EREM 77/2

Journal of Environmental Research, Engineering and Management
Vol. 77 / No. 2 / 2021
pp. 7–18
DOI 10.5755/j01.erem.77.2.28698

Future of the Waste Management in Distilleries for Home Fruit Growers – Case from Slovakia

Received 2021/03 | Accepted after revision 2021/05

http://dx.doi.org/10.5755/j01.erem.77.2.28698

Future of the Waste Management in Distilleries for Home Fruit Growers – Case from Slovakia

Ondrej Beňuš*, Peter Bielik, Natália Turčeková, Izabela Adamičková
Department of Economics, Faculty of Economics and Management, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra Slovakia

***Corresponding author:** ondrej.benus@uniag.sk

Distilleries for home fruit growers play an important role in the Slovak spirits industry. They represent from 5% to 15% of the total spirits production in the country. In this paper, businesses with a focus on waste management and its future potential were investigated. The investigated industry creates a significant amount of bio-waste when under 10% of raw materials used for the distillation process are transformed into the final product. The waste production in distilleries for home fruit growers based on the available annual production data was estimated in this research. Based on these estimations, distilleries for home fruit growers produce annually 37,407.07 tons of bio-waste on average. The median distillery produces annually around 211.4 tons of bio-waste. The bio-waste from investigated distilleries is used directly as fertilizer on the arable soil at this time. This option is the cheapest solution for distilleries for home fruit growers. The different reuse options for bio-waste from distilleries were compared. All of them were more expensive compared to direct use of bio-waste as a fertilizer. Due to the higher cost, there is no interest to reuse this significant amount of the bio-waste produced in small distilleries for home fruit growers at this moment.

Keywords: distilleries for home fruit growers, bio-waste, waste management.

Introduction

Distilleries for home fruit growers represent a specific kind of distilleries within the Slovak legislative environment. The distilling of spirits has a long tradition within the territory of the Slovak Republic. It can be traced back to the 13th century. But it is only the year 1400 when the first large distillery was established within our territory. The main raw material for the production of spirits was beer or wine (Dýr et al., 1963). During the following years, the first literature related to the distilling of spirits occured (Brunschwig, 1559). This helped to spread interest in the distilling of spirits across a broader audience.

Large commercial distilleries started to use a broader range of raw materials in the 16th century when producing spirits from the beer yeast, apple, pear, Juniperus and other sugar-containing raw materials. All these mentioned changes were helpful for further commercialization of fruit spirits within the territory of the Slovak Republic. (Dýr, 1963). The fruit became quickly a favourite raw material for the spirits production. There were 243 distilleries in Moravia between 1870 and 1875. 233 from 243 mentioned distilleries used fruit as the main raw material for their production. 102 distilleries produced exclusively plum brandy at that time (Grégr, Uher, 1974). The growth of distilleries was put to a halt in 1948 when all companies were nationalized. Large, united distilling companies were established in areas with the best climate conditions for growing fruit trees (in the case of the Slovak territory the focus was mainly on the southern areas).

The new era of fruit distilling companies started in 1996 when the act No. 289/1996 Coll. on the production and circulation of alcohol and on the amendment of Act no. 455/1991 Coll. on Trade Licensing was adopted. This act established the legal term "distillery for home fruit growers". Its purpose was to processes fruit and grape wines as the basic raw material. According to this legal act, a distillery for home fruit growers should only serve fruit growers and produce distillates using the fruit grower´s raw material. Later, this legal act was amended by the act No. 467/2002 Coll. on the production and marketing of alcohol. However, the main definition of distilleries for home fruit growers did not change. There were also numerous other amendments to this legal act in the next years. The most important change was made when the policymaker allowed fruit growers to buy fruit and process it in distilleries for home fruit growers.

The broad popularity of fruit spirits produced by distilleries for home fruit growers has been apparent in the last decades. This created concerns on the waste management of this type of companies distilling fruit spirits.

After the Slovak Republic joined the EU, policymakers were challenged by new requirements for waste management. This also included the area of biological waste created during distillation process in distilleries for home fruit growers.

Distilleries for home fruit growers operate under special legislation restrictions implemented by national authorities on the territory of the Slovak Republic. The act No. 467/2002 Coll. on the production and placing of spirits on the market and act No. 530/2011 Coll. on the excise duty on alcoholic beverages set specific circumstances of operation for the above-mentioned enterprises.

The most significant difference to other commercial distilleries is the fact that these companies do not possess the state´s approval to produce their own spirits and sell them to the end customer or wholesale (§49 of the act No. 530/2011 Coll.). Thus, distilleries for home fruit growers only operate as processing companies for fruit growers. This production cannot be sold by distilleries nor fruit growers.

