[1.]Attila BARCZI, [2.]Valeria NAGY, [3.]Dániel SZALAI

POSSIBILITIES AND LIMITATIONS IN ARABLE LAND UTILIZATION OF FERMENTATION AND DISTILLATION RESIDUE

[1,3.]Szent István University, H- 2100 Gödöllő, HUNGARY
[2.]University of Szeged, H-6725 Szeged, HUNGARY

Abstract: According to the decision of the Hungarikum Committee, the 'Pálinka' has been considered Hungarikum since March 2013 in Hungary. During the 'Pálinka' making (fermentation and distillation) "fermentation and distillation residue" (the solids from the alcohol production and the liquids left over from the distillation) is produced as by-product. Its nutritional properties allow for further agricultural utilization. Under certain circumstances, therefore, it can be used on arable lands. In terms of its properties, the "fermentation and distillation residue" has acidic pH and significant content of K and P, furthermore metal content may also occur because of the distillation technology, and it can be a limiting factor in case of arable land utilization. With the help of laboratory test and on-site soil analyze can be determined the quantity which does not risk for environmental and soil protection, but also serves of plant nutrition. The limitations in arable land utilization for the by-production of 'Pálinka' are parameters of "fermentation and distillation residue", however, there is a problem in the late autumn and winter prohibition period when the 'Pálinka' production is still going on, but the "fermentation and distillation residue" can no longer be taken on the frozen soil.
Keywords: 'Pálinka' production, by-product, arable land, soil analyses

1. INTRODUCTION

The word pálinka became widespread in Hungary in the 17th century, but it still referred to distillates made from grain. According to 2. § (1) of local law LXXIII of 2008 on the Regulation of Pálinka (often referred to as "Pálinka law"), Grape Marc Pálinka and the National Council of Pálinka, an alcoholic beverage may be called pálinka only if it is produced according to Category 9 of Annex II to Regulation (EC) No 110/2008, as amended and corrected several times, and if it is produced from fruit or fruit pulp grown in Hungary, the fermentation, distillation, maturation and bottling of which are also performed in Hungary. (It should be noted here that any product made from concentrate, dried or semi-dried fruit may not be called pálinka.)

Pálinka may not be flavored, colored or sweetened, even to round off the final taste of the product (HTTP1).

The process of classifying a national value registered in the Hungarian National Values as a Hungarikum is regulated by The Government of Hungary through Government Decree 114/2013. (IV. 16.) on the managing of Hungarian national values and Hungarikums.

By the adoption of law XXX of 2012 concerning Hungarian national values and Hungarikums based on Article P) of the Fundamental Law of Hungary, the Parliament established that Hungarian national values, including Hungarikums, are unique and should be protected. For the purposes of this act, Hungarikum is a collective term indicating a value worthy of distinction and highlighting within a unified system of qualification, classification, and registry and which represents the high performance of Hungarian people owing to its typically Hungarian attribute, uniqueness, specialty and quality.

2. THE PROCESS OF PÁLINKA PRODUCTION

The production of pálinka is a multi-stage process. The essence and purpose of the whole procedure is to incorporate as much as possible from the scent, taste, freshness and characteristic aroma of the fruit into the pálinka. Pálinka is therefore the essence of the soul of the fruit, its taste and fragrance. The whole process of pálinka making should therefore be characterized by this approach and commitment (MURPHY 2013; HTTP2; HTTP3).

The stages of pálinka making:

— Preparation of fruit

For the production of pálinka, only mature fruit (sugar content and aromatic content) can be used. Hard-shelled fruit should be pitted (in order to avoid the cyan content in the seed in the pit), and some fruits (e.g., apple, pear, quince) are ground in order to make the mash soft.

— Mashing and fermenting the pomace

Prepared fruit, the pomace is fermented (without added sugar). During fermentation, the sugar content of the fruit is transformed into alcohol by aid of yeasts, and the primary aroma constituents are released and the secondary aroma components are created. All of these are distilled into to the pálinka and give it its unique character. In order to accelerate the fermentation process and to complete it as perfectly as possible, the following excipients are allowed to be used: enzymes, acids, yeasts, flocculents, excipients for the removal of heavy metals, antifoam, nutrient salts.

It is important that the mash is fermented under anaerobic conditions. During the melting of the mash, heat is released (the ideal temperature for the fermentation process is 17-18 °C, overheating has a negative effect on the taste of the final product). And the process takes (Fermentation time is depending on the fruit and the circumstances) 2-3 weeks.

