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A CIRCULAR VINEYARD – THE POSSIBILITY OF USING THE CIRCULAR ECONOMY CONCEPT IN THE WINE SECTOR IN POLAND

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ABSTRACT: The purpose of the article is to assess the possibility of applying the circular business model to wine farms in Poland. The focus is on the economic aspects of producing grape seed oil as one of the waste products generated in the wine production chain. The manufacturing potential of grape seed oil in Poland was estimated based on the production resources and the processing capacity of wine farms. The profitability of oil production was determined for selected farms located in Lower Silesia. The data were obtained through interviews with wine producers participating in the "Cooperation" research project of the Rural Development Program. In the case of small wine farms, the scale of wine production does not allow achieving the level of oil production to cover its manufacturing costs. Large wine farms producing more than 10 thousand litres of wine may be interested in this type of production. The transition into the circular business model for wine farms based on grape seed oil production will, therefore, require establishing producer groups or developing relationships based on competition between wine producers.

KEYWORDS: circular economy, waste, profitability, vineyard

Introduction

The Polish wine market, unlike the traditional European wine-producing countries, is based on small grapevine plantations and vineyards. An average Polish vineyard covers an area of 1 up to 5 hectares, extending over an area of 769 hectares in 2023, which is 151 hectares more compared to the previous year. The vineyards are small, which translates into their production scale and cost. The volume of wine production in Poland does not even account for 1% of the European Union production, which in 2023 accounted for 61% of the global production (OIV, 2023). The existing demand is met by wine imports, which amounted to 167.977 hectoliters in the 2021/2022 marketing year. Despite its marginal position in the European market, the Polish wine market is placed among the more dynamically developing ones (Global Compass, 2020). Wine produced in Poland is of an artisanal, boutique nature and is perceived rather in terms of a curiosity, as evidenced, e.g., by the share of Polish wines in the total consumption of this beverage reaching approx. 0.5%.

Wine industry in Poland produces primarily quality wines using natural and time-consuming methods. This activity is non-competitive, considering labour productivity, technical equipment, cost intensity, scale of investment, distribution or volume of domestic demand. The profitability of a wine farm, therefore, depends largely on the adopted wine sales strategy and ability to maximise the product added value, thereby increasing the unit profit from the sale of each bottle of wine.

In this context, wine producers are increasingly looking for new business models promoting the reduction of the scale of adverse environmental impacts resulting from wine production on the one hand, and the emergence of innovative, ecological and unique products on the other. Wine production waste, due to its characteristics, remains a significant threat to the environment, but used in accordance with the idea of the circular economy becomes an extremely valuable raw material utilised, e.g., in food, cosmetics and pharmaceutical industries. The implementation of circular economy principles at wine farms appears to be not only a trendy solution, but also the one allowing the creation of new revenue streams through sustainable production. In addition, consumers are increasingly articulating their interest in these producers who do not blindly agree to the production resulting in more waste (Stena Recycling, 2023).

The available literature on circular economy referring to wine farms, especially in the context of economic analysis, is still fragmentary. The existing broad stream of research covers technological and chemical aspects of processing selected by-products. However, virtually none of these research trends provides a clear picture presenting the implementation of circular economy strategies at wine farms.

A systematic review of the source literature using the elements of bibliometric analysis allows conducting a thorough research based on reliable scientific sources (Karman & Bartoszczuk, 2023). The analysis carried out uncovered yet unexplored problems related to circular economy in the context of wine production. It was divided into three stages:

1. Database selection. Information provided by the Scopus database was used.
2. Selection of publications allowing an appropriate choice of the source literature. It was decided to search for the following keywords: circular AND economy AND wine AND production. While the issue of circular economy itself has been extensively covered in the literature, its reference to wine production remains relatively negligible. This resulted in a database of 102 publications, which were later subjected to preliminary verification. English-language articles (101) in peer-reviewed journals and reviews were selected for the analysis (conference proceedings, books, and series of book were rejected) (87), and the time span was limited to the period 2014-2024 (87). The time span turned out to be a factor that did not affect the analysed results, as the problem under study is new, and the oldest publications were from 2018.
3. Proper analysis. The keywords and abstracts of articles meeting the above criteria were analysed to exclude false-positive content, and thus qualified for the third stage, but not related to the subject matter of this study. In this way, the database of 40 articles was obtained.

