

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/356716306>

## CHAPTER V GRAPE POMACE – A PROMISING BIOCOMPONENT AS BIOSTIMULANT AND ECO-FERTILIZER. A REVIEW

Chapter · December 2021

CITATIONS

0

READS

25

6 authors, including:



**Artem Victoria**

Research Station for Viticulture and Oenology, Romania, Murfatlar

24 PUBLICATIONS 136 CITATIONS

[SEE PROFILE](#)



**Ranca Aurora**

Research and Development Station for Viticulture and Oenology Murfatlar

29 PUBLICATIONS 203 CITATIONS

[SEE PROFILE](#)



**Dan Razvan Popoviciu**

Universitatea Ovidius Constanța

66 PUBLICATIONS 71 CITATIONS

[SEE PROFILE](#)

## CHAPTER V

### GRAPE POMACE - A PROMISING BIOCOMPONENT AS BIOSTIMULANT AND ECO-FERTILIZER. A REVIEW

Prof. Dr. Ticuta NEGREANU-PIRJOL\*  
Assoc. Prof. Dr. Bogdan-Stefan NEGREANU-PIRJOL\*  
Senior Researcher II Dr. Victoria ARTEM\*\*  
Senior Researcher I Dr. Aurora RANCA\*\*  
Research Assistant Biologist Madalina CIOCAN\*\*  
Assistant Prof. Dr. Dan Razvan POPOVICIU\*\*\*

---

\*Ovidius University of Constanta, Faculty of Pharmacy, Romania.  
ticuta\_np@yahoo.com, bnegreanupirjol@yahoo.com

\*\*Research Station for Viticulture and Oenology Murfatlar, Constanta, Romania.  
artemvictoria@yahoo.com\_auroraranca@yahoo.com  
cmadalinaandreea6@gmail.com

\*\*\*Ovidius University of Constanta, Faculty of Natural Science and Agricultural Sciences, Constanta, Romania. dr\_popovicu@yahoo.com



## INTRODUCTION

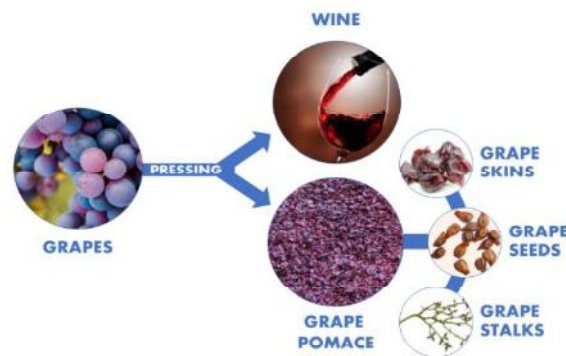
Grapevine represents one of the world's major crops. This perennial plant was first cultivated approximately 6000-8000 years ago, and as of 2019, it occupied 7.4 million hectares. In the same year, 260 millions of hectolitres of wine were produced, along with a great amount of residual grape skins, seeds and stems, their mixture being called "grape pomace" or "grape marc". Considering that for each 6 litres of wine results 1 kg of grape pomace, in 2019 only, 4.3 megatons of pomace were produced (OIV, 2020).

The considerable quantity of these solid remains from the vinification process creates a disposal issue, especially from the environmental and economic points of view. Scientists have been searching for ways of recycling and harnessing the potential of this by-product and have found applications in animal feed (Beres et al., 2016), as compost for soil amendments (Salgado et al., 2019), as a thermal insulator for buildings (Muñoz et al., 2014), to count a few. The potential of grape pomace can be also harnessed in the form of nutraceutical and pharmaceutical supplements, thanks to the high dietary fibre and polyphenol content, while the grape seed oil and antioxidant properties make grape pomace an important source of valuable cosmetic ingredients (Galanakis, 2017; Brezoiu et al., 2020; Abduraman et al., 2020). As a growth of interest has been noted for the valorization of this kind of winery residues, a large spectrum of applications has been developed, from fields that are very diverse.

This review summarizes different aspects of grape pomace applications in horticulture and agriculture as biostimulant-regenerator and ecological fertilizer.