— Distillation, "pálinka brewing"

During the distillation, certain constituents of the mash (with different volatility) are separated by distillation. This simple separation principle is applied by pálinka producing equipment. The process of distillation itself can be done in two different ways:

» One of the ways is "Kisüsti:" The term "Kisüsti" (meaning small pot, cauldron, distillation in a pot still) is considered to be the traditional way of distillation and the distillation apparatus can have a maximum capacity of 1000 liters. Pálinka distilleries operate in tandem. Pálinka distilled in a pot still is always double distilled. In the case of double phase distillation (the product is obtained by two separate distillations), the first phase of which is to heat the mash and distillate it to extract ethyl alcohol and other volatile substances. The resulting alcoholic liquid is the "alszesz" (low alcohol), which is further refined in a second phase. In the second step, the taste of the fruit is extracted from the fermented mash. The second distillation has the biggest influence on the quality of the pálinka and thus requires special skills. During the second distillation one distinguishes between "előpárlat" (foreshots), "középpárlat" (middle cut) and "utópárlat" (feints). The middle cut, which is actually the pálinka, is separated from foreshots and feints, which has poor flavour and fragrance. Actually the middle cut is the one that gives the body of the distillate. The foreshots is not used, even though much of the taste is contained in this cut.
» The other method is Distillation in a column still, involves a single distillation. For this technology, the "brewing" and the refinement of the mash are carried out in one step. In such an apparatus, the cooking vessel is combined with an aroma and alcohol concentration column, where refining takes place after turning the mash into steam. The process is faster and cheaper than distillation in a pot still, and hence the resulting pálinka is cheaper.

With both cooking methods, it is paramount that the separation of the three parts of the liquefied material produced in the course of the distillation process – namely foreshots, middle cut, feints – should be separated precisely. The essence of this separation is the perfect separation of the middle cut, the pálinka itself.

— Finishing (adjusting alcohol concentration, curing), bottling

Fresh pálinka is still unsuitable for consumption, because its alcohol content by volume is too high, its flavors are not yet harmonious. For this reason it is necessary to adjust the alcohol concentration (usually 40-60 (V/V)%) for the consumption of pálinka, but the alcohol content of the fruit distillate is min. 37.5 (V/V)%), which is achieved by the addition of soft water. The harmony of the pálinka is then achieved by curing, which usually takes 30-60 days, during which pálinka "calms", its inner balance is settled, its rawness ceases; it cleans and rounds off, becomes smoother and more drinkable (MURPHY 2013; HTTP2; HTTP3).

Since the processing of 100 liters of raw materials yields about 5-10% 50 (V/V)% alcoholic distillate, it raises the question whether the acidic residues of distillation as by-products of the production of pálinka (fermentation and distillation) could be applied to arable land, and if so, under what boundary conditions.

3. AGRICULTURAL USE OF FERMENTATION AND DISTILLATION RESIDUES

Some of the by-products and wastes may be applied to arable land under certain conditions in order to enforce soil protection considerations. The legal background is based on 90/2008. (VII. 18.) FVM decree, which takes professional considerations into account. Fermentation and distillation residue as "non-hazardous non-agricultural waste" in this Regulation is not self-identified for the purpose of land application. Thus, the regulation leaves the classification of unmentioned substances (e.g. biogas fermentation residue, fermentation and distillation residue from distilleries, residual (grape) pomace after distillation, wash water from milking parlors and canning factories, etc.) to the competence of soil experts.

From August 2013 onward, following the position of the soil protection authority, when laying down a soil protection plan specifying the conditions for land use, rules on non-hazardous wastes of non-agricultural origin should be applied with the following additions:

» Only the following parameters are to be tested from the sample of the fermentation and distillation residue for the purpose of land application: pH, water soluble total salt, total solids, total organic matter, total N, total P (P_2O_5), total K (K_2O), Cu, Ca, Na, B. (Note, however, that Cu and B are to be considered nutrients.)
» In the case of soil testing, when applying fermentation and distillation residue to arable land, the test parameters for slurry shall apply. There is no need to prescribe sanitary protection distances and public health waiting times.

In order to classify the by-products of pálinka production from the viewpoint of soil protection, we used test reports based on the accredited laboratory test of the average samples of fermentation and distillation residue taken from several different sources of different Hungarian pálinka distilleries. The values of the parameters recorded in the test reports are summarized in tables and charts.

4. RESULTS AND EVALUATION

Table 1 summarizes the data of several protocols, displaying the parameters deemed important for nutrient management and soil protection.