VOSviewer bibliometric map allows distinguishing 5 clusters covering the following topics: [1] the analysis of wine and agricultural waste in the context of chemical compounds, [2] the extraction of energy from wine waste, [3] the sustainability of wine industry and product life cycle planning using the biorefinery concept, [4] the use and recovery of wine by-products, in particular grape pom-

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ace and biochar, [5] the application of the circular economy concept to wine production in the context of climate change.

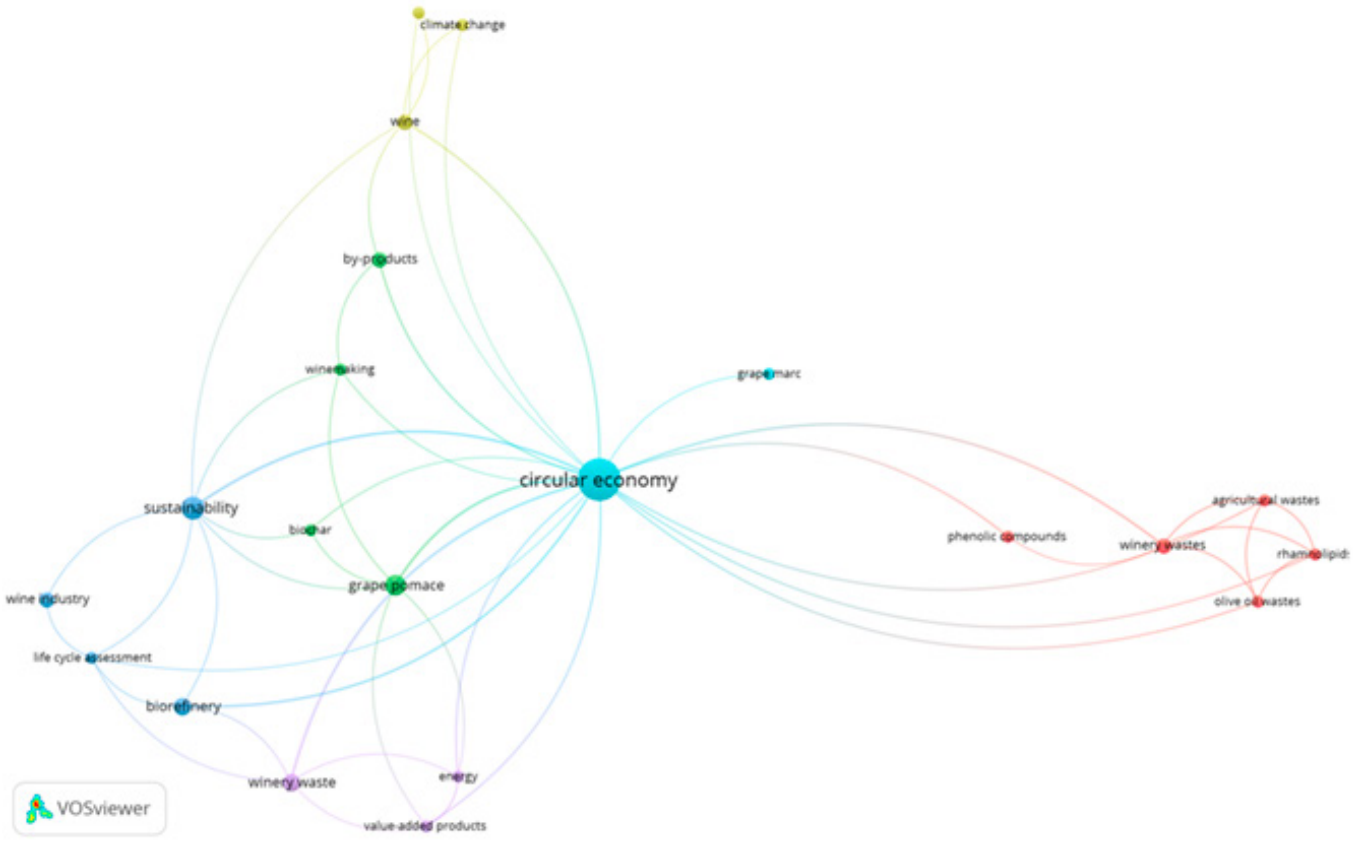

Figure 1. Keyword associations in the analysed scientific articles

Source: authors' compilation visualised using VOSviewer software.

