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ECONOMIC MANAGEMENT OF RURAL AREAS: ON THE WAY FROM LINEAR TO CIRCULAR ECONOMY

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Abstract

Waste management in the fruit and vegetable industry is becoming an increasingly important issue, as a significant part of the raw material ends up in the waste. Improper waste management can lead to environmental pollution and therefore must be disposed of in an acceptable way, but also to exploit the commercial potential of processing residues. In Požega-Slavonia County and Pannonian Croatia, very little attention has been paid to this issue, both by the scientific and professional public, and by those who have remnants of processing. This is a potential that has not been recognized, and consequently not used, and there is a lot to do in this area. The paper presents a research that defines products that can be produced from the remnants of fruit and vegetable processing and analyzes which raw materials can be processed and in which products given the level and capacity of production in Požega-Slavonia County and surrounding counties. A market analysis was performed for the identified products and the need to establish a plant was defined. The work is also a good basis for further research and development and production of products with higher added value, as a part of shift from the existing linear economy to a circular economy.

Key words**:** *circular economy, by-product, rural development, waste processing, environment*

INTRODUCTION

Man and nature have always been in constant interaction, and the segment in which man acts on nature in order to provide resources for development and life is especially important. Over the years, man has increasingly exploited natural material resources from his environment, and with the development of technology, exploitation has accelerated significantly. During this period, man considered natural resources unlimited and actually used the strategy of linear economy.

At a lower level of industrialization, the concept of linear economy had no serious limitations. Raw materials were becoming more accessible and cheaper, technologies were advancing and the concept of a linear economy was actually a model of growth. This growth has led to an increase in production, employment, profits, living standards, and consequently an increase in demand for all types of goods. In the context of the present study, it is crucial to emphasize that the concept of linear economy implied that waste generated as a result of production is thrown into the environment.

The development of the economy has continuously increased the demand for raw materials, while reducing the available quantities of natural resources. In addition, the impact on climate and the environment is significant, as excessive energy consumption directly affects the increase in CO2 emissions.

Fig.1. Concept of linear economy
Source: Analysis of the potential and development of agricultural production in Požega-Slavonia County [1].

Such awareness began to change a hundred years ago when it was realized that natural resources were limited and that their overexploitation had a negative impact on the environment. The term sustainable development entered general terminology in the 1980s and was defined as a development that meets the needs of today's generations without compromising future generations.

This issue was only seriously considered in 2008 during the great economic crisis, which was accompanied by the crisis of climate change. It was then that the introduction of the concept of a circular economy began, which was a response to the global environmental crisis and accelerated climate change. Thus, in 2010, the European Commission (EC) adopted the Europe 2020 strategy, a ten-year development strategy focused on sustainable growth, transition to a circular economy and waste reduction. The logical continuation is the Green Plan presented by the EC in 2020.

The circular economy is a completely different concept of managing economic processes in the field of sustainable use of natural resources and balanced economic development. It seeks to abandon the concept of a linear economy that has become unsustainable in the long run. In order to slow down the exploitation of natural resources, the circular economy is based on the principles of waste collection and recycling and its reuse as input raw materials in the production process. Thus, one type of waste could be recycled several times and used in the production process, depending on its technological characteristics. In this way, natural resources would be used much more optimally and their lifespan would be extended.

For citizens, the circular economy will provide highquality, functional and safe products, which are efficient and affordable, last longer and are designed for reuse, repair, and high-quality recycling. A whole new range of sustainable services, product-as-service models and digital solutions will bring about a better quality of life, innovative jobs and upgraded knowledge and skills [9].

The Circular Economy concept (CE) has gained momentum both among scholars and practitioners. However, critics claim that it means many different things to different people [4].

The term circular economy, like many other terms in science, and especially in economics, does not have a unique meaning. While some are focused on what constitutes the circular economy itself (input), meaning the process itself, others are focused on the determinants of that process, and still others on the results (outputs) of that process.

The Circular Economy represents the most recent attempt to conceptualize the integration of economic activity and environmental wellbeing in a sustainable way [5].

A central theme of the CE concept is the valuation of materials within a closed-looped system with the aim to allow for natural resource use while reducing pollution or avoiding resource constraints and sustaining economic growth [10].

Circular Economy is little implemented in practice, and in the present paper barriers to a transition to Circular Economy is identified. Barriers are financial, structural, operational, attitudinal and technological [7].