## 1. OBTAINING GRAPE POMACE

During the pressing process, 2 kinds of products are obtained from grapes: the grape juice, known as must, which will eventually become wine, and the grape pomace (Figures 1a, 1b). In the case of white wine, the grape marc is discarded immediately, while for the red wines, pressing residues are left in the must for a certain time period, in order to make the extraction of grape constituents (such as polyphenols and pigments) possible. After the maceration time has ended, the pomace may be taken out of the must and discarded. Pectolytic enzymes or cellulases are usually added in the must extraction or maceration processes, with the aim of obtaining a greater yield or a more intense colour (Galanakis, 2017).



**Figure 1a:** By-Products Obtained From Grapes



**Figure 1b:** Grape Pomace Obtained at Research Station for Viticulture and Oenology Murfatlar, Constanta County, Romania (Original by Artem)

## 2. PHYSICAL-CHEMICAL PROPERTIES

This important by-product represents approximately 15 to 25% of the total weight of the grapes, percentage varying in accordance with the wine-making process and the grape variety (Oliveira & Duarte, 2016). From a physico-chemical point of view, after pressing, the grape pomace has a pH in the range of 6.5 to 8.5, low electrical conductivity, a moisture level of 20-30% w/w, and a high organic matter content (García -Lomillo & Gonzalez-SanJose, 2017). Grape pomace is also rich in valuable products such as mineral substances, ethanol, dietary fiber, hydrocolloids, citric acid, tartrates, malates, and ethanol (Kosseva & Webb, 2020).

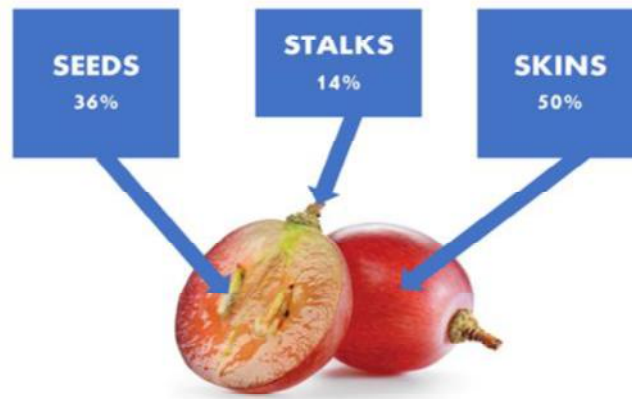
Grape pomace generally comprises 30% neutral polysaccharides, 20% polygalacturonic acid, 15% insoluble proanthocyanidins, 6-15% structural proteins, a wide diversity of phenols, lipids and lignin. The phenols and the structural proteins are an important source of organic compounds when they are obtained by fractioning, as they are bonded to lignin-carbohydrate complexes (Minjares-Fuentes et al., 2014).

In the case of red wine, the grape pomace is fermented, and in the end, it contains a very low amounts of sugars and phenols. The quantity of these constituents may vary as well, depending on the vinification processes and grape varieties. White grape pomace, on the other hand, is unfermented and has a greater quantity of carbohydrates and phenolic compounds, in comparison with the red, fermented pomace (Owen, 2015; Sirbu et al., 2021).

### **3. GRAPE POMACE COMPONENTS**

Grape pomace consists of roughly 50% skins, 36% seeds and 14% stalks (Figure 2). However, these proportions may vary, depending on the grape variety. Nonetheless, the skins are the predominant constituent, being represented by approximately one half of the grape pomace weight (Mendes et al., 2013).

Grape pomace has high quantities of phenolic antioxidants that make up 10 - 11% of the dry weight. Phenols are plant secondary metabolites, which, from a chemical point of view, contain a benzene ring with one or more hydroxyl groups. Polyphenols are organic compounds with more than one phenol units (Galanakis, 2017).



**Figure 2:** Approximate Composition of Grape Pomace (Galanakis, 2017)

Polyphenols found in foods are grouped into 4 major classes, namely stilbenes, flavonoids, phenolic acids, and lignans. The most commonly found stilbene of vegetal origin is resveratrol, a phytoalexin produced by plants as a response to being injured or attacked by pathogens, thus being a natural fungicide; flavonoids are the most intensely studied group of polyphenols, which comprises isoflavones, anthocyanidins, and proanthocyanidins; phenolic acids are represented by hydroxybenzoic and hydroxycinnamic acids, the latter including caffeic, chlorogenic, ferrulic, gallic, *p*-coumaric and sinapic acids. The polyphenol content of the grape pomace is variable, being determined by climate, location, grape maturity and the duration of the fermentation process (Pinelo et al., 2006).

