 10 mg/l in white wines (Kállay 2010).

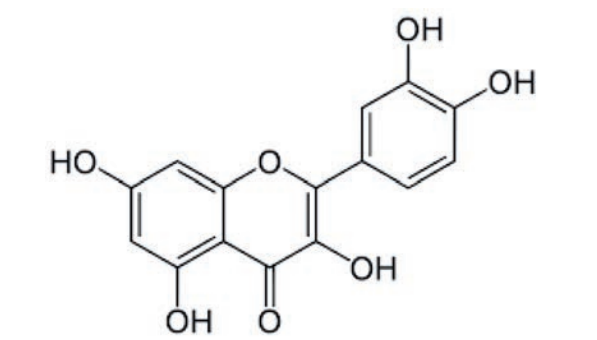

Figure 2: The chemical structure of quercetine

This molecule as an antiviral agent acts an important role even in the first stage of virus replication cycle: inhibits the virus entry of eg. influenza A (Wu et al. 2015), or Hepatitis C (Huang et al. 2014; Wagoner et al. 2011) viruses.

Chinese researchers find that the antiviral effects of quercetin can traced back to its alter effect to polymorphonuclear leukocyte phospholipid metabolism (Lee, Matteliano, and Middleton 1982).

Another study indicates that the glycoprotein hemagglutinin of influenza virus plays a crucial role in the initial stage of virus infection. Mechanism studies identified that quercetin showed interaction with the HA2 subunit showing inhibitory activity in the early stage of influenza infection (Wu et al. 2015). Quercetin showed viricidal action and inhibition of the viral replication cycle at 0 and 1. h. against equid herpesvirus 1 (EHV-1) as well (Gravina et al. 2011).

It was also shown to inhibit both the in vitro generation and effector function of alloantigen specific cytotoxic T lymphocytes (Schwartz, Sutton, and Middleton 1982).

Between others quercetin was shown to be one of the most active compounds in the inhibition of reverse transcriptases (RTs) of 3 different viruses but its effect was concentration-dependent (Spedding, Ratty, and Middleton 1989).

Human immunodeficiency virus (HIV) integrase- mediated integration of HIV DNA into the host genome is essential to the virus life cycle. In vitro results show that although several topoisomerase inhibitors-including quercetin-are potent integrase inhibitors (Fesen et al. 1993).

Quercetin exhibited both anti-infective and anti-replicative activity against four viruses: polio virus type 1, parainfluenza virus type 3, respiratory syncytial virus and herpes virus type 1, amongst others (Middleton 1998). In another experiments quercetin markedly blocked viral translation of hepatitis C, completely blocked NS5A-augmented IRES- mediated translation in an IRES reporter assay and differentially inhibited HSP70 induction (Khachatoorian et al. 2012). In another experiments quercetin markedly blocked viral translation of hepatitis C, completely blocked NS5A-augmented IRES- mediated translation in an IRES reporter assay and differentially inhibited HSP70 induction (Khachatoorian et al. 2012).

In another study quercetin was reported to inhibit of viral cytopathic effect presenting SI (selectivity index CC50/ EC50) = 3.5 value (Chávez et al. 2006).

British researchers find, that quercetin, possess activity against up to seven types of virus, including herpes simplex virus (HSV), respiratory syncytial virus, poliovirus and Sindbis virus(Cushnie and Lamb 2005).

In general, the antiviral activity of quercetin can be traced to its ability to bind to viral coat protein and polymerases and to damage DNA. The mutagenic/carcinogenic and anticarcinogenic activity of quercetin appear to be related to its ability to inflict or prevent damage to DNA, and that this action may impede the toxic or proliferative capacity of certain viruses(Formica and Regelson 1995).

Substituted quercetins such as "quercetin-3-gallate which is structurally related to EGCG showed comparable antiviral activity against influenza virus (porcine H1N1 strain) to that of EGCG with improved in vitro therapeutic index." (Thapa et al. 2012).

Significant reduction of the virus replication and lung pathology in influenza A virus infection was demonstrated in an in vivo experiment. In the same study suppression of emergence of resistant virus to amantadine or oseltamivir by isoquercetin co-treatment in vitro was discovered, suggesting the potential use of isoquercetin for the treatment of influenza virus infection (Yunjeong, Narayanan, and Chang 2010).

In general, the antiviral activity of quercetin is attributed to its binding to coat proteins and polymerases and its ability to damage DNA. It is possible that the mutagenic/ cancerogenic activity of quercetin is related to its DNA damaging ability, which may inhibit the toxic or proliferative ability of certain viruses (Formica and Regelson 1995).

In silico and in vitro studies have shown that quercetin is able to interfere with various stages of the coronavirus entry and replication cycle, such as PLpro, 3CLpro and NTPase/helicase. Due to its pleiotropic effects and lack of systemic toxicity, quercetin and its derivatives may be target compounds that should be tested in future clinical trials to enrich the drug arsenal against coronavirus infections (Agrawal, Agrawal, and Blunden 2020).

It was first suggested that quercetin might also be effective against COVID-19 in an 18-year-old man with asthma (Moskowitz 2020). Later, the anti-inflammatory, antioxidant and analgesic effects of quercetin made it likely that it could be suitable for the treatment of patients with severe pneumonia and life-threatening COVID-19 (Saeedi-Boroujeni and Mahmoudian-Sani 2021).

Knowledge of viral proteins is key in the search for new antiviral drugs against CoviD-19. The 3-chymotrypsin-like protease (3CLpro), papain-like protease (PLpro), RNA-dependent RNA polymerase and spike (S) protein are targets for drug development against SARS-CoV-2. Molecular docking studies show that quercetin inhibits 3CLpro, PLpro and S proteins, its 3CLpro inhibitory activity has been confirmed by biophysical studies (di Pierro, Derosa, et al. 2021; di Pierro, Khan, et al. 2021).

OTHER POLYPHENOLS

Nucleocapsid protein (NC) involved in reverse transcripton processes of HIV-1 was reported to be inhibited by two plant polyphenols: acutissimins A and B present in oak-aged wines (Sosic et al. 2015).

Studies points, that some other flavonoids, e.g. apigenin, fisetin, hesperetin and chalcone also can inhibit both CTL (cytotoxic T lymphocytes) generation and effector function, with the effective concentration varying with the specific flavonoid tested (Schwartz and Middleton 1984).