The circular economy analysed in the context of wine production shows the strongest relationships with the concepts of sustainability, wine waste and grape pomace. Similar correlations can be observed while analysing the scientific fields in which studies examining this issue are published. It can be noted that the most extensively studied problems are analysed in the environmental, agricultural, and biochemical contexts, as well as in energy and engineering sciences, whereas regarding economic aspects the discussed subject matter has not yet been covered. It should be emphasised that the problem of circular economy in terms of wine farms is a new, however, up-to-date topic, as indicated by the growing trend in the number of publications addressing this concept. A particularly important issue is, beyond any doubt, the economic viability which determines the pace and method of implementing new solutions at wine farms.

From the perspective of Polish wine producers, investments in the closed-loop circuits will be of strategic importance, even though they still remain a considerable challenge. In practice, winemakers do not opt for such solutions easily due to no knowledge regarding methods for waste valorisation in a more economical and sustainable way than the ones used so far, which would enable them to further develop and strengthen their competitive position in the market (Diaconu & Bugaian, 2021).

The purpose of this article is to draw attention to the valorisation of waste generated in the process of wine production and to assess the possibility of its practical application using the example of grape seed oil production in the context of its economic viability. The properties of grape seeds allow pressing oil characterised by important nutritional properties and provide a certain sales potential resulting from consumer interest in food offering health-promoting parameters. It was adopted that the profitability of production would be the main criterion in the transformation of Polish wine farms towards the model of a circular vineyard.

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The authors reviewed the source literature on circular economy with regard to wine production, focusing, in particular, on the management of production waste. It was followed by the analysis of the production potential ingrained in grape seed oil based on the volume of wine production in Poland, and the estimation of oil production profitability in three groups of wine farms located in Lower Silesia and identified according to the criterion of wine production volume. The primary data necessary to determine the production capacity of grape seed oil were obtained from the records of the National Support Centre for Agriculture and through interviews with the selected wine producers participating in the Frizzy Bubbles research project entitled "Innovative sparkling wine production and bottling technology and the production organisation method as factors for increasing the quality of locally manufactured wine products", under the "Cooperation" measure of the Rural Development Program for 2014-2020.

Circular economy in winemaking

The circular economy concept is based on the approach that what was perceived as waste should be considered a resource for as long as possible. It is opposed to the popular linear economy model, which follows the principle: take – make – consume – throw away. The concept of linear economy was actually a reflection of the growth model as it did not have the fundamental constraints resulting from costs and availability of raw materials, hence encouraging increased production and intensive consumption. Thus, the linear economy turned out unsustainable in the long run. The circular economy provided a response to the attempt for integrating economic activity and environmental well-being in a sustainable manner (Murray et al., 2017).

The circular economy does not have a single universal meaning. It is also difficult to define it from the perspective of economics. In a general sense, the circular economy model illustrates resource-efficient production processes that minimise waste and, in the case of those generated provides them with economic value as a raw material according to the approach: "take – make – dispose" (Merli et al., 2018). This allows maintaining added value of the products for as long as possible, thus creating conditions for their reuse in a productive way and, as a result, generating further value.

As Michalak et al. (2020) point out., the circular economy is not just an approach based on actions aimed at managing the generated waste and returning it to the economy (e.g., incineration and recovery of some energy), but to bring it back into the system and maintain its value, i.e., to transform waste from one industry into raw material for another. Therefore, the logic of the system for managing no longer waste but raw materials that can and should be returned to the production cycle is changing. However, this is not the part of waste that cannot be reused in a commercially viable way. It is eliminated outside the economic cycle – end of life waste (Michalak et al., 2020). In this context, the boundary of the transition from a linear economy to a circular economy is not rigid. As Greer et al. (2021) points out, there is a Waste-Resource Paradox consisting in the fact that a particular material appearing at the end of a production process or life cycle can be considered waste or resource, depending on its practical applicability, cultural, legal, technological or just economic context. The result of this paradox, however, leads to optimising linear models, rather than shifting to circular models (Greer, 2022).