The second specific condition regulating distilleries for home fruit growers is the production limitation. According to the legislative regulation set by the Act No. 530/2011 Coll., distilleries for home fruit growers must produce only up to 43 l.a. (litres of pure 100% spirits) per one household. With the production of fruit spirits limited to 43 l.a., fruit growers are subject only to 50% of regular excise duty from alcohol (§6 of the act No. 530/2011 Coll.).

The third specific regulation set by the Slovak legislation is the limitationof the processed type of fruit. The fruit of the moderate climate zone can be only processed in distilleries for home fruit growers. It represents a crucial restriction for distilleries for home fruit growers. Thus, these companies are not allowed to distil any other raw material than fruit from the moderate climate zone (i.e. starch-based cereals). Without a possibility to distil starch-based cereals, these companies are limited to operate during only a few months in the year. This has also a significant impact on the further development of alternative methods for spent wash reuse. If the policymaker adds a possibility to process starch-based cereals, these companies would be able to proceed or supply other companies with the spent wash through the whole year.

EU authorities are closely tied to the bioeconomy and sustainable development. The EU Bioeconomy Strategy is focusing on five key objectives: ensuring food and nutrition security, managing natural resources sustainably, reducing dependence on non-renewable and unsustainable resources, mitigating and adapting to climate change, strengthening European competitiveness and creating jobs (European Commission, 2018). The bioeconomy deals with biological resources and their use or reuse. In the centre of interest are animals, plants, micro-organisms and derived biomass, including organic waste (European Commission, 2018). This approach was supported by abroad research oriented on different types of biological resources and their use within national economies. First, the main objective became the use of biological raw materials such as maize, corn or wheat for the production of biofuels (Dhugga, 2007, Rosegrant, 2008, Quintero et al., 2008). Thus, this approach brought a significant amount of criticism. Numerous studies are dealing with competition between biofuels and food (Kapustová et al. 2017, Valdemaras et al., 2018). Later, a significant amount of research activity can be seen within the use of wood biomass as a source of biofuels (Burliai et al., 2018, Lovrić et al., 2020, Kallio, 2021).

The latest trend seems to be connected heavily with bio-waste reuse. This approach follows the EU Action Plan of the Circular Economy which focuses on keeping values of raw materials within the economy for as long as possible and, of course, with the minimalization of the produced waste (Hagelüken, 2016). A complex research oriented on food waste reuse can be identified in the past few years (Arina & Bendere, 2018, Bhargava, 2020, Zhao et al., 2021). However, there is an emerging trend in the research focused on the use of waste created within the food processing industry (Yusoff, 2006).

Alcoholic beverages and the bio-waste created during their production also became an object of interest in the recent research. The production of this type of beverage is often connected with a significant amount of bio-waste. All alcoholic beverages use only a fraction of the raw material included in the production process. The majority of used raw materials turns into bio-waste. The distilling industry produces by far the most direct waste during the production of spirits despite a significant efficiency growth in the last decades (see Table 1). The highest amount of bio-waste represents spent wash depending on the type of alcoholic beverage made. Its structure and possible areas of reuse differ significantly.

Table 1. *Example of the spirits production efficiency during last decades. The data from distilleries in Scotland. (litres of pure 100% spirits) (Russell et al., 2014)*

Year	Spirits yield (l.a.)
1950	350
1965	390
1970	410
1990	430
1995	445
1997	460
2001	460

Methods

The manuscript is exclusively focused on distilleries for home fruit growers in the Slovak Republic. Within their production process, the highest amount of direct bio-waste represents spent wash. We focused on this type of waste produced within these enterprises in our research.

At the beginning of the research, the contribution of distilleries for home fruit growers to the bio-waste production in the Slovak Republic was estimated. Estimations were be based on:

- the number of distilleries,
- yearly production,
- production efficiency.

Later in the research process, thebio-waste production in investigated distilleries was calculated. There was no data available in this research area at the moment the research was conducted. The estimation of bio-waste production was based on the fruit spirits production and the average fruit spirits' yield.

The average yearly production and the average number of distilleries were estimated using the median value:

$$Median = L + \frac{\frac{N}{2} - cf_p}{f_{med}} (W) \quad (1)$$

Where: L – The lower limit of the median class interval; c_{fp} – A cumulative total of the frequencies up to but not including the frequency of the median class; f_{med} – The frequency of the median class; W – The width of the median class interval; N – Total number of frequencies.

The research process required an estimation of the bio-waste produced by distilleries for home fruit growers. This data was not available at the moment the research was conducted. The amount of waste produced in these enterprises was estimated based on available information on the yearly fruit spirits production and the average yield for different fruit varieties. The process for estimation of the waste produced by distilleries was conducted in three separate steps. First, the most commonly used fruit varieties for fruit distillation were identified and their hypothetic share of the total fruit harvest in the Slovak Republic was calculated.