Another polyphenol, (-)epicatechin 3-gallate was also reported to inhibit HIV-1 viral polymerase and reverse transcriptase, but this inhibition effect found to be non-specific (Moore and Pizza 1992).

Baicalein, quercetin, quercetagetin and myricetin found to inhibit reverse transcriptases of Rauscher murine leukemia virus (RLV) and human immunodeficiency virus (HIV). The inhibitory effect of baicalein was highly specific, while the other polyphenols also inhibited DNA polymerase I and DNA polymerase alpha or beta as well (Ono et al. 1990).

Inhibition of HIV expression in TNF-alpha-treated OM-10.1 cultures was detected by three compounds (chrysin, acacetin, and apigenin). The findings indicate that flavonoids inhibit HIV-1 activation via a novel mechanism (Critchfield, Butera, and Folks 1996).

Figure 3: Chinese star anise (Illicium verum) (Shahrajabian et al. 2019)

Selway reports that eight polyphenols (quercetin, morin, rutin, dihydroquercetin, dihydrofisetin, leucocyanidin, pelargonidin chloride and catechin) were found to have antiviral effects against several viruses including herpes simplex virus (HSV), respiratory syncytial virus, poliovirus and Sindbis virus. The mechanism of these polyphenols were different, in most of the cases the viral polymerase enzyme was blocked, but binding of viral nucleic acid or viral capsid proteins were also detected (Selway 1986).

Enterovirus 71 (EV71) is known to trigger encephalitis; pulmonary oedema; hand, foot, and mouth disease; herpangina; aseptic meningitis; and poliomyelitis-like paralysis. For EV71 viral protein translation an internal ribosomal entry site (IRES) is required. 7,8-dihydroxyflavone, kaempferol, quercetin, hesperetin and hesperidin exhibited more than 80% of cell survival and inhibition of EV71 infection, from them kaempferol changed the composition of these IRES associated trans-acting factors, and affect IRES function and EV71 virus replication (Tsai et al. 2011).

SHIKIMIC ACID

Indian researchers explains the application of shikimic acid as preventive medicine for the outbreak of swine or Avian flu due to H1N1 virus (Singh et al. 2020).

Shikimic acid plays a pivotal role in the synthesis of a number compounds for the pharmaceutical industry and represents an essential starting material for the synthesis of the antiviral drug Oseltamivir (Tamiflu®) (Bianco et al. 2001; Bradley 2005; Kim and Park 2012; Rabelo et al. 2016; Satoh et al. 2009).

However Chinese star anise (Illicium verum) was reported to be the most important plant source of shikimic acid, it is not easily cultivable, attaining its first seed- bearing stage after 6 years of growth (Raghavendra et al. 2009), other sources are needed.

Less known, but important source of shikimic acid and quercetin are reported to be white wines. The analysis of six Italian and four Austrian white wines yielded concentrations of shikimic acid of 15-27 mg/l and quercetin up to 10.6 mg/l (Bertelli 2006).

According to the findings of Bertelli et al. shikimic acid alone is not able to modulate innate immunity in antiviral terms. However, their data show that the shikimic acid + quercetin combination, even at low doses, maybe effective for the modulation of innate immunity (Bertelli et al. 2008).

CONCLUSIONS AND SUMMARY

As it is outlined above wines could contain several compounds, which have different antiviral effects. However, the consumption of wines pops up some questions in everybody.

First, everybody heard about undesirable effects of alcohol, and wines contains alcohol at about 9-14 v/v%. Beside other, American researchers conducted a study on, whether alcohol consumption and/or smoking increases the chance for common cold. They concluded, that the moderate alcohol consumption decreases the risk of illness for non-smokers (Cohen et al. 1993). It is also known that the favourable effects of the Mediterranean diet could be traced back to the moderate consumption of wines as well (Cohen et al. 1993).

Second, if the moderate wine consumption is sufficient to have the appropriate amount of the compounds. Professor Bertelli in his review (Bertelli 2007) concluded, that "the bioavailability of the components of wine, which appears to be adequate as a broad range of biological effects have been documented at low concentrations that can be achieved by moderate chronic wine consumption".

Summarizing the results detailed in this review, it can be concluded, that the moderate chronic consumption of either white or red wines could have beneficial effect to the immune system to prevent virus infections and moderate the symptoms. It is suggested to drink wine every day for everybody excluding those who cannot do that because of the increased risk of addiction, who have religious reasons for abstaining, who have allergic reactions for one or some of the substances who are taking medication that adversely interacts with alcohol, and perhaps during pregnancy or breastfeeding.

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BIOGAS POTENTIAL AND CALORIFIC VALUE OF DIFFERENT AGRICULTURAL MAIN AND BY-PRODUCT

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ABSTRACT

This study assessed the biogas potential and calorific values of the different agricultural main and by-product. Adequate management of different agricultural biomass, residues and by-products can reduce their negative impacts on the environment. An alternative way to use for agricultural wastes, biomass to produce biogas or agripellets to heating. Our work is depending on an ongoing project where the aim is to increase the biogas production, increase the capacity of the biogas plant and reassemble the mixture if it is needed. We investigated the methane potential of 14 sample with the Automatic Methane Potential Test System (AMPTS II) (NaWaRo Ltd) and 9 sample calorific values with Elementar CHNS. system. The significance of our research is that due to the measurements we can exactly determine the possible methane production from the local agricultural wastes, biomass. Our results have shown that the retention time is currently is too long, and the feeding frequency of the digester is also too wide. The calorific values of the samples are parallel with the literature. The pelletized product calorific value similar like the dry wood or straw.

Keywords: biogas potential, calorific value, agricultural residues

INTRODUCTION

The use of biomass, including biogas, for energy purposes is possible mainly in counties with favourable conditions for agricultural production. The technology can be used to reduce fallow land, provide an alternative source of income for local agri-businesses and recover waste from livestock farms and food processing plants. It is necessary to determine the theoretical potential of the county in order to have a comprehensive picture of the amount of biogas that can be extracted in the area. The theoretical potential is the total amount of energy that can be physically extracted. It is important to note that there can be large variations in the specific biogas yield depending on certain factors (feedstock composition, technology used, etc.). The biogas potential of landfills and wastewater treatment plants and the biogas potential of waste materials from the food industry have not been taken into account in our calculations.

