

## **Mapping of agri-food and bio-based industries in the region of W. Macedonia for potential valorization of agri-food residual streams into high-added value products**

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### **Introduction**

The disposal of residual streams from the food supply chain consists a major environmental problem and a serious wastage of valuable resources as well. According to FAO estimations, around 1.3 billion tons per year of food edible parts are discarded and wasted worldwide, with more than 88 million tons being generated in EU [1]. Focusing on the processing sector, large volumes of solid and liquid wastes are generated, thus representing almost one third of the total annual food waste production [2]. Based on the above the residual streams of agri-food companies comprise a significant burden for environment when non-properly handled, while their rich nutrient content renders them a very promising source of valuable compounds. Agri-food residues management is based on conventional and non-conventional valorisation routes. The conventional pathways involve landfilling, incineration, composting and animal feeding, that have been applied for many years now, while the non-conventional methods involve valorization to products with higher added value that can be used in food industry, pharmaceuticals and cosmetics.

The non-conventional valorization of agri-food waste is promoted, especially through circular economy models and bioeconomy approaches, in view of environmentally sustainable methods of production, pollution prevention and economical motives. To this direction, Bio-Based Industries (BBIs) can act as the key creating bridges between sectors supplying biomass and sectors using biomass ending up to new products. The main problems towards the application of this sustainable scenario are the variability in quantity and composition of residual streams, as well as the lack of information regarding the operation and viability of the bio-industries. Model2Bio project (Model2Bio Project, <https://www.model2bio.eu/>) aims at developing an innovative Decision-Support (DSS) tool for assessing the composition of residual flows in the agri-food sector and identifying optimal solutions for their utilization and alternative valorisation on the basis of social, economic, environmental and regulatory criteria. The purpose of the present study is to record the current situation in agri-food companies in Western Macedonia Region (WMR) with reference to by-products generation, management and possible valorisation via any bio-industrial applications.

## Methodology

The collection of the required information was based on combined activities. Literature search was performed using available databases via the Greek Ministry of Environment and Energy [3], the Hellenic Agricultural Organization [4] and other EU databases for the mapping of the existing agri-food companies and BBIs in WMR. Moreover, and considering the restrictions imposed by the Covid-19 pandemic, the authors contacted existing companies via a detailed questionnaire and personal communication as an intensification of research activities to define their production capacity and the residual quantities generated, as well as to identify the management or valorisation routes of the here examined agri-food residual streams. For the residual stream quantities specification, literature research was also applied in the cases where real data was not available. The names of the companies will not be presented due to confidentiality issues and personal data protection.

### Agri-food residual streams in Western Macedonia Region

In WMR, the main activities of agri-food companies include the production of several agricultural products in family or small businesses mostly. For the purposes of MODEL2BIO project, residual stream categories examined in the present study involve by-products derived from animal processing sector (pork and veal meat), dairy sector s (milk and cheese), vegetable sector (pepper products) and wineries. To this direction, an effort was made to detect the existing agri-food companies in WMR, as well as the products and residual streams quantities that are of interest in this study. As shown in Fig. 1a, around 50 companies have been detected so far, with dairy industry dominating in the studied area. Table 1 presents the quantities of the products and by-products as collected by the relative sources.

**Table 1.** Agri-food products and by-products in WMR

| Product           | Product quantity (tn/y) | By-product(s)            | By-product quantity (tn/y) | Utilisation     |
|-------------------|-------------------------|--------------------------|----------------------------|-----------------|
| Pork meat         | 1700 [4]                | Non-consumable parts [7] | 1850                       | Energy (biogas) |
|                   |                         | Manure (dry solids) [13] | 6000                       | Energy (biogas) |
| Veal meat         | 1900 [4]                | Non-consumable parts [7] | 3700                       | Energy (biogas) |
|                   |                         | Manure (dry solids) [13] | 10500                      | Energy (biogas) |
| Soft Cheese       | 2600 [4]                | Whey [8]                 | 7300 – 17700               | Animal feed     |
| (Semi)Hard Cheese | 300 [4]                 | Whey [8]                 | 1500 – 2700                | Animal feed     |
| Pepper (roasted)  | 150*                    | Peels, seeds [9]         | 18                         | Compost         |
| Wine              | 6630 [11, 12]           | Spent marcs, stalks [10] | 2040                       | Compost         |