The investigation of the waste production within distilleries for home fruit growers followed by percentual share estimation of different fruit varieties compared to the total fruit harvest within the Slovak Republic. The equation for tour estimate can be specified as follows:

$$S_f = \frac{P_f}{P_t} * 100 \quad (2)$$

Where: S_f – Share of specific fruit variety on the total annual fruit production; P_f – Annual production of the specific fruit variety; P_t – Annual fruit production.

In the second step, the ideal fruit spirits yield from 100 kg of fruit mash was estimated. Each fruit variety has a different yield of the final product due to the difference in the sugar content. The used equation has the following form:

$$I_{ideal} = I_{current\ 1} * Sj_1 + I_{current\ 2} * Sj_2 + I_{current\ 3} * Sj_3 + I_{current\ n} * Sj_n \quad (3)$$

Where: I_{ideal} – Ideal fruit spirits yield combined for the most common fruit varieties; $I_{current\ 1\ to\ n}$ – Fruit spirits yield for a specific fruit variety; S_f – Share on the total fruit harvest for a specific fruit variety.

With available data for the total alcohol production (median) and the ideal fruit spirits yield combined for the most common fruit varieties, the total bio-waste production in distilleries for home fruit growers was estimated:

$$W_p = \frac{P_m}{I_{ideal}} * 100 \quad (4)$$

Where: W_p – Total waste production; P_m – Total annual fruit spirits production in distilleries for home fruit growers.

The average waste production in one distillery for home fruit growers was calculated based on the following assumption:

$$W_{pa} = \frac{W_p}{D_m} \quad (5)$$

Where: W_{pa} – Average waste production in one distillery for home fruit growers; D_m – Number of distilleries for home fruit growers (median).

The total cost for disposal of the bio-waste was calculated using the following equation:

$$W_{rc} = W_p * c \quad (6)$$

Where: W_{rc} – Total cost for waste disposal; c – Cost of bio-waste disposal per unit.

The cost of the bio-waste disposal per one distillery was estimated based on the following equation:

$$W_{rca} = \frac{W_{rc}}{D_m} \quad (7)$$

Where: W_{rca} – Average cost of bio-waste disposal per one distillery for home fruit growers.

The data were collected from datasets of following institutions:

- The Ministry of Agriculture and Rural Development of the Slovak Republic,

_ The Central Control and Testing Institute in Agriculture.

The legislation used in the research can be divided into two separate categories. The first category is dedicated to European law (directives and regulations governing the use and reuse of the bio-waste). The second category represents the national legislation governing the use of the bio-waste produced within distilleries for home fruit growers.

Results and Discussion

The research outcome was divided into three separate areas. The position of distilleries for home fruit growers was investigated at the beginning of the research. Based on available data, an estimation of the annual bio-waste production within investigated enterprises was conducted. In the third step, a cost analysis of different bio-waste processing methods and their impact on the economics of distilleries for home fruit growers was compared.

Position of distilleries for home fruit growers within the Slovak spirits industry.

Distilleries for home fruit growers were growing rapidly in the last years, especially if we consider the total number of enterprises (Figure 1.) There were 233 Distilleries for home fruit growers in the year 2020. It is a significant change compared to 149 distilleries in the year 2010. There was not a single year of stagnation during the last eleven years. Preliminary data show that the year 2021 may become one of the strongest in terms of newly established distilleries for home fruit growers. After the first three months of the year 2021, the Ministry of Agriculture and Rural Development of the Slovak Republic registered already eight new distilleries. Despite the economic downturn and production restrictions related to the COVID-19 pandemic, the trend in this segment will probably not change.

Compared to the number of distilleries for home fruit growers, the yearly production did not follow the same path. Economic years were investigated instead of calendar years because distilleries for home fruit growers follow the seasonality of fruit growing in the country. The strongest result was achieved in the economic year 2018-2019 when production of fruit spirits grew to 2,965,717 l.a. It is a change of 289% compared to the previous economic year 2017-2018. One year later and the production was down to 1,244,922 l.a. representing only 42% compared to the previous year.