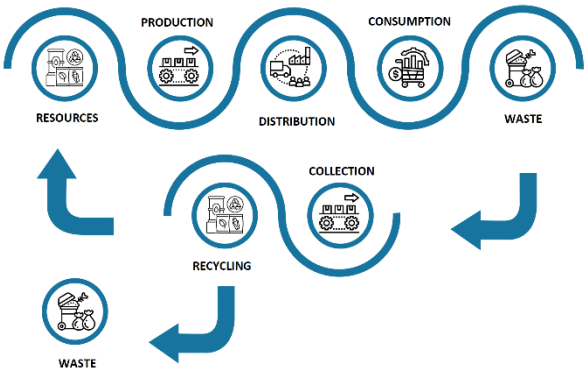

Fig. 2. Concept of circular economy
Source: Analysis of the potential and development of agricultural production in Požega-Slavonia County [1].

The Concept of the circular economy is based on the collection and recycling of waste, which eliminates its harmful impact on the environment, and through recycling it returns to the production process as a valuable material resource or raw material. This only permanently disposes of a small part of non-recyclable waste. In this way, the production process continues in cycles with the rational use of material resources and environmental protection. This concept implies that with the help of nature, everything that man needs is produced, and that he then takes care of how to return to nature what he took from it. With such management, the added value of the product lasts significantly longer in use before it becomes waste.

The concept of the circular economy is ubiquitous today and is embedded in

European regulations that all EU member states implement as regulations in their national institutional framework and their national economy.

The transition from the concept of a linear economy to the concept of a circular economy requires a number of changes in the overall value system. It is primarily necessary to change the consciousness of society as a whole, create an appropriate institutional framework, create an appropriate material infrastructure, devise new business and market models, use modern technologies for the circular economy, develop a waste management system etc.

MATERIALS AND METHODS

The focus of this research is on the disposal and processing of by-products and residues in the processing of fruits and vegetables. Capacities, obligations and possibilities of everything related to by-products and/or residues in fruit and vegetable processing, such as mixed municipal waste management centers, residues and by-products of field production, etc. were taken into account. The key document on which the data on the quantities of fruits and vegetables and projections until 2025 are based is the study of the Faculty of Agrobiotechnical Sciences Osijek, Josip Juraj Strossmayer University in Osijek "Analysis of the potential and development of agricultural production in Požega-Slavonia County" made in 2020 [1]. Pozega Slavonia County (from now on, PSC) is part of Pannonian Croatia, as the least developed Croatian region, and also most significant agricultural region. Characteristics of this region are a decrease in population, stagnation in terms of development, lack of recognized prospective [2].

In addition to the above materials, a comprehensive search of all available sources of information was performed, and through the chapters of this study an overview of everything relevant to the implementation of appropriate analysis and projections was presented. economic justification of the investment. All products that can be produced from the remnants of fruit and vegetable processing are defined and it is analyzed which raw materials can be processed and in which products with regard to the level and capacity of production in PSC and surrounding counties.

Based on the conducted analysis, the processing of wine production products, ie wine pomace oil and pellets, was identified as an important option. Given the quantities of grapes produced in the County, it is estimated that such an investment would be economically justified, but for detailed economic justification of such an investment it is necessary to prepare a feasibility study with appropriate economic assessment of the project in accordance with the European Commission Guide for the current programming period 2021-2027 [3].

Based on the total processed amount of grapes and the resulting pomace, it is estimated that the maximum production can be 27,222 liters of oil and 544 tons of pellets, which is a sufficient and serious amount of products that can be sold on the market. During the analysis, a conservative estimate of the processing of 1,000 tons of grape pomace per year was taken into account, with a production of 10 tons of oil and 200 tons of pellets. It is envisaged that the plant for the production of grape pomace oil and pellets would be operational 50 days a year, given that white grape pomace is processed immediately after grape mulching and pressing, while black grape pomace would be taken over after maceration.

An overview of the necessary equipment for technological processes of oil and pellet production indicates significant possibilities of overlap with part of the equipment for the planned cold store and dryer as well as possible with part of the equipment for composting. This represents a great potential for eliminating the problem of seasonality of oil and pellet production from grape pomace, and would enable even year-round productivity of most production machines.

