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CURRENT STATE OF KNOWLEDGE IN THE FIELD OF INTEGRATING THE CIRCULAR ECONOMY INTO AGRICULTURE

Cătălin Alexandru Bîtea[1,2], Ioana Mihaela Bălan[1,*], Olimpia Iordănescu[1], Nicoleta Mateoc-Sîrb[1,3]

[1]University of Life Sciences “King Mihai I” from Timisoara, Romania; [2]Doctoral School “Plant and Animal Resources Engineering”, Timisoara, Romania; [3]Romanian Academy, Branch of Timisoara, Romania

*Corresponding author: ioanabalan@usvt.ro | First author: catalin.bitea@usvt.ro

Abstract: *The paper synthesises the state of knowledge on integrating the circular economy into agriculture, focusing on winery by-products and their relevance for the Romanian wine sector. A structured narrative review of the literature was combined with a documentary analysis of European and national policy documents. The results outline the conceptual foundations of the circular economy and bioeconomy, the policy framework and three valorisation pathways: grape seeds for oil, pomace for distillates and bioactive compounds, and stalks and vine canes for pellets. Good practices from five countries are compared in terms of transferability. The analysis reveals a lack of integrated economic case studies at winery level in Eastern Europe, addressed by the doctoral research at Cramele Recaș.*

• Introduction

The circular economy replaces the linear “take–make–use–dispose” model with regeneration, reuse and the continuous circulation of materials and nutrients. Agriculture has the highest circularity potential, as most residual flows can return to biological cycles or become food, energy and industrial products. Wine production alone generates about 9 million t of waste per year worldwide.

Aim: to synthesise the state of knowledge on integrating the circular economy into agriculture, with emphasis on winery by-products, and to discuss its relevance for the Romanian wine sector.

• Material and method

Structured narrative review and documentary analysis, carried out within the first doctoral research report:

- peer-reviewed literature (Scopus, Web of Science, PubMed Central)
- EU and national policy documents (Directive 2008/98/EC, Regulation (EU) 1308/2013, GD 1172/2022)
- OECD, Ellen MacArthur Foundation and LIFE HAproWINE reports
- context data on Cramele Recaș from the doctoral research documentation

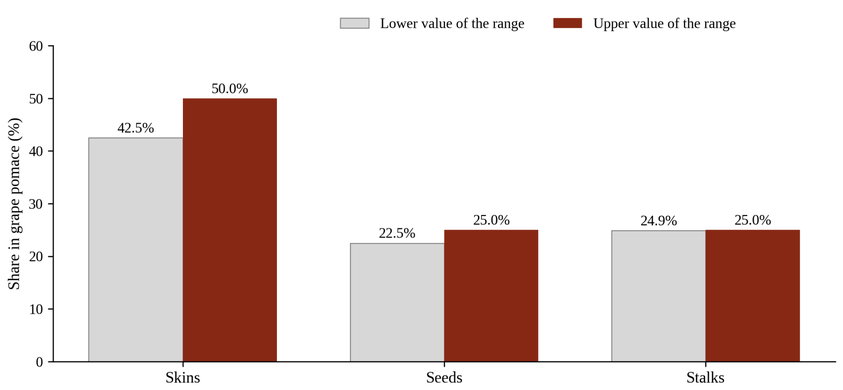


Fig. 1. Composition of grape pomace by fraction, range reported in the literature (source: Laqui-Estaña et al., 2024)

Table 1. Valorisation pathways of winery by-products

By-product	Valorisation route	Products	Evidence
Grape seeds	Cold pressing; solvent, ultrasound, supercritical CO_2 extraction	Edible and cosmetic oil	Commercial; 3.9–18.5 g oil/100 g
Grape pomace	Distillation; extraction of bioactive compounds; vermicomposting	Distillates, extracts, fertiliser	Consolidated / pilot scale
Pomace in biorefinery	Cascade: oil and tartrate first, then energy or soil use	Oil, calcium tartrate	Italian winery (LCA)
Vine canes, stalks	Pelletising	Solid biofuel	>97.5% durability; >17 MJ/kg

Source: own synthesis based on the literature reviewed

• Results and discussions

Concepts and policy. More than 114 definitions of the circular economy exist; the circular bioeconomy and agriculture-specific strategies are the most relevant frameworks. Romania’s National Strategy for the Circular Economy lists agriculture among 7 priority sectors, while resource productivity was the lowest in the EU (0.79 €/kg in 2019).

Valorisation pathways. Pomace consists of skins, seeds and stalks (Fig. 1); the pathways in Table 1 confirm the cascade principle.

Cramele Recaș. Over 1,150 ha, about 18,000–23,000 t of grapes processed per year and more than 20 million litres of wine; preliminary estimate: over 2,000 t of by-products per season (Table 2).

Table 2. Indicative structure of by-products at Cramele Recaș (lower-bound estimate)

Fraction	Share (%)	Quantity (t)	Main route
Skins	42.5–50.0	850–1,000	Bioactive compounds, distillation, composting
Seeds	22.5–25.0	450–500	Oil (theoretical 59–100 t)
Stalks	24.9–25.0	498–500	Pellets, cascade biorefinery

Source: own calculation based on doctoral research estimates and Laqui-Estaña et al. (2024)

International good practices. Five models offer lessons for the Romanian wine sector (Table 3).

Table 3. International good practices and their transferability

Country	Circular mechanism	Transferability to Romania
Italy	Winery upgraded to biorefinery	High for large wineries
Spain	Integrated waste management, LCA (LIFE HAproWINE)	High; scenario comparison
Netherlands	National vision of circular agriculture (2018)	Medium; policy coordination
Israel	87% of treated wastewater reused, mainly in agriculture	Medium; relevant under drought
Denmark	Kalundborg industrial symbiosis	High at territorial level

Source: own synthesis based on OECD, Ncube et al. (2021) and project documentation

Research gaps. Few economic evaluations at commercial scale, separate analysis of by-product streams, under-representation of Eastern Europe and insufficient quantification of social effects.

• Conclusions

- agriculture has a high circularity potential if by-products are valorised in cascade
- winery by-products can yield oil, distillates, bioactive compounds, fertilisers and pellets
- Romania still lacks a dedicated framework for winery by-products
- international models must be adapted to local conditions
- the Cramele Recaș case study addresses the economic and social gaps

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