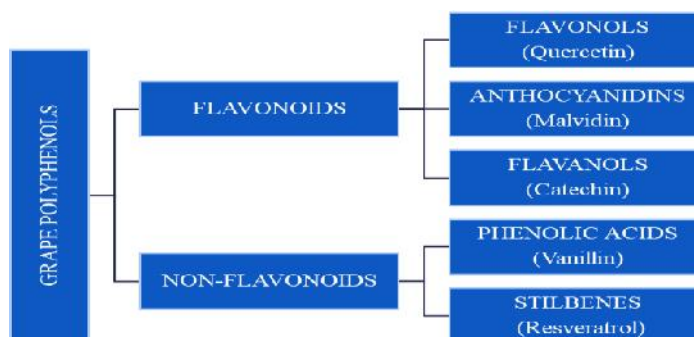
### 3.1. Grape Skins

The skins have a great amount of fibers and phenolic compounds, a protein content ranging from 5 to 12%, 2 - 8% ash and a soluble sugar

content in the range of 1 to 70%, the latter being conditioned by the applied vinification processes (Galanakis, 2017).

The main constituent of grape skins is dietary fiber, representing up to 60% of the dry matter, being almost entirely made up of the insoluble kind. According to Pinelo et al. (2006), the cell wall of the grape skins comprises neutral polysaccharides such as cellulose, arabinan, mannan, galactan, xylan and xyloglucan, substances of acidic pectin nature, lignin, structural proteins and proanthocyanidins.

Polyphenolic molecules are located in the highest amount in the skin of the grape berries, these compounds reaching a great diversity in this part of the fruit (Figure 3).



**Figure 3:** Types of Grape Polyphenols Found In the Grape Skin and Examples

The skin of red grapes contains flavonols, hydroxycinnamic acids and, according to Benmeziane et al., (2016), anthocyanin compounds such as acylated anthocyanins, coumaroyl-acetylated anthocyanins, coumaroylglucoside anthocyanins, cyanidin, delphinidin, malvidin, non-acylated anthocyanins, peonidin and petunidin. This grape skin anthocyanin profile is correlated with the intensity of the berry color

and although it is genetically determined for each grape variety, most of the times it is dependent on the agronomical and environmental factors. The skin of white and red grapes does not differ significantly, except for the fact that the skin of red grapes contains anthocyanins, whereas the skin of white grapes contains minor phenols like vitexin (Pinelo et al., 2006).

The applied winemaking techniques can also influence the polyphenol content of the grape skins from grape pomace. For red wines, the skins are left in the fermenting must for a certain period of time, which results in a polyphenolic extraction in the hydroethanolic solution that results from the fermentation process. Nonetheless, at the end of the maceration-fermentation step, the skin still contains a great amount of polyphenols, which can be used in various applications, due to their valuable properties (Galanakis, 2017).

### **3.2. Grape Seeds**

Grape seeds constitute between 2 - 5% of the fresh grape weight (Choi & Lee, 2010) and approximately 36% of the grape pomace resulted from the pressing process. However, these proportions may vary, as not all grape varieties have the same number and weight of seeds (Galanakis, 2017).

Their main constituent is fiber, representing 40% of the total mass. Grape seeds contain 10 - 20% lipids, 10% proteins, 5 - 8% complex phenolic compounds sugars, and minerals (Rockenbach et al., 2012). The fiber content is represented by 80% cellulose and pectin, the

percentage taking into account the dry matter, without the sugars (Kosseva & Webb, 2020).

One of the reasons for which grape seeds are valuable is the fact that they are rich in tocopherols and unsaturated fatty acids: linoleic acid constitutes 66.76 - 73.61%, oleic acid 17.8 - 26.5%, palmitic acid 6.35 - 7.93%, and stearic acid 3.64 - 5.26% (Owen, 2015). The use of grape seed oil has applications in the cosmetic, food, pharmaceutical and biodiesel industries (Górnaś & Rudzinska, 2016).