RESULTS AND DISCUSSIONS

The production of fruits and vegetables in PSC is diverse, but in the context of the

production of by-products from the remnants of fruit and vegetable processing, the possibilities are limited. In order to identify raw materials that can be processed into some of the by-products, the Analysis of the potential and development of agricultural production in PSC was used. For the purposes of this study, figures for 2019 and projections for 2025 were taken [1].

According to the analysis, there are 44,956.04 ha of agricultural land in operation in the County. Observing the structure of agricultural land according to the method of use, most agricultural land belongs to the category arable land (82.7%), followed by meadows (5.9%) and pastures (2.4%). These categories make up 91% of the total agricultural land in the County. Areas for fruit and vegetable production make up only 8.8% of the area, and the largest share among them are orchards with 5.2%.

Furthermore, the Analysis shows that on 36,895.06 ha of agricultural land there are areas in the support system, and they are divided into cereals, oilseeds, vegetables, fruits and grapes. Cereals are on a total of 67.0% of the land, oilseeds on 19.8%, vegetables on 0.9%, and fruits on 8.2%.

Since each crop differs in yield per hectare, taking it into account, the Analysis showed the total production in tons for each crop. The total production at the county level in 2019 amounted to 205,147 t, and according to estimates in 2025 it will amount to 237,868. Looking at the structure in 2025, the largest share will be cereals (76.9%), followed by oilseeds (12.3%), followed by fruits (7.7%) and vegetables (3.1%).

For the purposes of further analysis, as a starting point for the processing of by-products from residues from fruit and vegetable production, projections of fruit and vegetable production in 2025 were taken. Compared to the last available year 2019, vegetable production will increase by 12.3%, to 7,380 t. Vegetable production will increase by 12.7% in the same period, to 18,341 t, for a total of 25,721 t.

Furthermore, the vegetable crops that dominate the County are cabbage and potatoes, which in 2025 will account for 86.0% of production in the vegetable segment. These are vegetables that are primarily sold as a fresh product in markets and shopping malls (especially potatoes), while only a small part of cabbage is processed. As the market of companies that would buy these products as raw materials and use them in processing (which would generate waste) is not developed in the County, the part of the product that ultimately ends up in processing is processed outside the County. According to the Croatian Chamber of Commerce, in activity C 10.3. Processing and canning of fruits and vegetables, only two companies operate in the County.

The situation with fruit indicates that grapes are the dominant product, accounting for 71.2% of total fruit production. They are followed by apples with 16.3% and plums with 5.9%, while nuts (walnuts and hazelnuts) account for 3.3% of total production. In this case, too, most fruit is sold as a finished product, but in this segment there is the potential to use waste from grapes for wine production and from apples, plums, pears and peaches for juice production, to produce by-products from fruit waste.

Based on the analyzed situation in the County, which includes the amount of waste from fruit and vegetable processing, technological and human capacity, it was determined that the real options are, according to priority: 1) compost production, 2) wine pomace oil and pellet production, 3) bioactive components and 4) production of synthetic organic leather. Biofuel production is economically unprofitable due to insufficient waste, biodegradable polymers are based on advanced technology that is still in the process of research and development, while alternative products can be produced for personal use.

Almost 12,000 t of grapes are produced annually in PSC, of which 80% is used in grape production, or slightly more than 9,000 t. This amount of processed grapes results in approximately 2,300 t of pomace, a by-product that has not been recognized as a high-value raw material, but ended up in compost or discarded into the environment causing major pollution, so pomace is a major

environmental problem. Namely, the process of humification of the pomace is long and therefore the piles of discarded pomace pollute the environment for a longer time.

In addition, the pomace is a problem for the winemakers who produce it, because if they do not take care of it properly, they pollute the soil and the environment, and large accumulations of pomace attract pests and flies that can cause the appearance and spread of various diseases.

On the other hand, pomace can be a quality raw material, highly sought after by the food, pharmaceutical and cosmetic industries, and can also be used as animal feed, natural organic fertilizer, and building materials. Therefore, a logical question arises, why the raw material that is in large quantities, and which represents waste to winemakers, is not used for further processing of highly sought-after by-products.

Wine pomace was once primarily used for the production of spirits, the production of which over time became unprofitable due to a significant reduction in market price due to the increase in quantity. Today, winemakers can use it in larger quantities for planting new vineyards when the soil is too wet when preparing the soil, so by adding the pomace, it can be acidified. But this is not a continuous need, so the problem of care arises again.