Differences in the yearly production of distilleries for home fruit growers are related to the raw material used for the spirits production. The fruit growing process is strongly influenced by weather conditions during the whole year. Differences in the total yearly production

Fig. 1. *The number of distilleries for fruit home growers between the years 2010 and 2020*

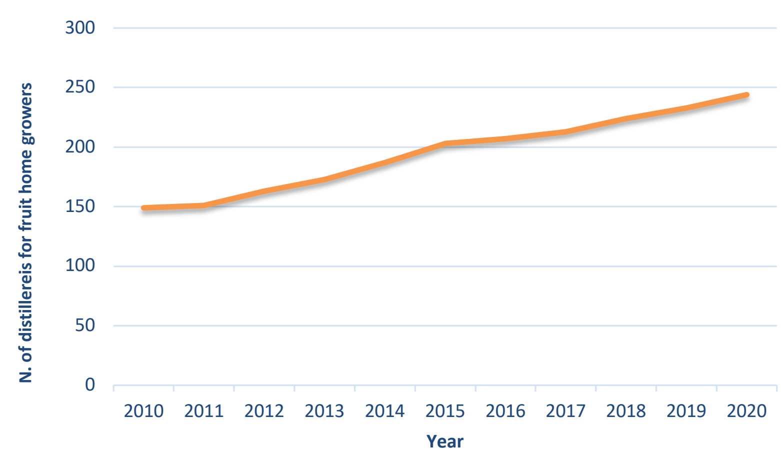
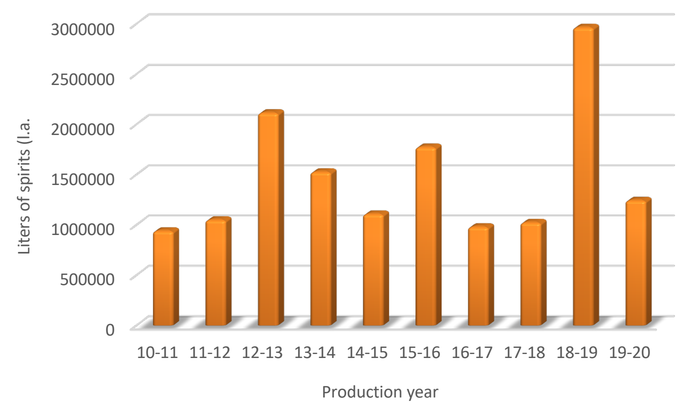


Fig. 2. *The yearly production in distilleries for home fruit growers (in liter of pure 100% spirits)*



of the fruit are apparent and each year brings different yields of the total fruit harvest. This factor is the main cause of differences in the yearly production of spirits in distilleries for home fruit growers.

The average production per one distillery for home fruit growers experienced phases of growth, as well as phases of stagnation (see Figure 3.). Two variables are influencing the measured yearly production per one distillery for home fruit growers. The first variable is the number of distilleries registered by the Ministry of Agriculture and Rural Development of the Slovak Republic in each individual year. A continuous growth in the number of distilleries during observed years can be clearly identified. The second variable is the total production of spirits in distilleries for home fruit growers in each individual year. Changes in this second variable are more obvious if individual economic years are compared. The average production of fruit spirits in distilleries for home fruit growers was above 10,000 l.a. only in two economic years (in the economic year 2012-2013 the average production per distillery grew to 12,980.72 l.a. and in the economic year 2018-2019 the value of average production grew to 13,239.81 l.a. per one distillery). On the other hand, the lowest average production was under 5,000 l.a. (4,743.12 l.a.) in the economic year 2016-2017.

Fig. 3. *Average production of fruit spirits per distillery for home fruit growers between years 2010 and 2020*

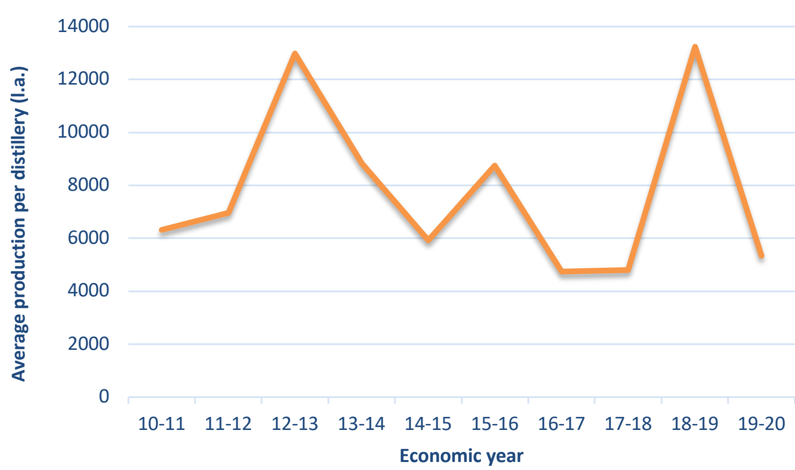


Table 2. *The total production of spirits and the production of spirits in distilleries for home fruit growers comparison (values in thsd. litres of pure 100% spirits, percentual comparison of production in %)*