\* Based on available data from companies in the region

Examining the meat processing industry (including slaughterhouses), the residual streams include parts that are not intended for human consumption (i.e. blood, bones, meat trimmings, skin, fatty tissues, horns, hoofs, feet, skull and viscera) assigned to Category 3 materials [5]. As only 30-50 % of the animal is edible [6, 7], meat industry generates large volumes of by-products, while animal manure in livestock farms is also significant. In dairy industry, especially from the cheese production sector, whey is the main by-product. Depending on the type of milk (cow, sheep or goat) used as raw material and the final product,

whey quantities vary between 2.8-6.8kg/kg milk for soft cheese and 5.1-8.9kg/kg milk for hard cheese [8]. In vegetable processing, pepper waste is removed during cleaning, processing and cooking stages and involves mainly peels, skins, and seeds. Like in the case of tomato, it is estimated that residues consist a percentage of 10-18% of the total amount processed [9]. Wine production is one of the largest food processing industries entailing the generation of huge amounts of by-products, which consist around 20% of the total grape volumes processed [10]. In 2020, the cultivated areas for wine grapes production were around 1700 ha [11], resulting in 10000 tn/y wine grapes [12].

### Valorisation of agri-food residual streams in Western Macedonia Region

Examining the current situation in WMR regarding the utilization or valorisation of agri-food residual streams, based on personal communication with the existing companies, the applied pathways include mostly conventional routes. In particular, winery by-products are usually composted in the companies' fields. The same is for the pepper residues. In the case of whey, the cheese factories following all the legal procedures for its management, are storing it in special vessels before used for animal feed by farmers. As for animal by-products, after applying all the necessary processes for their legal treatment, they are usually subjected to anaerobic digestion for biogas (energy) production or rendering for the production of proteins and fats (used as for feed purposes). Currently, there are 7 industries in WMR, as shown in Fig.1b, that valorise the here examined agri-food residual streams. Two (2) companies are active in valorising animal by-products and manure, whey and also vegetable residues towards biomaterials for animal feed production. There are four (4) anaerobic digestion units for biogas (energy production) utilizing animal and vegetables by products as feedstocks, while there is one compost unit in the region processing all the residues from food production, vegetable and fruit processing together with the biowaste quantities from households. It should be mentioned that composting activities in wineries are not marked in the following map.

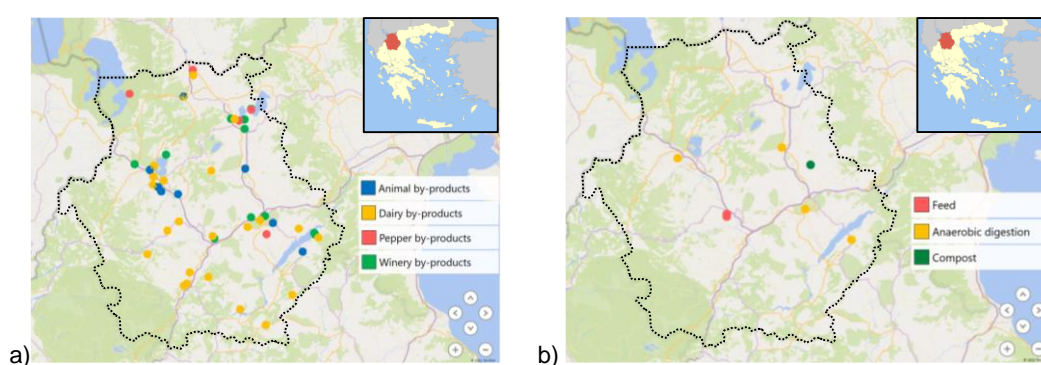


Figure 1. a) Agri-food companies in WMR, b) BBIs in WMR

### Towards higher-added value products

Mapping the agri-food companies and the BBIs in WMR reveals that a high percentage of the residual streams from agri-food processing is simply managed and only conventional pathways are employed for their utilization. This can be justified if the small size of the existing companies is considered.

However, given the high nutrient content of these by-products, non-conventional pathways can be applied towards the production of high added value products, like functional ingredients and bioactive compounds (carotenoids, phenolic compounds, essential oils, dietary fibres and proteins) via extraction or fermentation techniques for use in food and beverage industry, pharmaceuticals and cosmetics. This is foreseen to be covered within Model2Bio project and the DSS tool that will examine the feasibility of the development of a non-conventional BBI in the region taking into consideration environmental, societal and economic data or study the possible connections between existing BBIs in the wider area.

## Conclusions

Given the above-presented data, it can be concluded that there is a significant agri-food activity in WMR generating by-products that can be utilised as feedstocks for processes leading to high-added value products. For some residual streams, like animal and vegetable by-products, the valorisation cycle is complete, as they are handled and treated towards energy production or additives for animal feed production. However, there are still agri-food residues, like whey, that remain unexploited or are utilized for composting without any valorisation, like winery and vegetable by-products.

Therefore, the development of new sustainable pathways via Model2Bio project for agri-food by-products valorisation into high added value products via non-conventional routes, could create and promote a new development model able to restructure local economy especially during the post-lignite era WMR is experiencing.

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