Large-scale livestock farming with livestock housing is best suited to the requirements of biogas production. The production of cattle, pigs, sheep, chickens and turkeys produces concentrated manure and causes environmental problems. To calculate the potential, the livestock population of the county was aggregated using the 2021 KSH data, and then the population of the different livestock species per livestock was determined from the KSH data series based on the following:

Based on literature data, the gross average gas yields for each species were calculated. Animal species produce manure with different properties, so the gas yield can be further differentiated by species In Hungary and Western Europe, "wet process" biogas plants based on slurry containing 5-15% dry matter are the most common.

Calculations show that more than 100 million m^3 of biogas can be recovered from livestock production, with an energy content of 2.21 PJ/year. The calculations do not include the biogas potential from manure from other poultry and other animal species.

The main and by-products from the crop production sector can also be considered as a source of biogas. There are changes in agricultural production in Europe today, where industrial and energy (non-food) crops are increasingly being produced, with food production being reduced.

This process foresees the emergence of a new industrial-energy crop production sector, requiring new agrotechnical, mechanisation and logistical applications. The crops most suitable for biogas production must meet a number of conditions. The characteristics of plants that can be easily integrated into the process must include excellent cultivability, storability, smooth harvesting, high dry matter yield, resistance to pests and, last but not least, excellent digestibility.

MATERIAL AND METHODS

Locally available biogas plant input materials

Organic matter load is an important consideration in sizing, which determines how much organic matter (on a dry matter basis) can be loaded per unit time for a given volume.

The aim of the methane potential test is to investigate the digestibility of the samples under mesophilic conditions (39°C) and the amount of biogas potential that can be produced from the samples.

Determine the formulation leading to the maximum methane yield

FOS/TAC analyses provide guidance on the optimal conditions for methane formation. The FOS/TAC analysis was developed to determine the ratio of acid concentration to buffer capacity in the digestion mixture. FOS is an abbreviation for volatile organic acids, measured in mg acetic acid equivalent/ dm^3, while TAC is an abbreviation for total inorganic carbon (the basic buffer capacity), measured in mg $CaCO_3$ /dm^3. Methane production slows down below pH 6.0 and stops above pH 8.0. The pH can vary greatly if the system is not adequately buffered.

Table 1: Test material characteristics

Sample name	Dry matter content [m/m %]	Organic dry matter content [m/m %]
Liquid separat	5.49	65.40
I. digester	8.51	74.75
II. digester	5.91	70.79
Pre-tank	0.89	63.86
Solid separat	21.05	84.98
Manure	16.04	82.14
Grass haylage	36.86	91.49
Straw	81.42	92.28
Compost	50.71	76.38
Corn refuse grain	83.94	96.79
EKO Nyíregyháza	14.59	97.03
Sunflower refuse grain	82.21	85.88
Corn husk	44.66	93.87
Corn silo	25.1	96.37

In practice, a FOS/TAC ratio of between 0.3 and 0.4 is normal, but each plant has its own optimum ratio, which can be determined by long-term monitoring and system control, whereas a wider optimum (0.15 - 0.45) has been established.

The pH in the digestors of the plant varied between 7.1 and 8.0, indicating that the buffer capacity of the system is about adequate, with only a few cases of significant pH fluctuations.

The basis for pelletisation of potentially available local agricultural by-products

CHNS elemental analysers, used for the calorific value determination of various agricultural products, offer the possibility of rapid determination of carbon (C), hydrogen (H), nitrogen (N) and sulphur (S) in organic matrices and other types of materials.

The calorific value is the amount of heat that is released when a unit mass of fuel is burnt perfectly, if the temperature of the fuel before combustion and the temperature of the combustion products after combustion are both 20°C, the carbon content of the fuel is present in the combustion products in the form of carbon dioxide, and the initial moisture content of the fuel and the water produced during combustion is in the form of vapour after combustion, i.e. it does not give off any heat of vaporisation when the combustion products are cooled. The calorific value is therefore less than or equal to the heat of combustion.

The advantage of burning agricultural biomass, pelleting, briquetting is that the calorific value is similar to domestic brown coal (15 500 – 17 200 kJ/kg), but cleaner. It has a lower ash and sulphur content than coal.

RESULTS

Locally available biogas plant input materials

In Figure 1, methane production is plotted as a function of time. The length of the digestion time was 30 days, which is considered as an average time. Since there was no significant increase in the overall gas production curve from day 25, it is likely that a longer experiment would not have yielded better results.

The Corn Silo (4 993 Nml) and EKO Nyíregyháza (4 882 Nml) samples gave the highest total biomethane yields.

Lower gas production was recorded in five samples compared to the control sample: Compost, Solid Separat, Liquid Separat, I. Digester, II. Digester.

Figure 1 shows the specific biological methane production in terms of dry organic matter content of the samples (Nml/g oTS) without the amount of gas produced by the inoculum.

Of the test materials, the EKO Nyíregyháza and the Corn Silo samples had the highest specific methane production capacity. By the 15th day of the digestion process,