	2011	2012	2013	2014	2015	2016	2017	2018	2019
Distilleries for home fruit growers	942	1,051	2,116	1,528	1,109	1,775	982	1,025	2,966
Total spirits production	15,548	15,079	15,106	15,329	15,347	15,850	16,206	17,004	17,506
Percentual comparison of production	6	7	14	10	7	11	6	6	17

The position of distilleries for home fruit growers within the Slovak spirits industry can be clearly identified, if the data presented in the table 2 are compared. Compared to large distilleries, small independent distilleries for home fruit growers rely heavily on the harvest in local orchards and gardens. Current legislation (act No. 467/2002 Coll.) restricts the spirits production in distilleries for home fruit growers only to fruit brandies based on fruit from the moderate climate zone. Thus, the production is dependent on weather conditions for each individual year. Climate change brings changing weather conditions and the spring frost causes often significant damage to the local fruit production. Thus, distilleries for home fruit growers register different production for each individual year. As highlighted by the table 2., the production difference between observed nine years is 315% (comparing the year 2011 and 2019). On the other hand, large distilleries proceed starch-based cereals which are not prone to the climate change in the same manner as the fruit is.

Table 3. *The descriptive statistics of the yearly production, number of distilleries for home fruit growers and the average production of fruit spirits per one distillery between years 2010 and 2020 (production in litres of pure 100% spirits)*

Indicator	Production (l.a.)	Number of enterprises	Average production (l.a.)
Nbr. of observations	10	10	10
Minimum	941,616	149	4,743
Maximum	2,965,717	233	13,239
1st Quartile	1,031,597	166	5,490
Median	1,177,094	195	6,639
3rd Quartile	1,713,534	211	8,812
Mean	1,473,893	190	7,791
Variance (n)	382,250,655,711	822	8,908,488
Standard deviation (n)	618,264	29	2,985
Variation coefficient (n)	0.419	0.151	0.383
Standard error of the variance	200,216,319,086	431	4,666,113
Geometric mean	1,370,744	188	7,288

The average number of distilleries for home fruit growers and the yearly production in these distilleries were estimated to conduct further research related to waste production. The main task was to establish the yearly production in distilleries for home fruit growers that could be used for the calculation of the produced waste by this type of enterprises. The data from the descriptive statistics showed (Table 3.) higher levels of the standard deviation and the variation coefficient. Thus, it was not possible to choose a representative year from the sample included in the research. Thus, the decision was made to use the median of the yearly production between economic years 2010-2011 and 2019-2020. Following this approach, the average yearly production of distilleries for home fruit growers was established at a level of 1,1170,094 l.a. and this value was used for estimation of the produced waste by these enterprises. The same approach was used for the estimation of the average number of distilleries for home fruit growers. The median value was 195. The average production of spirits per one distillery did change in various directions during observed years and was strongly influenced by the yearly production of fruit spirits at the national level. The median (estimated at 6,639 l.a.) was accepted as a reference value for further calculations of the bio-waste production per one distillery in this case, too.

The stimation of the waste production in form of the spent wash by distilleries for home fruit growers.

It was not possible to obtain accurate information on the total amount of the bio-waste produced by distilleries for home fruit growers at the time we conducted the research. The only possibility to establish the overall production of the bio-waste from the spent wash was a calculation based on the total amount of production. The first step was to identify the efficiency of the production. Compared to large distilleries using usually only one starch based raw material, fruit distilleries for home fruit growers process different varieties of fruit. There is also a problem with the quality of the mash provided by the home fruit grower. To estimate the bio-waste production by investigated distilleries, the fruit production and the overall yield anticipated from different fruit varieties was investigated (see table 4.).

Table 4. *The fruit harvest for selected fruit varieties (in the year 2020) and the fruit spirits yield*

Fruit variety	Share on the total fruit harvest (tons)	Fruit spirits yield (per 100kg of fruit)	Share on the total fruit harvest (%)
Apples	28,428.5	3	87.3
Plums	1,261	5	3.9
Pears	1,104.8	3	3.4
Peaches	1,074.8	4	3.3
Cherries	535.6	4	1.7
Apricots	134.7	6	0.4

The total fruit production in the year 2020 (The Central Control and Testing Institute in Agriculture, 2021) was investigated and the average fruit spirits yield for the most common fruit varieties processed in distilleries for home fruit growers was estimated according to the already published research outcomes (Grégr, 1974, Pieper, 1977, Albrecht et al., 2010, Hartmann, 2018). It is apparent that the share of the total fruit harvest is different for each individual fruit variety. Home fruit growers use for their fruit spirits the raw material available in the Slovak Republic (both harvested in their own gardens or bought from commercial fruit growers). Each fruit variety has different sugar content which results in a different fruit spirits yield.