In the agri-food sector, the part of which is winemaking, the concept of circular economy has not been fully specified (Velasco-Muñoz et al., 2021). According to Sękowski (2016), circularity in agriculture means, i.a., promoting waste efficiency, combining the end of the processing system with its beginning by creating a closed loop for these raw materials. Producers and consumers are closely linked in such a case, as the beneficiaries of valorising products considered waste. Thus, circular economic practices in agriculture and processing focus on optimising processes aimed at avoiding waste (Velasco-Muñoz et al., 2021).

Wine production is considered a relatively sustainable industry, yet it has to deal with a large amount of production waste, the management of which is frequently the reason for economic and environmental problems (Ncube et al., 2021). Significant environmental impacts of the wine supply chain are also indicated by the disposal and composting of waste outside the vineyards. The impacts are evident in soil quality (e.g. salinisation, organic and mineral compounds content) (Santos et al., 2023). In addition, the use of chemical sprays, pesticides and greenhouse gas emissions contribute to

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environmental degradation, in addition to the carbon footprint (Provenzano et al., 2024). By adopting circular strategies, these by-products can be fully utilised, gaining a competitive advantage, reducing disposal costs and promoting sustainability while responding to the growing market demand for environmentally friendly solutions (Provenzano et al., 2024; Mura et al., 2024).

Circular economy in the wine industry has many dimensions. One of them is the segregation of cardboard, glass and plastic for proper disposal, with an emphasis on reuse or recycling (ASX, 2024). The broadly approached wine industry remains one of the largest consumers of water and "producers" of agricultural waste (Ahmad et al., 2020; Zacharof, 2017; Conradie et al., 2013). The management of post-production waste has, therefore, become the topic of numerous discussions in recent years, mainly concerning the optimal and effective ways to valorize them, especially since they present a great economic potential.

Global grape production can account for 5 to 13 Mt/year of waste, most of which is discarded. The winemaking process generates waste in the form of grape stalks, wine lees and grape pomace. A few residues are produced during the production of wine that can be used for various purposes, such as fertilising compounds, supplements, animal feed, biofuels. These materials are typically provided to local livestock owners for compost (ASX, 2024). The stem can be processed in order to extract its cellulose fibers for incorporation in plastics making them more environmentally friendly (Moreira et al., 2024).

The most important oenological by-product is grape pomace. Grape pomace is rich in structural carbohydrates, lignin, and other components such as oil and polyphenols, products with potential value (Frontini et al., 2024). The grape marc can be used for the extraction of oil that can be used in the cosmetic industry, the bioethanol resulting from its fermentation can be used for incorporation in animal feed or as organic fertiliser. The red wine grape skin recovered from pomace production can be processed to produce by-products that prevent glycol-oxidative stress associated with type 2 diabetes (Moreira et al., 2024).

It accounts for 25 to 45% of the total grape weight and approx. 60% of all wine by-products (Oliveira & Duarte, 2016; Chedea et al., 2021). Another important by-product is grape seeds generating 38-50% of grape pomace per dry weight and approx. 5% of grape weight (Beres et al., 2017).

Annually, the wine industry discards about 3 megatons of seeds, which are high in carbohydrates, fiber, lipids, polyphenols and proteins (Spinei & Oroian, 2021). Due to their nature and properties, they are, in terms of the circular economy, a valuable raw material used in the process of manufacturing new products.

Research methods and result

Grape seeds, as one of the by-products generated in the course of wine production, present great potential for valorisation, and thus for obtaining certain economic benefits. The purpose of the study was to estimate (1) the production potential in Poland based on the manufacturing resources and processing capacity of wine farms, (2) the profitability of oil production based on the selected wine farms located in Lower Silesia. Other by-products such as grape stalks, wine lees, and biomass, which may constitute the material for other, separate valorisation processes, were excluded from the study.