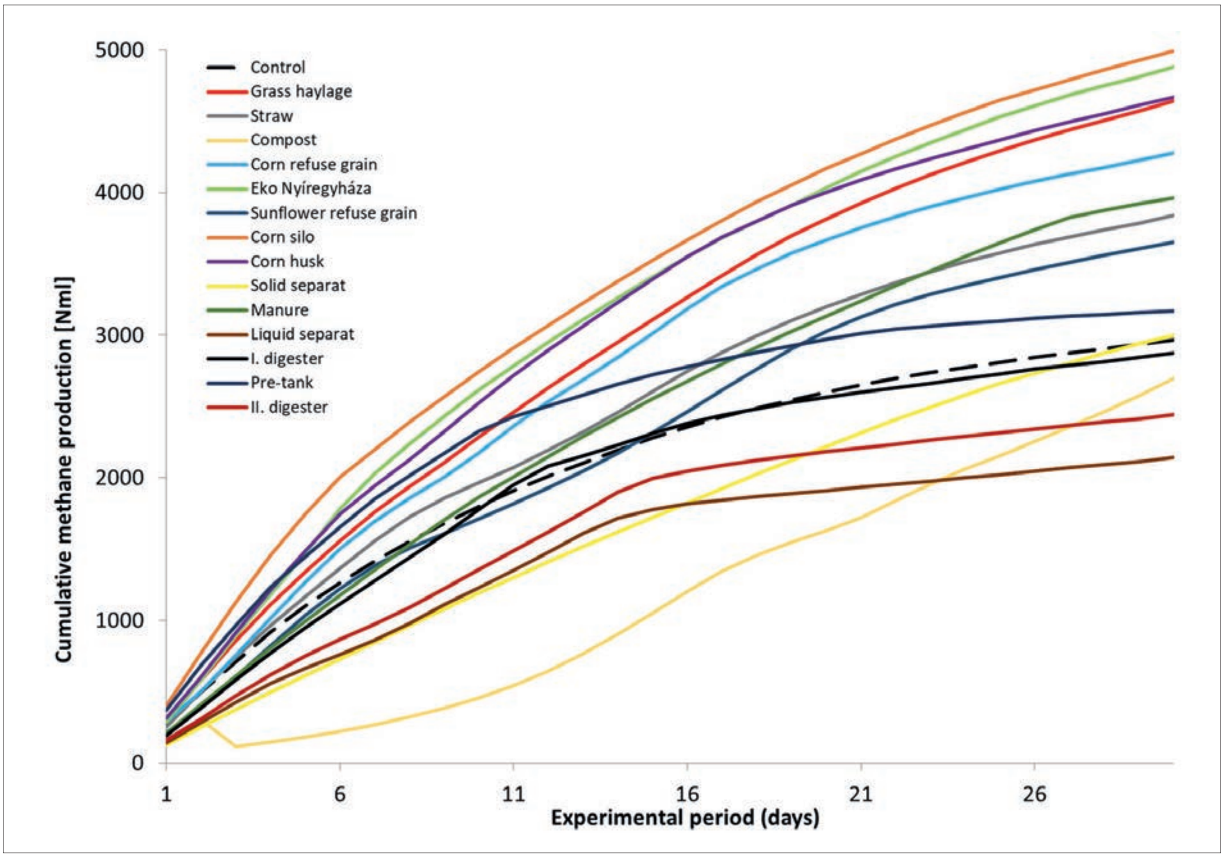

Figure 1: Total methane gas production over the period

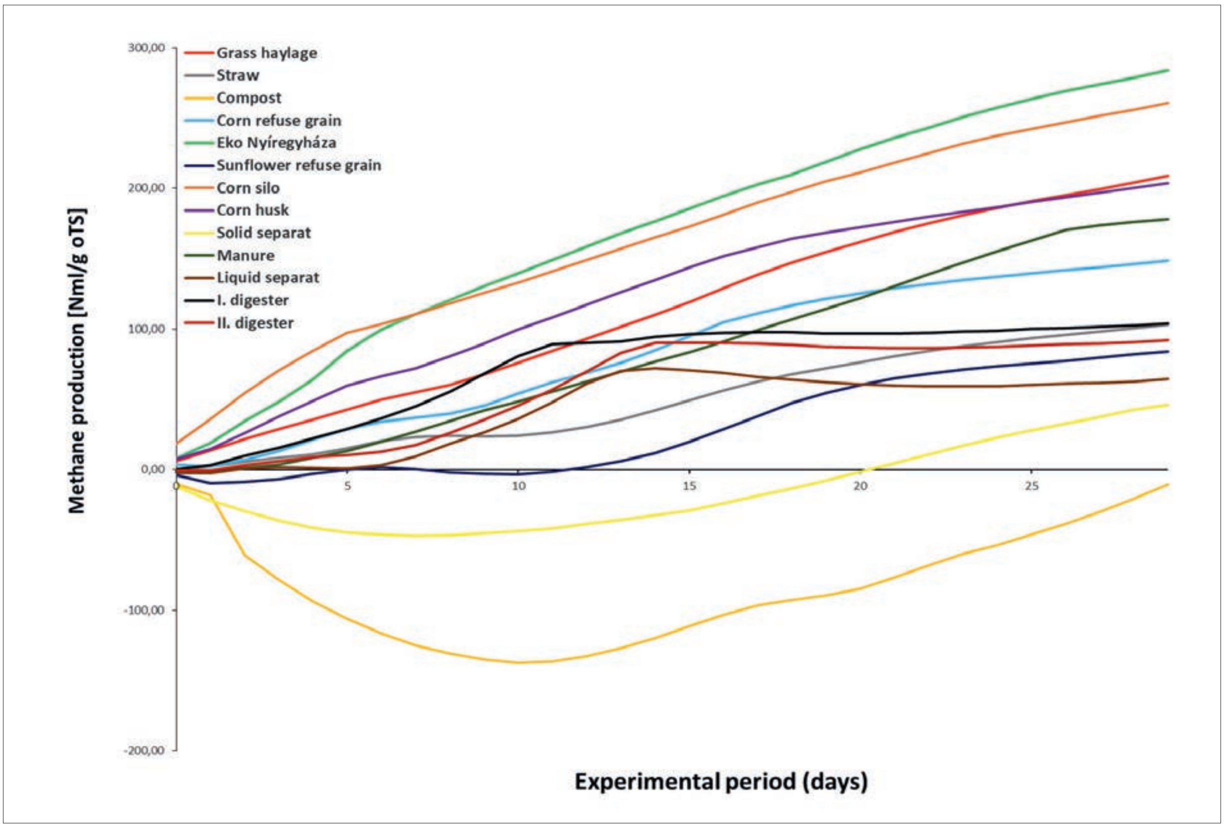

Figure 2: Specific methane production per organic matter corrected for negative control (inoculum)

the specific biomethane production potential of the EKO Nyíregyháza sample was 176.56 [Nml/g oTS], while the Corn Silo sample had a specific biomethane production potential of 165.21 [Nml/g oTS]. After further incubation, their values measured on day 30 of the study increased to 284.06 [Nml/g oTS] and 260.79 [Nml/g oTS], respectively.
Straw, Sunflower refuse grain, Manure, Liqiud Separate and Digester II samples showed reduced gas production at the beginning of the measurement compared to the control, which can be attributed to the characteristics and composition of these feedstocks. After the initial phase, their gas production was in line with expectations.