Due to a different share of the total fruit harvest and the total fruit spirits yield for each fruit variety, the ideal average fruit spirits yield was estimated. This ideal fruit spirits yield represents the average yield anticipated from the most common fruit varieties used for fruit spirits production in distilleries for home fruit growers respecting both the share on the total fruit harvest and the fruit spirits yield (see Table 5.).

Table 5. *The ideal average fruit spirits yield (litres of pure 100% spirits) for the most common fruit varieties (per 100kg fruit)*

Fruit variety	Apples	Plums	Pears	Peaches	Cherries	Apricots	Total
Ideal average fruit spirits yield (l.a.)	2.619	0.195	0.102	0.132	0.068	0.024	3.140

Table 6. *Estimation of the spent wash production in distilleries for home fruit growers*

Yearly production of spirits (median)	1,177,094
Average yearly production of spirits per distillery (median)	6,639
Yearly spent wash production	37,487,070
Average yearly spent wash production per distillery	211,433

The estimation of the average yearly production of fruit spirits (median value for years 2010-2020) and the ideal average fruit spirits yield (l.a. in 100kg fruit mash) were used to establish the average value of the bio-waste production in distilleries for home fruit growers. The combination of these two indicators revealed the total bio-waste production at a value of 37,487.07 tons. The average yearly spent wash production per one distillery for home fruit growers was calculated at 211.43 tons.

Different methods of the bio-waste reuse and its economic impact on distilleries for home fruit growers.

The spent wash from distilleries for home fruit growers is classified as a bio-waste according to the act No. 79/2015 Coll. on waste, as amended. Despite its classification as a non-hazardous waste, it sets new challenges for small independent producers. Distilleries for home fruit growers may produce as much as 44 million tons of spent wash per economic year, according to our calculations. The most common use for this bio-waste product is for the fertilization of the soil. New trends and actions adopted by the EU emphasize the reuse of bio-waste products. Based on legal regulations and the statistical data, four available options for the bio-waste resue were identified.

Biogas plants

Biogas plants accept the liquid or solid waste from distilleries. If only the liquid waste is accepted, distilleries are required to remove any fruit stones. Stones can be used for the heating purposes of the distillery. One kilogram of fruit stones is equal to 6 kWh of the heating power. (Christen, 2013).

Compost

Bio-waste from distilleries has still a relatively high nutrition level and is well suited for further use as the compost. There is also a negative side of the bio-waste from distilleries for home fruit growers. Fruit mash lacks solid particles and requires more energy for its processing, thus distilleries pay a higher processing fee.

Direct use as fertilizer on the arable soil

This is the most common use of fruit spent wash from distilleries for home fruit growers. It is the least expensive option for distilleries (Table 6.) because they only pay for the transportation of the spent waste in the field. Agricultural companies do not charge any fee to the distilleries. The disadvantage of this approach is that in this case, we are limiting the use of the spent wash only for fertilizing.

Sewage treatment plants

Sewage treatment plants use the bio-waste from distilleries for home fruit growers as a co-product when producing the biogas. After this treatment is finished, the bio-waste from distilleries can not be further used for agricultural purposes as the fertilizer. This fact relatively restricts the final use of the spent wash as a valuable nutrition product for the arable soil.

All the above-mentioned methods of the spent wash reuse have a negative effect on the economics of distilleries. The bio-waste represents material for the further production in all of them, but no processing plants are paying for the bio-waste. After the yearly spent wash production in distilleries for the home fruit growers was estimated, the cost of all the abovementioned methods for further reuse of the fruit spent mash from these companies were investigated (see Table 7.). Calculations are based on the survey between enterprises processing the spent wash from distilleries and literature research (Christen, 2013). Obviously, the most efficient is the direct use as the fertilizer on the arable soil. On the other hand, the most expensive occurs to be the processing of the spent wash in facilities producing the compost, closely followed by sewage treatment plants.

Table 7. *The economic impact of different spent wash reuse approaches*

Spent wash processing method	Total cost (€)	The average costper distillery (€)
Biogas plants	1,199,586	6,766
Compost	2,061,789	11,629
Direct use as fertilizer on the arable soil	312,392	1,762
Sewage treatment plants	2,399,172	13,532

Conclusions

Distilleries for home fruit growers represent a dominant form of enterprises within the Slovak spirits industry with a share of the total spirits market from 5% to 15% (Ministry of Agriculture and Rural Development, 2021). According to special conditions set by the Slovak legislation (act No. 530/2011 Coll.) these enterprises have a favourable taxation system. Mentioned distilleries pay a lowered excise duty in the amount of 540 € per 100 l.a. compared to the basic excise duty of 1,080 € per 100 l.a. (paid by commercial distilleries). This taxation system allows distilleries for home fruit growers to offer a lower price of the service they provide to home fruit growers.