The data indispensable to determine the production potential of grape seed oil refer to small-scale wine producers who manufacture an average of less than 1000 hectoliters of wine per vintage year, based on the average annual production of at least three consecutive vintage years, as provided by the Act of 2021 on wine products. Production uses fruit from the company's own vineyard or purchased (up to 50% by weight) from neighbors in the same voivodship or counties neighboring this voivodship.

The number of winegrowers in Poland and their wine production potential were obtained from the records of the National Support Center for Agriculture. In the further part of the study, three Polish wine producers (individual farmers running an agricultural retail trade business) presenting different production capacities from the Lower Silesia voivodship were interviewed.

The calculations were based on the methodology for estimating pomace volume adopted by Tsali and Goul (2018). According to it, 1 kg of pomace is produced per 6 l of finished wine. However, it is difficult to accurately determine the amount of grape seeds extracted from pomace. This is because

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the composition of pomace depends on the type of grapes and the adopted winemaking technology (Taifouris et al., 2023). Therefore, while determining the amount of grape seeds extracted, it was adopted that they accounted for an average of 45% in 1 kg of pomace (Fiori et al., 2014; Beres et al., 2017). To assess the potential for grape seed oil production from domestic grape crops, an average oil content of 9.59% in the seeds was adopted (Satora et al., 2015). This potential was calculated using the following formula:

$$Pow = \frac{Ppw \times Mp \times Zopw}{6} \quad (1)$$

where:
P_{ow} – grape seed oil production potential,
P_{pw} – wine production potential in Poland,
M_p – percentage by weight of seeds in grape pomace,
Z_{opw} – percentage of oil in grape seeds.

Table 1. Production potential of grape seed oil in Poland

PRODUCTION POTENTIAL OF GRAPE SEED OIL IN POLAND	
Wine production in Poland [l]	2.267,509
Waste production potential in Poland [kg]	427.918
Recovery potential of grape seeds [kg]	192.563
Grape seed oil production potential [l]	18.467

Source: authors' calculations based on the data provided by the National Support Center for Agriculture (2023).

Based on the scale of wine production estimated at slightly over 2 million liters, the potential for grape seed oil production can be set at 18.467 liters. Comparing the Polish wine production potential to, e.g., the countries of the so-called Big Three, i.e. Italy, France and Spain, reaching production volumes of between 36 million mhl (Spain) and almost 50 million mhl (Italy) (OIV, 2023), it is too small to supply the right amount of pomace, and thus seeds needed for oil extraction. Therefore, the quantity of grape seed oil obtained in Poland is of no economic or market significance.

Wine farms, striving to improve their competitive position, are looking for new opportunities to develop and diversify their income streams, increasingly reaching for new sources of raw materials. The goal of an individual farmer's production activity is to obtain the highest possible farm income per hectare of agricultural land, in other words, to generate the highest possible farm income with the given inputs. The method proposed by the Institute of Agricultural and Food Economics (Skarżyńska & Sadowska, 1999) was used to calculate gross farm income from grape seed oil production. It allows calculating gross farm income taking into account direct, actual indirect and estimated indirect costs.

In estimating the profitability of grape seed oil production at the wine farm level, three selected vineyards presenting the minimum, average and highest wine production potential among wine farms located in the Lower Silesia voivodship were used as a basis. The production level is the starting point for determining the volume of grape seeds and next the production size of oil. The calculations did not take into account the type of grape, the applied technology and the costs resulting from purchasing or renting an oil press. The analyzed farms used this type of equipment at no cost due to their participation in the research project. Table 2 shows the production potential of grape seed oil at the selected farms.

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Table 2. Grape seed oil production potential of the analyzed vineyards in Poland

Specification	Vineyard 1	Vineyard 2	Vineyard 3
Wine production potential [l]	3.000	10.000	18.000
Waste production potential [kg]	500	1.667	3.000
Recovery potential of grape seeds [kg]	225	750	1.350
Grape seed oil production potential [l]	21.6	71.9	129.5

Source: authors' calculations based on the data provided by the surveyed wine producers.