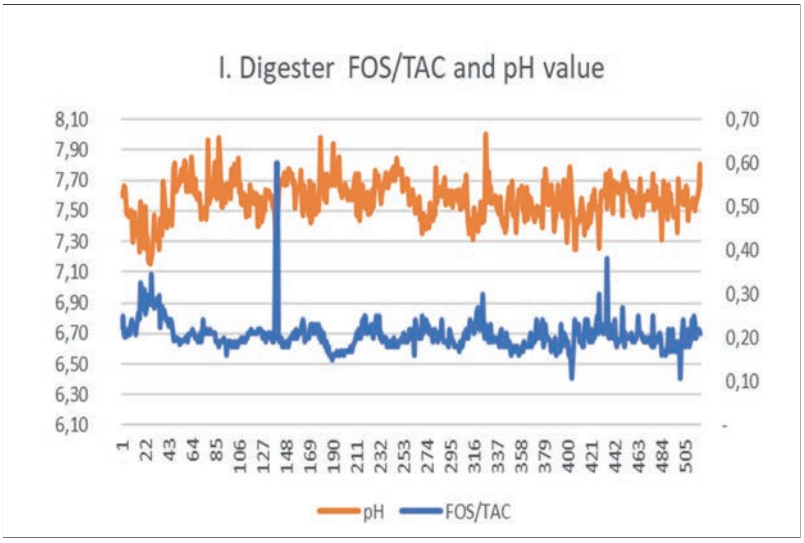

Figure 3: Evolution of the FOS/TAC and pH ratio in digester I

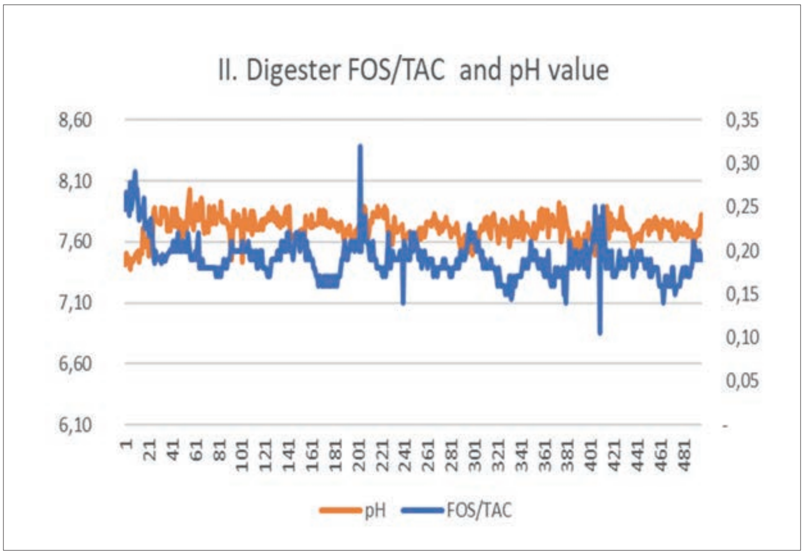

Figure 4: Evolution of FOS/TAC and pH ratio in digester II

Determine the formulation leading to the maximum methane yield

The data in the diagram 3 and 4 show that the plant is on average characterised by a slightly alkaline chemistry and low FOS/TAC (Figure 3, 4). Overall, although the values obtained are lower than those reported in the literature, this does not mean that the plant is out of balance. However, based on this and on the biogas potential measurements, it is worth reconsidering the frequency of feeding and the hydraulic retention time (HRT).
According to the data of the consortium leader Zrt., in 2021 the number of animals was 2,612, and the total amount of manure produced in livestock farming was 3,962,560 kg, including solid and slurry manure.
For the calculations, only the amount of material that could potentially be taken into account was taken into account, which in 2021 was 2000 t of Corn silo, 2.3 t of Corn straw, 2893.32 t of Corn husk and 83.5 t of sunflower straw.

Table 2: FOS/TAC ratio assessment based on literature data (Mézes et.al.; 2011)
Evaluation of FOS/TAC ratios according to empirical experience

FOS/TAC ratios	Background	Suggestion/Counter Action
>0,6	Highly excessive biomass input	Stop adding biomass
0,5-0,6	Excessive biomass input	Add less biomass
0,4-0,5	Plant is overflowing	Monitor the plant more closely
0,3-0,4	**Biogas production at the maximum**	**Keep biomass input constant**
0,2-0,3	Biomass input is too low	Slowly increase the biomass input
<0,2	Biomass input is far too low	Rapidly increase the biomass input

Calorific value calculation results

The samples with high nitrogen content were solid separation, manure, compost and sunflower straw. Higher sulphur content was also measured in these samples, which may cause corrosion of the combustion equipment in the long term.
As in the literature, calorific values between 16 and 18 MJ/kg were measured, except in two cases, compost and manure.
The moisture content of the samples fell within their typical range, and in order to pelletize or briquette them, pre-treatment is required to achieve the right

Table 3: C/N ratio of samples on dry weight

Sample name	C%	N%	C/N ratio	S%
Liquid separate	45.54	2.14	21.28	0.42
Manure	43.36	1.75	24.78	0.34
Grass haylage	46.51	1.14	40.80	<0.13
Straw	46.06	0.70	65.80	<0.13
Compost	40.64	4.02	10.11	0.71
Corn refuse grain	47.22	1.41	33.49	<0.13
Sunflower refuse grain	47.26	2.49	18.98	0.20
Corn husk	47.13	1.36	34.65	<0.13
Corn silo	39.96	0.80	46.20	<0.13

Table 4: Calorific value of samples on a dry matter

Sample name	Calorificvalue MJ/kg
Liquid separate	16.830
Manure	15.784
Grass haylage	16.792
Straw	16.769
Compost	14.161
Corn refuse grain	17.333
Sunflower refuse grain	17.961
Corn husk	17.218
Corn silo	18.200

Table 5: Moisture and ash content of samples

Sample name	Moisture content % moisture	Ash content %
Liquid separate	21.05	15.26
Manure	16.04	18.47
Grass haylage	36.86	8.62
Straw	10.55	8.36
Compost	50.71	25.50
Corn refuse grain	83.94	3.30
Sunflower refuse grain	82.21	14.27
Corn husk	44.66	6.32
Corn silo	25.10	3.68

moisture content. The ash content was well below the ash content of lignite. Compost and manure only showed higher values. Based on the results of the sample analysis, the most suitable feedstocks for pelleting can be clearly selected from the locally available biomass raw materials.

CONCLUSIONS

These researches were completed within a project whose aim was to take a good practice for the implantation of an innovative biomass based renewable energy production and use. At least the final output of the system will be renewable energy and energy carriers, which are and will continue to be of key importance from both an environmental and energy security perspective.