A surge in new distillery openings within the last eleven years (the total number of distilleries for home fruit growers rose by 164%) is apparent. Despite challenging weather conditions resulting in inconstancy of the fruit harvest it seems that there is still a relatively high demand for services provided by distilleries for home fruit growers.

The European Union has ambitious goals related to the green economy, bioeconomy or circular economy. This may have an impact on distilleries for home fruit growers in the future. These enterprises faced already significant changes in past years. The business changed due to joining the EU in 2004 and the adoption of the EU legislation. The next big concern is the efficiency of the waste management and the protection of nature. The spirits industry produces a significant amount of bio-waste during the distillation process. The final product represents only 4% to 10% of raw materials used during the distillation process (Dýr, 1956, Grégr, 1974, Pieper, 1977, Albrecht et al., 2010) and additional waste is produced during fermentation, storing and bottling.

The main focus of the research was on the bio-waste production within the distillation process in distilleries for home fruit growers. There is not an accurate method to identify the amount of bio-waste produced by this kind of enterprises. Estimations were based on the average efficiency of the distillation process and the sugar content of different fruit varieties mostly used in these distilleries. Distilleries for home fruit growers produce as high as 37,487 tons of bio-waste with an average of 211.4 tons per distillery during the distillation process, according to our estimations. This considerable amount of bio-waste is mostly used as a fertilizer for the arable soil without any further processing.

In the future, an effective way of the bio-waste processing will come into question. Distilleries will be obliged to follow the main aim of the EU and keep values of processed raw materials within the economy for as long as possible (Hagelüken, 2016). It is essential to put a next step between the distillation process and the final use of the bio-waste as a fertilizer on the arable soil. The comparison of different methods suitable for the fruit spent wash reuse was conducted within this research. However, the research shows that this additional step could significantly raise the economic cost of production in distilleries for home fruit growers. Even the cheapest bio-waste processing method, the biogas production in biogas plants, is almost four times more expensive compared to direct use of the bio-waste as a fertilizer on the arable soil. The direct use of bio-waste may have a negative effect on the arable soil as well as on the water quality. (Zerrouqi et al., 2020) The implementation will require a coordinated action made at the national level that will lead to a harmonized approach in this field. The higher cost for distilleries may be compensated by funding from national, EU and other international funds dedicated to the green energy and circular economy.

The research outcomes compared to already available data show that the use of the spent mash within the bio-gas plant is the best option for both the economy and the environment. The direct use of the spent wash from distilleries for home fruit growers may harm the ecosystems because of its low acidity of around 3,5 pH, if used extensively on the arable land. If the spent wash is used within the biogas stations first, the pH will adjust more towards the neutral value (7 pH).

The research outcome clearly shows that there is a considerable amount of green energy wasted in distilleries for home fruit growers. Estimations were made using available literature, statistical data and the cost survey of different bio-waste processing methods. To precise the economic potential of this segment, a deeper field research is required.

Acknowledgements

This research paper was prepared in the frame of the Erasmus+ Jean Monnet Module project "Economic and Legal Basics of Entrepreneurship in Agrifood Industry" No. 600459-EPP-1-2018-1-SK-EPPJMO-MODULE.

With the support of the Erasmus+ Programme of the European Union

References

Act No. 289/1996 Coll. on the production and circulation of alcohol and on the amendment of Act no. 455/1991 Coll. on Trade Licensing (Trade Licensing Act), as amended

Act No. 467/2002 Coll. on the production and distribution of spirit into the market, as amended

Albrecht, W., Dürr, P., Gössinger, M., Hagmann, K., Pulver, D., & Scholten, G. (2010). Technologie der Obstbrennerei (3. Auflage. ed.). Ulmer Eugen Verlag.

Arina, D., & Bendere, R. (2018). Waste as energy source in EU action plan for the circular economy. Environmental Research, Engineering and Management, 74(1), 43-49. https://doi.org/10.5755/j01.erem.74.1.19779

Bhargava, N., Sharanagat, V. S., Mor, R. S., & Kumar, K. (2020). Active and intelligent biodegradable packaging films using food and food waste-derived bioactive compounds: A review. Trends in Food Science & Technology, pp105, 385-401. https://doi.org/10.1016/j.tifs.2020.09.015

Burliai, A., Ryabchenko, O., Bielik, P., & Burliai, O. (2018). Energy security FACETS: verification of horticultural wooden waste potential with bioenergy development purpose. Journal of Security & Sustainability Issues, 8(1). https://doi.org/10.9770/jssi.2018.8.1(5)

Brunschwig, H. (1559), 536 s, Kníhy o pravém umění distilování aneb vod pálení, Olomouc, Czech Republic: Nakladatelstvo Jána Gúnthera

Christen, D., Heiri, M., & Petignant-Keller, S. (2013). Entsorgugnswege der schlempe. Schweizer Zeitschrift für Obst- und Weinbau, 150, (9), 2014, 10-13.