Table 3. Costs per grape seed oil production [PLN]

Specification	Vineyard 1	Vineyard 2	Vineyard 3
Staff costs	552.00	736.00	1.840,00
250 ml bottle	160.54	535.12	963.22
Label, cap	129.47	431.55	776.79
Electricity	100.00	130.00	150.00
Total	842.00	1.702,67	3.580,01

Source: authors' calculations based on the data provided by the surveyed wine producers.

The calculations are presented in Table 4.

Table 4. Net farm income on direct surplus from grape seed oil production [PLN]

Specification	Vineyard 1	Vineyard 2	Vineyard 3
Production value	2.592,00	8.628,00	15.540,00
- Direct costs	842.01	736,00	0.00
= Direct surplus	1.749,99	7.892,00	15.540,00
- Actual indirect costs	100.00	130.00	1.990,00
= Gross farm income	1.649,99	7.762,00	13.550,00
- Estimated indirect costs	0.00	0.00	0.00
= Gross farm income	1.747,30	7.762,00	13.550,00

Source: authors' calculations based on the data provided by the surveyed wine producers.

The above results clearly indicate that Poland has little potential for grape seed oil production regarding small-scale winemakers. Even though oil production was profitable at all of the analyzed wine farms, the derived gross agricultural income is so small, especially in the case of vineyard 1, that oil production has to be treated as a non-core business activity. It should also be noted that the presented estimates do not take into account purchasing an oil press and the costs associated with its operation.

This type of production may be of interest primarily to the producers manufacturing more than 10 thousand liters of wine. However, practice shows that the economic value of the waste generated in the process of wine production is lower than the cost of its recovery (Ellen Macarthur Foundation, 2015).

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Discussion and conclusion

Grape seed oil is predominantly produced in traditional wine countries such as France, Italy and Spain, but also in Chile, Australia and the United States. The dominant producers are: Mediaco Vrac (France) Tampieri Group (Italy), Borges Mediterranean Group (Spain), Lesieur Solutions Industries (France), etc. There is little statistical information available on the volume of such production by country. Growing awareness of the benefits resulting from using this oil in the cosmetics industry, especially in Europe and the Asia-Pacific region, drives and will continue to stimulate growth in the value of this market. Globally, the grape seed oil market was worth $505.6 million in 2022 (Grand View Research, 2023). This, in turn, indicates that a venture in the form of grape seed processing is not viable at the level of an individual producer, who often does not obtain enough pomace to ensure profitable production (Devcic, 2022).

The possibilities of grape seed oil production by Polish wine farms are in no way comparable to the similar ones located in other wine producing countries. In Poland, due to the nature and scale of viticulture and wine production, this type of activity should be approached as ancillary to other ongoing and profitable agricultural activity such as, e.g., crop production. Moreover, weather conditions (drought, heavy rainfall), vine diseases will affect the quantity and quality of the harvest, and thus the production capacity of oil.

Therefore, the indicated way for implementing circular economy in the Polish wine industry seems unrealistic. It is more likely that the circularity trend will focus on implementing solutions aimed at reducing the carbon footprint, striving to achieve energy self-sufficiency through the use of biomass (grapevine shoots, pomace, stalks) as green energy, or the development of organic farming. Waste such as pomace will be approached as a source of reducing costs (e.g., used as fertilizer, biofuel) rather than as a potential source of income.

On the other hand, however, the dynamic development of ecotourism, along with consumer preferences focused on a healthy lifestyle, which is indirectly related to proper nutrition and simultaneously preserving both pro-ecological and pro-health properties of food (so-called functional food) (Grochowicz & Fabisiak, 2018) may provide motivation to diversify the existing sales offerings.

The implementation of circular economy solutions at Polish wine farms, especially in terms of carrying out further production using the generated waste, will turn out feasible when such projects are at least cost and quality neutral. Indeed, a significant problem of the transformation to a circular vineyard results from the fact that investments in the circular economy are cost-intensive, in the case of which one has to wait relatively long to see the benefits. Small wine farms (usually 1-2 hectares) will, therefore, have the greatest difficulty in adapting to the circular economy, mainly due to the small scale of operations. The transition from linearity to circularity at Polish wine farms will continue to be considered through the prism of economic viability.