ACKNOWLEDGEMENTS

The authors would like to extend their thanks to VP3-16.1.1.1-4.1.5-4.2.1-4.2.2-8.1.1.1-8.2.1-8.3.1-8.5.1-8.5.2-8.6.1-17 "Creation of Innovation Operational Groups and Investment for the implementation of innovative projects", call number 1907643541, and the participant for the support. The research was also supported from the NRDI fund (National Laboratories Programme) by the National Research, Development and Innovation Office (NRDI) and the Ministry of Culture and Innovation (KIM) within the framework of the Agrotechnology National Laboratory project.

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SURVEYING THE EXPERIENCE OF USING AGRICULTURAL EMISSION REDUCTION TECHNOLOGIES – PARTIAL RESULTS OF THE QUESTIONNAIRE

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ABSTRACT

Examining the air protection situation in Hungary, it can be concluded that the current situation with regard to ambient air pollution is the most unfavourable for small aerosol particles (commonly known as particulate matter), it is the high concentration of this air pollutant that currently poses the greatest risk to environmental health. The most significant source of this air pollutant is the residential sector (domestic heat energy supply) but it is immediately followed in importance by emissions from agriculture. Therefore, it is important to know how these agricultural emissions can be reduced. In the framework of the HUNGAIRY LIFE integrated project, a nationwide questionnaire survey will be carried out in 2022–2023 among the farmers who voluntarily participate in the survey. Among other things, with the help of this survey will collect information on knowledge and experience of the use of agricultural emission reduction technologies. This article presents some of the partial results of this questionnaire survey so far.

Keywords: air quality, particulate matter, emission, agriculture, HUNGAIRY LIFE integrated project

AIR QUALITY STATUS OF OUR COUNTRY, EMISSIONS FROM AGRICULTURAL ORIGIN

Examining the air protection situation in Hungary, it can be concluded that the current situation with regard to ambient air pollution is the most unfavourable for small aerosol particles (commonly known as particulate matter), currently, it is the high concentration of this air pollutant that poses the greatest environmental health risk. Looking at the share of each sector in particulate matter emissions (PM_{10} – particulate fraction with a particle size below 10 micrometres) it can be established that the most significant emission source for this air pollutant is

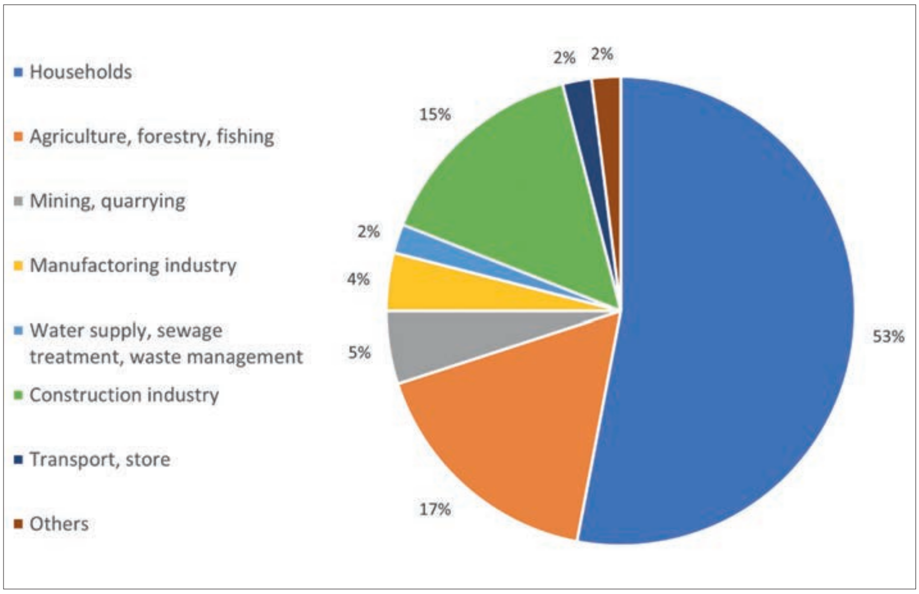

Figure 1: Emissions of particulate matter (PM_{10}) of national economic and residential sectors, 2018 (KSH 2020)

the population (domestic heat energy supply), but it is immediately followed in importance by emissions from agriculture. (*Figure 1*).

As described in a previous article (Béres & Litauszki 2022), typical sources of emissions and significant amounts of air pollutants in the agricultural area 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).

In addition to the above, of course other local emissions of air pollutants may also occur 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. Research and application of technologies to reduce small particulate emissions from agricultural sources goes back decades. These technologies are – listed without claiming to be complete – as follows:

- Technologies proposed to reduce deflation (e.g. specific arable and tillage technologies, precision farming, timing of soil tillage, cover plant, use of mulching, etc.).
- Special non-arable technologies (e.g. keeping clean the surface of agricultural roads, the use of windbreaks – e.g. plant strips, speed limits for vehicles on agricultural roads, etc.).
- Low emission harvesting technologies
- Technologies proposed to reduce emissions for diesel-powered agricultural machinery.
- Ways to reduce dust emissions on livestock farms from stables and cow-sheds, bedding material and feed.
- Ways to reduce ammonia emissions from livestock manure (e.g. optimisation of feeding, appropriate husbandry techniques and manure management).
- Other technologies for reducing emission.

Some of these technologies have been widely used by farmers for a long while (e.g. specific field and tillage technologies, precision farming, optimisation of animal feeding, appropriate husbandry techniques, etc.). However, in the vast majority of ths cases, the main reasons for the application are cost efficiency, increasing the safety of production and improving the quality of the product manufactured. That is, farmers did not always aim to reduce emissions by using emission reduction technology.

THE HUNGAIRY LIFE INTEGRATED PROJECT

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 best practices can help to improve air quality also in the rest of the country, even by reducing emissions of air pollutants from agriculture.

Within the frame of the project, the *For Everyday Culture Society,* as a project beneficiary, is engaged in the dissemination of the application of agricultural emission reduction technologies and the collection of experiences related to the application of them. During the implementation of the project, the Society put together a collection of agricultural emission reduction technologies and best practices [3], 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-preparers and decision-makers in 2023 entitled *"Repeatability and transferability plan of low-emission agricultural technologies to Hungary"*.