Table 1: Parameters of fermentation and distillation residue relevant to soil protection

	pH [-]	Total dissolved salts	Na	Total N (Kjeldahl)	P	K	B	Cu
Sample 1 [mg·L^{-1}]	3.51	31000	39.6	373	151	1721	2.35	3.06
Sample 2 [mg·dm^{-3}]	3.33	27500	28.5	546	694	1800	3.93	4.11
Sample 3 [mg·dm^{-3}]	3.66	61100	35.7	1197	321	2497	4.27	4.98
Sample 4 [mg·dm^{-3}]	3.64	73100	23.7	1080	244	2530	5.21	6.77
Sample 5 [mg·dm^{-3}]	3.82	23500	24.3	771	254	1600	2.91	4.71
Sample 6 [mg·L^{-1}]	3.39	20700	8.38	454	140	1300	2.88	6.29
Sample 7 [mg·L^{-1}]	3.80	21500	11.2	404	121	1089	4.64	4.09
Sample 8 [mg·L^{-1}]	3.91	18100	28	391	265	1373	3.4	5.0

During mashing and alcoholic fermentation, a highly acidic substance is produced. After brewing the mash, pH value does not change significantly, therefore the pH value of the distillation residue remains in the highly acidic range. This is one of the most important limiting factors when applying it to arable land. While the acidifying effect of residues applied to slightly alkaline, calcareous soils is experienced slowly, in case of acidic soils it further decreases the pH value of the soil. Thus, in such areas (e. g. in the acidic soils of mountains and hills), fermentation and distillation residues may be applied only with the addition of lime.

According to test protocols, the total saline content of fermentation and distillation residue is significant (18000-73000 mg·L^{-1}). Since it is a liquid substance, it is expected that the infiltrating substance, on the one hand, increases the salt content of the soil, and, on the other hand, it can significantly increase its salinity when it comes into contact with groundwater below 5m underground, and may cause secondary salinisation when groundwater is evaporated. For this reason, the dosage and frequency of application should be designed such that the residue does not come into contact with groundwater. Na and B content can also be a limiting factor because of the risk of salinisation and salt accumulation.

N, P and K content of fermentation and distillation residue plays a role in plant nutrition, therefore land application can be planned for nutrient management purposes. The applicable dose is equally determined by the nutrient content of the residue, the nutrient content of the soil, and the nutrient requirement of the cultivated plant (BARKER – PILBEAM 2015).

Based on the test results of “sample1”, the application of e.g. 1 m^3 residue to arable land will enrich the soil with 0.396 kg N, 3.46 kg P (converted to P_2O_5) and 20.73 kg K (K_2O) per hectare. If the sites are not nitrite vulnerable, a maximum amount of 200 kg N·ha^{-1} can be applied, and in case of nitrate vulnerability, 170 kg·ha^{-1} N may be applied annually. According to FVM Decree 90/2008. (VII. 18.), the amount of K should not be more than 250 kg·ha^{-1} per year and the amount of P should be 150 kg·ha^{-1} per year. Considering the fact that the amount of fermentation and distillation residue that can be applied on the basis of the nutritional requirements of the plants is usually greater than the legal requirements, the annual amount of applicable residue is not determined by nutritional requirements of cultivated crops, but by legal regulations based on professional backgrounds, as mentioned above. When calculating the amount of fermentation and distillation residue to be applied, the limiting factor is in most cases K and/or P.

Owing to the methods of pálinka brewing and the nutritional characteristics of the fruits used, the Cu and B content of the residue is significant (based on the parameters of the samples in Table 1). B is an indispensable nutrient for plants: not only does it have a role in the formation of sugar, but it also plays a role in nutrient transport, as well as flower and fruit production. At the same time, high levels of B in the soil (above 1.8 mg·kg^{-1}) show the symptoms of boron toxicity (BLEVINS 1998). Cu can already be regarded toxic in the soil above 75 mg·kg^{-1} (Government Decree 50/2001 (IV.3.)), therefore it may also limit the amount of plain fermentation and distillation residue. However, according to the Soil Protection Authority's resolution of 2013, Cu and B content should be considered as an essential micro-nutrient, so if the amount of Cu and B applied is adjusted to the plant's needs, soils are not expected to be contaminated with soils.