The analysed valorisation of waste can constitute one of the strategies towards achieving social, economic and environmental benefits, however, one should remember that it requires: firstly, an appropriate waste stream derived from the volume of production, secondly, awareness, understanding the essence of the circular economy and the need for its implementation on the part of the producer, and thirdly, a responsible scale of demand. The wine sector in Poland, despite its development, is based on artisanal initiatives generating high costs due to: investments in the vineyard and winery, production, employment of workers, margins of middlemen in the sales chain or tax burdens, along with low consumer interest in Polish wine (Polish wine is a low-turnover product). Hence, large vineyards based on intensive methods of viticulture and wine production which, in Poland, account for as little as 2% constitute the proper environment for the development of circular economy. Poland is not one of the European countries considered to be wine-producing countries, so viticulture and wine production are rather niche, often hobbyistic, based on small vineyards. This is due to the very high investment costs required to establish and operate a vineyard. Most vineyards in Europe and beyond are vineyards with more than a few decades of tradition, where all costs are much lower.

In Poland, wine traditions began to be rebuilt practically after the accession to the European Union in 2004 and entry into the Common Agricultural Policy of the wine sector, which defined a common organisation of the wine market in terms of exports and imports of wine in the member states, standards for marketing wine, appropriate grape varieties, oenological practices, designations

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of origin and geographical indications. The national policy, meanwhile, focuses on measures to support the development of the wine industry and wineries. These include:

- the abolition of VAT on wine products in the year following the occurrence of accidental phenomena with a significant negative impact on wine production,
- regulating the sale of wine products through the Internet,
- enabling easier support of the wine industry in case of extreme weather events and other negative random factors.

No less important is the policy focus on promoting viticulture as a means of diversifying agriculture and drawing attention to oenotourism as a potentially important future branch of rural development and an important source of income for farms.

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The contribution of the authors

Conceptualization, T.P., M.K.-M. and A.K.; literature review, T.P., M.K.-M. and A.K.; methodology, T.P.; formal analysis, T.P. and M.K.-M.; writing, T.P., M.K.-M. and A.K.; conclusions and discussion, T.P., M.K.-M. and A.K.

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CYRKULARNA WINNICA – MOŻLIWOŚĆ WYKORZYSTANIA KONCEPCJI GOSPODARKI CYRKULARNEJ W SEKTORZE WINIARSKIM W POLSCE

STRESZCZENIE: Celem artykułu jest ocena możliwości zastosowania cyrkularnego modelu biznesowego w gospodarstwach winiarskich w Polsce. Skoncentrowano się na ekonomicznych aspektach wytwarzania oleju z pestek winogron, będących jednym z odpadów powstających w łańcuchu produkcyjnym wina. Oszacowano potencjał produkcyjny oleju z pestek winogron w Polsce w oparciu o zasoby produkcyjne i możliwości przetwórcze gospodarstw winiarskich. W odniesieniu do wybranych gospodarstw zlokalizowanych na terenie Dolnego Śląska określono opłacalność produkcji oleju. Dane pozyskano w drodze wywiadów z producentami wina uczestniczącymi w projekcie badawczym PROW "Współpraca". W przypadku małych gospodarstw winiarskich skala produkcji wina nie pozwala na osiągniecie takiego poziomu produkcji oleju, pozwalającego na pokrycie kosztów jego wytwarzania. Tego rodzaju produkcją mogą być zainteresowane duże gospodarstwa winiarskie wytwarzające powyżej 10 tys. l wina. Przejście na cyrkularny model biznesowy gospodarstw winiarskich w oparciu o produkcję oleju z pestek winogron będzie wymagać zatem rozwijania grup producenckich czy też budowania relacji opartych na koopetycji między producentami wina.

SŁOWA KLUCZOWE: gospodarka cyrkularna, odpady, opłacalność, winnica

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