GATHERING EXPERIENCE ON THE USE OF EMISSION REDUCTION TECHNOLOGIES – THE APPLIED METHOD

A semi-structured questionnaire was developed to collect experiences with the use of agricultural emission reduction technologies, which can be used to collect information about knowledge and experience of agricultural entrepreneurs during personal interviews. In designing the semi-structured questionnaire, we basically took methodological recommendations for data collection and research using questionnaires (Hornyacsek 2014, Lengyelné 2014, Hekliné 2002, HBH Stratégia és Fejlesztés Kft. és Collective-Intelligence Kft. 2018, Barancsuk 2012, Lisányi 2011) and the characteristics of published surveys in similar fields and related topics (Polyák & Varanka 2021, Gaál & Illyés 2020, Szűcs 2008, KSH 2016) into account.

The semi-structured questionnaire contains the following groups of questions and relevant questions within them:

- Survey the basic information about the respondent: geographical location, production sector, farm size, age, education.
- Survey of the basic knowledge (impact of agriculture on air quality, knowledge of emission reduction technologies, sources of these knowledge, opportunities to acquire further knowledge).
- Do they use any emission reduction technologies?
- If they do not use any emission reduction technologies, then why not.
- If they use any emission reduction technologies,
- which technology(ies) are used in crop and livestock production (dust emissions, ammonia emissions);
- the reasons for using the technology;
- description and evaluation of the technologies used;
- factors affecting the further spreading of the technologies used.

The project partners involved in carrying out the questionnaire survey are: FECS, Herman Ottó Intézet Nonprofit Ltd., Békéscsaba Town Development Nonprofit Ltd., Towns of Békéscsaba, Eger, Karcag, Miskolc and Szolnok. The participation of farmers in the survey is voluntary and anonymous, the range of participants involved in filling in the questionnaire are farmers already known by each project partners through their professional relationships or randomly selected. In line with the objectives of The HUNGAIRY LIFE integrated project, the questionnaire survey will involve at least 60 agricultural entrepreneurs or enterprises.

RESULTS

The questionnaire survey carried out so far by the FECS has been answered by 20 farmers and entrepreneurs. From the information obtained so far, we present some typical results for the Northern and Southern Great Hungarian Plain regions. We have chosen these regions because the severe drought experienced also by our country in 2022 affected these areas the most (Szentesi 2022) Many of the emission reducing technologies in agricultural industry (including crop production) and site-specific management also have an important role to play in adapting to climate change and protecting against the effects of drought. It may therefore be interesting to see what the test results so far show, for example in terms of knowledge of emission reduction technologies in these regions.

In the surveyed Northern Hungarian Plain and Southern Hungarian Plain regions, all respondents to the questionnaire survey (10 person) claimed to have some knowledge of technologies to reduce air pollutant emissions from agriculture (Figure 2). However, most respondents considered themselves to be only moderately or less well informed (3 and 2 person), and only two out of 8 respondents indicated that they were well informed or quite familiar with the subject.

Respondents were aware of all the agricultural air pollutant emission reduction technologies listed in the questionnaire, although to varying degrees, but did not mention any other technological solutions (Figure 3). Of the options listed, most respondents identified the technologies proposed to reduce deflation as the emission-reducing technology they were aware of. Almost as frequently was identified the reduction of dust emissions from bedding material and feed in stables and cow-shed, as a known emission reduction option in livestock farms.

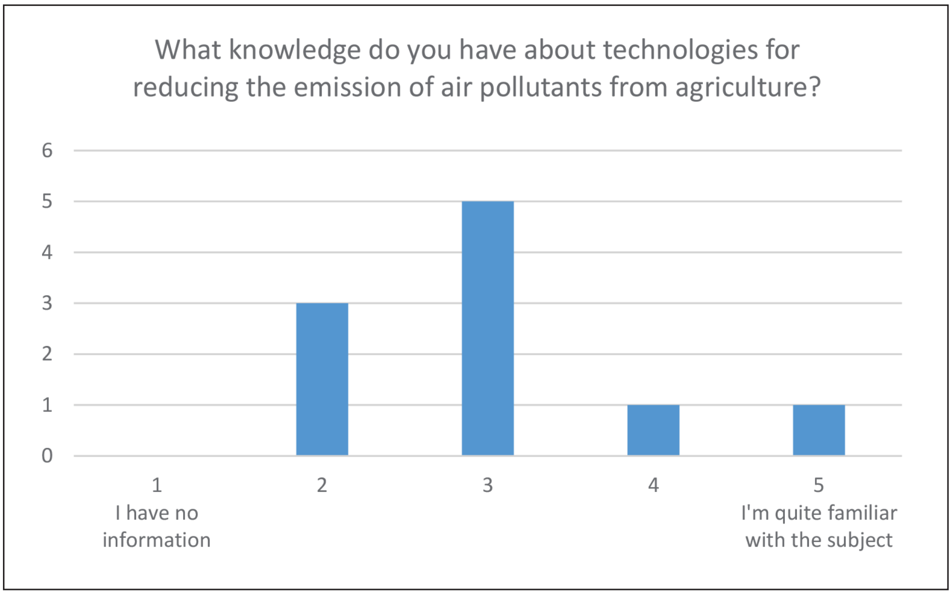

Figure 2: Level of respondents' awareness of technologies to reduce air pollutant emissions from agriculture (Northern Hungarian Plain and Southern Hungarian Plain region, n=10)