With the emergence of the circular economy, which has become a key factor in sustainable economic development, many studies have been conducted through the development and application of new technologies that enable new methods of recycling and reuse, ie the use of wine pomace as a byproduct with great potential for further processing. Thus, wine pomace has become a highly sought-after raw material in the food, pharmaceutical cosmetic industries, and some of the most commonly produced products are grape seed oil, grape seed flour and skin, and pomace pellets.

Based on the conducted analysis, as a logical continuation of the project of building a ULO cold store for fruits and vegetables, the option of establishing a production plant for grape seed oil and pomace pellets was recognized. It would solve the problem of wine pomace that winemakers face, and would provide the possibility of organized collection and processing of pomace at the county level.

Grape seed oil was chosen for its growing use in Europe and its use in many industries, from gastronomy to the pharmaceutical and cosmetics industries.

Grape is one of the main fruit crops produced worldwide, being *Vitis vinifera* L. the most common cultivated specie. Approximately 71 % of the grape production is used in winemaking production, while 27 % in direct consumption as table grapes and 2 % as dried fruits. [6]. If we took in consideration well known fact, that after the processing of wine, the ¼ weight of grapes remains in the pomace, when compared to the figures on the total processing of grapes into wine, we come to a significant potential for the use of wine pomace.

Functional food is point of interest for many and for a long time. Not only food chemists but also many scientists from diverse areas, including biology, biochemistry, botany, plant/animal sciences, and nutrition as well as medical science, have become involved in research associated with functional foods today. Moreover, consumers are now deeply interested in the food factors which provide beneficial effects to humans in terms of health promotion and disease risk reduction. They also demand more detailed information about food factors in order to obtain appropriate functional food products [8].

Namely, grape seed oil contains high-value ingredients that have a positive effect on human health, such as omega 6 and 9, 3, 5 and 7 fatty acids, vitamin E and antioxidants. In addition, it tolerates high temperatures and is increasingly used in gastronomy as a substitute for conventional oils for this purpose. The plant proposal is based on, widely available, cold pressing technology.

In order to fully implement the concept of circular economy, the plant proposal also includes the production of pomace pellets. In that way, the residues from the production of oil would be further used for the production of pellets. Due to the high content of organic matter and potassium and significant amounts of nitrogen and phosphorus, wine pomace can be used as a biofuel in the form of pellets for

heat production. Wine pomace pellets have a calorific value of fuel released during complete combustion of 19 MJ/kg, which is more than, for example, coal with 17 MJ/kg. From the aspect of environmental protection, wine pomace pellets have a minimum content of harmful substances caused by combustion, especially sulfur. Based on calorific values, it can be determined that 2 kg of wine pomace pellets has an approximate value as well as 1 liter of fuel oil, and 1 m3 of wine pomace pellets weighing 650 kg can replace approximately 300 kg of fuel oil. The technology for the production of pomace pellets is also widely available.

CONCLUSIONS

The production of oil and pellets from wine pomace is recognized as a potential of PSC in the context of processing by-products from fruit processing, given the quantities of grapes produced in the County. Investment in such a plant is not realistic at the level of an individual winemaker, primarily due to insufficient quantities of processed grapes and the resulting pomace. For this reason, production needs to be centralized and a production facility set up to collect the sufficient amount of pomace needed for profitable production. According to estimates, 2,722 tons of wine pomace will be produced in 2025. If the conservative estimate is taken into account that it is possible to collect and process 1,000 t of wine pomace, it is possible to produce 10,000 l of oil and 200 t of pellets.
Furthermore, the production of grape seed oil and pomace pellets is seasonal because they can only be produced during the grape harvest. As at that time all the focus of winemakers was focused on wine harvesting and production, they also have insufficient human and time capacity. This is one of the biggest problems, because the pomace needs to be collected and processed within 24 hours in order to prevent spoilage of the raw material. Therefore, the whole process is logistically demanding, because in a short time it is necessary to collect and process extremely large quantities of pomace. An additional problem of such production is the storage of raw materials that require large capacity, because the wine pomace has a high proportion of water (55-60%).
By establishing the plant in question, every winemaker would solve the problem of the pomace that he has to take care of, without having to invest significant time that is important for his harvesting and production of wine, but only needs to agree on taking over the pomace.

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