Food Research International 65 (2014) 350–358

Contents lists available at ScienceDirect

Food Research International

journal homepage: www.elsevier.com/locate/foodres

Valorization of the major agrifood industrial by-products and waste from Central Macedonia (Greece) for the recovery of compounds for food applications

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ARTICLE INFO

Article history:
Received 11 July 2014
Received in revised form 17 September 2014
Accepted 21 September 2014
Available online 28 September 2014

Keywords:
Central Macedonia
Olive oil
Wine
Rice
By-product valorization
Waste valorization
Food ingredients

ABSTRACT

Food by-products and waste valorisation practices have gained much attention lately as a means of a sustainable management, which can concomitantly increase the profit for local economies. So far, these materials constitute an underexploited source for the recovery/production of compounds for food applications and other needs of the food chain (energy production, feeds). To highlight new trends and show the potential for regional economies the present contribution focuses on Central Macedonia, the largest Greek region with significant agro-industrial activities, such as olive oil, wine and rice production, that generate different types and quantities of by-products and waste. Proposals for the exploitation of selective streams using chemical and biotechnological tools for the recovery/production of compounds of high interest for the food industry are critically discussed. Know-how developed by academia and research institutions in the Central Macedonia should be examined by the respective stakeholders in order to contribute to the zero-waste society target set by European Union till 2025.

1. Introduction

Among the thirteen administrative regions of Greece, Central Macedonia (Fig. 1) occupies the largest area (18,811 km^2) being the second one in population (almost 1.9 million) and economic importance (almost €27 billion to Gross Domestic Product) according to updated statistics (data reported from the Hellenic Statistical Authority, 2014).

Statistical data before the financial crisis in Greece (Reid, Komninos, Sanchez-P., & Tsanakas, 2012), indicated that the economy of Central Macedonia was dominated by services (74.5%) and the sector of industry and construction (21%). The agricultural sector accounted for only the 4.5%, a figure that is nowadays changing positively as more people are involved in such activities. The major agricultural products are fruits, vegetables, olives, grapes, cereals (durum wheat, corn, rice) and cotton (data reported from the Ministry of Rural Development and Food, Hellenic Republic, 2014).

All of the abovementioned agricultural activities and the corresponding manufacturing ones generate considerable quantities of different types of by-products and waste. Two of the major activities, olive oil and wine industry, which account for approximately 8267 and 36,090 tons of end products (data reported from the Hellenic Statistical Authority, 2014), are well known polluting sectors (Devesa-Rey et al., 2011; Vlyssides, Loizides, & Karlis, 2004). Taking into account that the total area of water resources in Central Macedonia is 10,390 km^2 (http://www.waterincore.eu/deliverables/03_01_01_en.pdf), it is evident that the risk for water contamination due to these agri-food industrial activities is high. The majority of olive oil mills and wineries, small in size but numerous, are located in short distance among each other (mainly in the region units of Halkidiki, Thessaloniki and Imathia) (http://winesurveyor.weebly.com/tour1213.html) and close to highways. Thus, their collection, transportation and treatment of the derived by-products and waste in dedicated plants appear to be a plausible milestone. Similarly, rice production that accounts for the ~65% of the national produce (Karamanos, 1999), that is around 170,000 tons (data reported from the Ministry of Rural Development and Food, Hellenic Republic, 2014), deserves attention regarding the utilization of by-products (rice hulls, rice bran) and waste.

Valorization of agricultural by-products and waste for edible purposes is a challenging field of research of great importance in the local and international economy (Galanakis, 2012; Tornberg & Galanakis, 2008). Recovery/production of antioxidants is a good example of desirable added value compounds. In the following sections characteristic examples of by-products and waste are discussed. The sources can be exploited in Central Macedonia for the production of added value compounds for food applications on the basis of already developed know-how by academia and research institutions in this area. The scientific

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http://dx.doi.org/10.1016/j.foodres.2014.09.013
0963-9969/

Fig. 1. Central Macedonia location in Greece (in the insert details on regional units).

contribution of the group of authors to this direction is highlighted with reference to international literature and recent patents.

2. Olive oil industry

In olive oil production, the processing stages include cleaning of impurities, cold-water washing, malaxation of the olive paste after crushing of olives, and olive oil extraction, centrifugation, storage in stainless steel tanks, filtration and bottling. A key point is that the technology applied for olive oil extraction determines the types and quantities of waste generated (Borja, Raposo, & Rincon, 2006; Vlyssides et al., 2004). Upon the 3-phase process (Fig. 2), which is mainly adopted in Greek olive oil mills (Markou, Georgakakis, Plagou, Salakou, & Christopoulou, 2010), besides an average yield of 200 kg of oil/ton of processed olives, wastewater (vegetable water) and solid residue are generated. Vegetable water constitutes a major environmental problem because of the large volumes produced within a limited period of time (2–4 months) and the toxicity of the phenolic compounds present (Vlyssides et al., 2004). According to the *Standard Environmental Commitment Legislation for Industrial Activities* (Joint Ministerial Decision, no 4187/266, 2012), wastewater after appropriate treatment (oil collection, neutralization, and sedimentation) is disposed in open evaporation ponds. The above decision also regulates alternative reuse technologies such as agricultural irrigation. The minimum requirement is that this stream should comply with regulatory microbiological and chemical limits. The prospect of recovering high added value natural constituents from olive mill waste water (OMWW) is challenging. Application of the membrane filtration technology as an alternative to conventional treatments for the separation and exploitation of the OMWW phenolic fraction is of high interest (Paraskeva, Papadakis, Kanellopoulou, Koutsoukos, & Angelopoulos, 2007). The establishment of a central unit for the treatment of 50,000 tons per harvesting period was found to strengthen the techno-economics of such an investment in the Region of Western Greece (Arvaniti, Zagklis, Papadakis, & Paraskeva, 2012) and is also applicable in Central Macedonia, which faces similar environmental problems.

Regarding the solid residue, *olive pomace*, there is an established technology for the production of crude pomace oil, which is then directed to refineries for the production of edible forms of pomace oil. The above procedures are strictly regulated (Joint Ministerial Decision, no 4187/266, 2012). Pomace oil production process includes raw material storage and drying, oil extraction by means of hexane, solvent evaporation, and storage of the end product. Olive oil producers sell pomace to olive-pomace oil manufacturers so that waste is turned into a resource, which is a very critical point to a circular economy promoted by EU (http://ec.europa.eu/environment/circular-economy/index_en.htm). A key point in the above process is that in case pomace is not dried under suitable conditions, or contaminated solvent is used, or heat is