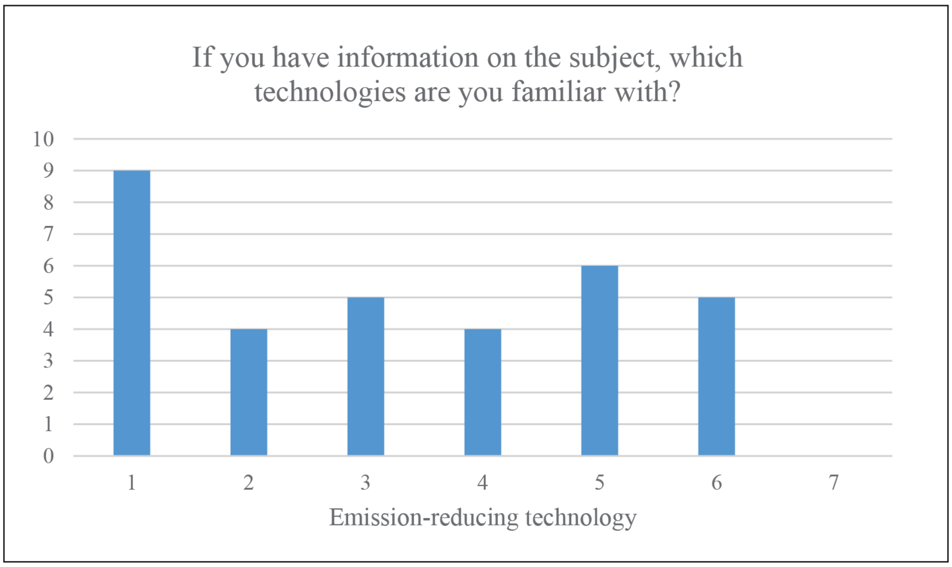

Figure 3: Level of awareness of certain technologies that reduce air pollutant emissions from agriculture (respondents could indicate several technologies known to them; Northern Hungarian Plain and Southern Hungarian Plain region, n=10)

Legend:

1. Proposed technologies to reduce deflation (e.g. special field and tillage technologies, precision farming, timing of tillage, use of cover crops, mulching, etc.).
2. Special non-arable technologies (e.g. keeping clean the surface of agricultural roads, the use of windbreaks – e.g. plant strips, speed limits for vehicles on agricultural roads, etc.).
3. Low emission harvesting technologies.
4. Technologies proposed to reduce emissions for diesel-powered agricultural machinery.
5. Ways to reduce dust emissions on livestock farms from stables and cow-sheds, bedding material and feed.
6. Ways to reduce ammonia emissions from livestock manure (e.g. optimisation of feeding, appropriate husbandry techniques and manure management).
7. Other technologies for reducing emission.

In line with the objective of the application, the questionnaire survey and the study based on it, titled *„Plan for replicability and transferability of low emission agricultural technologies to Hungary"* by carrying out a study to answer, among many other questions, which sources farmers find most appropriate for information on emission reduction technologies. Based on the answers to the question asked in this regard and the partial results available, it seems that farmers consider the most suitable source of information for this purpose to be the professional websites and the information published there. Equally important, however, is the use of agricultural advisers to provide advice tailored to their own production, and the opportunity to find out more at thematic events on the subject. This partial result of the survey is partly similar to the results of a recent survey of individual farmers and agricultural company managers on a similar topic (Polyák & Varanka 2021). These results reflect the fact that the most important source of information for a wide range of respondents is the free newsletter, brochure (this ranked sixth in our survey), the second source of information is a friend, a colleague, or a consultant (it has the same ranking), and third place went to the online agricultural portal (and this is the first in our survey).

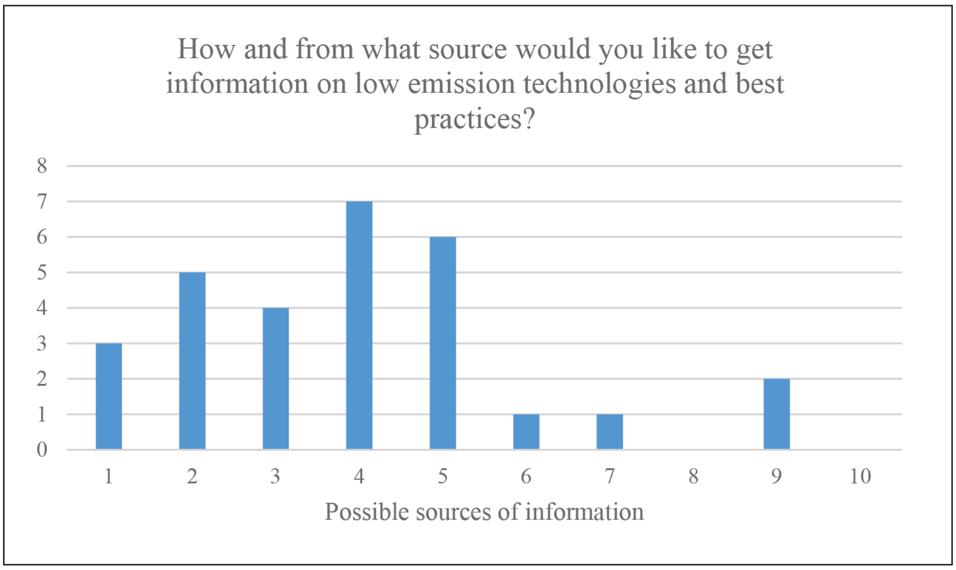

Figure 4: Evaluation of the sources of information that farmers consider suitable for learning about emission reduction technologies (a respondent could indicate more than one source; Northern Hungarian Plain and Southern Hungarian Plain region, n=10)

Legend:

1.	In the context of special, specialised training on this subject, in the context of continuing vocational training.
2.	During thematic events (e.g. trade exhibitions, presentations, etc.).
3.	Through articles published in specialized journals.
4.	From professional websites.
5.	With the help of agricultural consultants, in the context of advice tailored to their own production.
6.	Information received from interbranch organisations.
7.	Within the framework of short, online thematic training sessions and briefings on a specific technological area.
8.	Within the framework of short, thematic, face-to-face training and information sessions on a specific technological area.
9.	Short online newsletters, sent to you on a regular basis, featuring one of these technologies.
10.	Other ways.

SUMMARY

In our homeland, the current situation with regard to ambient air pollution is the most unfavourable for small aerosol particles (commonly known as particulate matter), for this air pollutant, emissions from agriculture are the second most important emission sector after emissions from residential sources. Therefore, it is important to know how these agricultural emissions can be reduced, what knowledge have agricultural producers in the area of emission-reducing technologies and best practices. Within the framework of the HUNGAIRY LIFE integrated project, a national questionnaire survey will be carried out in 2022–2023 among the farmers who voluntarily participate in the survey. The results of the questionnaire survey so far for the Northern Hungarian Plain and Southern Hungarian Plain regions reflect that farmers in these regions who responded to the questionnaire and answered the questions already have some knowledge of emission reduction technologies. Based on the answers and the partial results, it can also be concluded that the information published on professional websites is of great importance for the transfer of further knowledge and for informing the farmer in this respect, and the role of agricultural consultants is expected to remain significant.

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. More information about the project can be found at www.hungairy.hu. 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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