In addition to examining the substance to be applied, characterization of soil condition must also be carried out, since the land application of fermentation and distillation residue must be preceded by making a soil protection plan. The aim of the soil protection plan is to present the suitability of the planned agricultural area (soil, groundwater, environment) and to calculate the theoretical annual load capacity in the light of the test results of the fermentation and distillation residue and the plants grown in the given area. To this end, soil profiles (Figure 1) should be explored in the planned application area, from which soil sampling takes place per genetic level. Also, in order to determine soil properties and nutrient content in the area, a so-called aggregate sample should also be collected.

Samples should be taken from the residue and groundwater deeper than 5 m underground, as well. The method of sampling, the scope of parameters to be tested, and the standards required for the test method are set out in Decree 90/2008. (VII.18.) FVM Decree. Laboratory tests must in all cases be performed by an accredited soil laboratory.

Figure 1: Opened soil profile for sampling and description (depth – 150 cm)

If a soil protection plan has been prepared, and the subsequent license from the competent authorities has been acquired, fermentation and distillation residue may be applied to arable land, but conditions of application must be designed so as not to cause damage. When the soil is covered with snow, it is frozen, or saturated with water, the residue cannot be applied; in such case the substance must be temporarily stored.

When applying, particular attention should be paid to even distribution, while the local unevenness of the area and the terrain characteristics of the area should be taken into account in order to prevent possible confluence. According to our experience, a major problem in the above specifications is the late autumn and winter prohibition period, when pálinka is still being produced, but the fermentation and distillation residue can no longer be applied to the soil. One possible solution to this problem is the setting up of an EU compliant, insulated container with a suitable size for each pálinka making community.

In order to monitor changes and to prevent possible soil degradation processes due to continuous land application, an agricultural utilization plan tailored to the needs of the cultivated crop is needed, as well as regular soil inspections (usually in every 5 years) required by the Soil Protection Authority, with special emphasis on the analysis of acidity, lime and nutrient content, and in some cases, microelements found in soil.

5. CONCLUSIONS, SUMMARY, CLOSING REMARKS AND FINAL THOUGHTS

By highlighting the interdisciplinary nature of sustainable and adaptable agriculture, our publication intends to indirectly contribute to the development of a responsible approach in farming. We have presented the possibilities and limitations of the land application of fermentation and distillation residue.

From the viewpoint of environmental and soil protection, recycling of organic waste is advantageous. The utilization of non-agricultural, non-hazardous by-products and wastes for agricultural use can primarily be based on soil surveys. Specifically, fermentation and distillation residue is a highly acidic, heterogeneous substance. This fact necessitates that, despite the unchanging technology, the nutritional characteristics of such residues should be determined annually, while, in order to monitor the state of the soil, the physics and chemistry of the soil should be investigated, and nutrient content should be determined.

In the future, it will be appropriate to conduct development-oriented research in order to create opportunities for agricultural use, to select the methods of application, to make decisions about application, and to introduce the newly developed technologies.

Bibliography

[1] Blevins, D. G. (1998): Functions of Boron in Plant Nutrition. In: Annual Review of Plant Physiology and Plant Molecular Biology, 49: 481-500
[2] Barker, Allen V., Pilbeam, David J. (2015): Handbook of Plant Nutrition. (Second Edition) CRC Press, Boca Raton - London - New York. 773 p.
[3] Murphy, J. (2013): The Drinks Handbook; Chapter 6: Distilling: How spirits are made. Goodfellow Publishers Ltd, Woodeaton, Oxford. pp. 166-180
[4] Regulation (EC) No 110/2008 on the definition, description, presentation, labelling and the protection of geographical indications of spirit drinks
[5] 2008. évi LXXIII. törvény a pálinkáról, a törkölypálinkáról és a Pálinka Nemzeti Tanácsról
[6] 2012. évi XXX. törvény a magyar nemzeti értékekről és a hungarikumokról
[7] 50/2001. (IV. 3.) Korm. rendelet a szennyvizek és szennyvíziszapok mezőgazdasági felhasználásának és kezelésének szabályairól
[8] 90/2008. (VII. 18.) FVM rendelet a talajvédelmi terv készítésének részletes szabályairól
[9] 114/2013. (IV. 16.) Korm. rendelet a magyar nemzeti értékek és a hungarikumok gondozásáról
[10] HTTP1: http://www.hungarikum.hu/en/content/p%C3%A1linka (2017. 09. 11.)
[11] HTTP2: http://www.palinka.com/hu/palinka/palinka-eloallitasa/ (2017. 09. 11.)
[12] HTTP3: https://en.wikipedia.org/wiki/P%C3%A1linka(2017. 09. 11.)