Dhugga, K. S. (2007). Maize biomass yield and composition for biofuels. Crop Science, 47(6), 2211-2227. https://doi.org/10.2135/cropsci2007.05.0299

Dýr, J., Grégr, V., Kutttervašer, Z., Seiler, A., Tomášek, J., & Zelenka St. (1956). Lihovarství I. díl. Praha, Czech Republic: Práce, n.p.

Dýr, J., Grégr, V., Seiler, A. (1963). Lihovarství II. díl. Praha, Czech Republic: Práce, n.p.

European Commision (2018) A sustainable Bioeconomy for Europe: strengthening the connection between economy, society and the environment, Brussels, ISBN: 978-92-79-94145-0

Grérg V., Uher J. (1974). Výroba Lihovin. Praha, Czech Republic: Nakladatelství technické literatury, n.p.

Hagelüken, C., Lee-Shin, J. U., Carpentier, A., & Heron, C. (2016). The EU circular economy and its relevance to metal recycling. Recycling, 1(2), 242-253. https://doi.org/10.3390/recycling1020242

Hartmann, W., & Schwarz, P. (2018). Die 100 besten Obstsorten für die Brennerei. Ulm, Germany:Ulmer Eugen Verlag.

Kallio, A. M. I. (2021). Wood-based textile fibre market as part of the global forest-based bioeconomy. Forest Policy and Economics, 123, 102364. https://doi.org/10.1016/j.forpol.2020.102364

Lajdová, Z., Kapusta, J., Bielik, P., Čeryová, D., & Dobošová, L. (2017). Biofuel production versus food-commodity prices: using case of ethanol against sugar, corn and wheat. Agrarian Perspectives XXVI. Competitiveness of European Agriculture and Food Sectors, Proceedings of the 26th International Conference, 13-15 September 2017 Prague, Czech Republic (pp. 182-189). Czech University of Life Sciences Prague, Faculty of Economics and Management. Lovrić, M.,

Lovrić, N. š., & Mavsar, R. (2020). Mapping forest-based bioeconomy research in Europe. Forest Policy and Economics, 110, 101874. https://doi.org/10.1016/j.forpol.2019.01.019

Pieper, H. J., Bruchmann, E. E., & Kolb, E. (1977). Technologie der Obstbrennerei. Ulm, Germany: Verlag Eugen Ulmer.

Quintero, J. A., Montoya, M. I., Sánchez, O. J., Giraldo, O. H., & Cardona, C. A. (2008). Fuel ethanol production from sugarcane and corn: comparative analysis for a Colombian case. Energy, 33(3), 385-399. https://doi.org/10.1016/j.energy.2007.10.001

Rosegrant, M. W. (2008). Biofuels and grain prices: impacts and policy responses (pp. 1-4). Washington, DC: International Food Policy Research Institute.

Russell, I., Bamforth, C., & Stewart, G. (2014). Whisky: technology, production and marketing. Elsevier.

The Central Control and Testing Institute in Agriculture (2021). Production of fruit. Available at: https://www.uksup.sk/ooepv-datasety-ov

Valdemaras, M., Astrida, M., Tatiana, S., Natalia, T., & Tadas, S. (2018). The impact of biofuels production development in the European Union. Agricultural Economics (Zemědělská Ekonomika), 64(No. 4), 170-185. https://doi.org/10.17221/285/2016-AGRICECON

Yusoff, S. (2006). Renewable energy from palm oil-innovation on effective utilization of waste. Journal of cleaner production, 14(1), 87-93. https://doi.org/10.1016/j.jclepro.2004.07.005

Zerrouqi, Z., Tazi, M. R., Chafi, A., & Zerrouqi, A. (2020). Impact of Sewage Sludge Leaching on Soil Constituents and Quality. Environmental Research, Engineering and Management, 76(4), 87-96. https://doi.org/10.5755/j01.erem.76.4.25632

Zhao, Y., Wang, C., Zhang, L., Chang, Y., & Hao, Y. (2021). Converting waste cooking oil to biodiesel in China: Environmental impacts and economic feasibility. Renewable and Sustainable Energy Reviews, 140, 110661. https://doi.org/10.1016/j.rser.2020.110661