Polyphenolic compounds are another important component of grape seeds. The most notable are flavonoids, phenolic acids, resveratrol and procyanidins. The polyphenol composition of the grape seeds, like many other aspects related to the grape pomace, depends on a multitude of factors, such as the variety, the ripeness degree of the grapes, and also the soil and climate where the grapes were grown (Bordiga et al., 2015; Galanakis, 2017).

The tannins present there share the same component units as those present in the skin, but the polymerization degree of the seed tannins is lower, reaching a value of 11, because most of the times they are found in the monomeric form. The gallate levels, however, are 30% higher in the grape seeds, in comparison with the stalks and skins (Pinelo et al., 2006).

This portion of the grape berry has the highest antioxidant activity. Besides the polyphenolic compounds, the grape seeds also contain non-

phenolic antioxidants, such as carotenoids, vitamin E, and phytosterols, mainly present in the lipid components (Owen, 2015).

### **3.3. Grape Stalks**

Grape stalks are the skeleton of the grape cluster, constituting approximately 3 - 5% of the weight of the fresh grape and 14% of the grape pomace. The stalks contain lignocellulosic compounds (hemicelluloses and cellulose), between 22 and 47% lignin and are rich in tannins, which amount about 16% of the total mass (Galanakis, 2017). The latter represent approximately 80% of the phenolic compounds found in grape stalks, and their polymerization degree averages 9 (Souquet et al., 2000).

Tannins such as flavonols, catechin, and galocatechin are bonded with lignin, which has a higher condensation degree in comparison with conventional lignins from other agricultural residues and from wood, thus making it very difficult to extract pure cellulose from them (Prozil et al., 2014).

## **4. IMPACT ON THE ENVIRONMENT AND BIOECONOMY**

The viticulture and winemaking industry has to face a serious environmental problem: the adequate disposal of grape pomace (Patti et al., 2009). Scientists and vintners have tried to find sustainable methods for discarding wine residues, as the by-product quantity increases proportionally with the growth of the wine industry (Dobrei et al., 2016).

Due to its high phenolics content, grape pomace has a significant impact on the environment, as these compounds increase the biochemical and chemical oxygen demands (Owen, 2015). Soil degradation, water pollution, flora deterioration and odour emissions are examples of unwanted effects produced by wineries, through which the environment is affected. Thus, it is compulsory to find means of mitigating the scale of the consequences, through technologies which allow the recovery and reuse of vinification by-products (Oliveira & Duarte, 2016).

The impact is not only felt speaking from an environmental point of view, but also economically (Galanakis, 2017). Grape pomace has a high economic value, and therefore it is necessary to recover its valuable components in order to valorize it at its full potential (Barba et al., 2016). The capitalization of grape pomace can take many forms (Figure 4). Conventional methods applied for the valorization of grape pomace include distilling it, using it as fertilizer, or as animal feed, while modern applications include processing it in order to obtain biofuel, green materials, as well as bioactive compounds for the pharmaceutical, food and cosmetic industries (Chedea & Pop, 2019; Brezoiu et al., 2020).



**Figure 4:** Grape Pomace Applications

## **5. GRAPE POMACE IN HORTICULTURE AND SUSTAINABLE AGRICULTURE**

### **5.1. Grape Pomace As a Source of Biostimulants-Bioregenerators**

Currently, there is a growing interest for the usage of agricultural and horticultural residues in sustainable agriculture, as fertilizers, biopesticides and biostimulants. Among these easily available resources are fruit pomaces.



2020). Apart from directly supplying valuable compounds, pomace also indirectly stimulates the uptake of other nutrients (Artem et al., 2021). There are numerous methods of extraction of valuable chemicals from fruit tissue. Phenolic compounds can be extracted with ethanol or other solvents, usually at high temperatures and with long extraction times. Due to environmental and health concerns, there is a growing trend of searching alternative methods, including high pressure, ultrasound or supercritical fluid extraction. For protein-derived compounds, enzymatic hydrolysis (although traditionally used mostly for animal residues) is gaining attention as an effective method, with low environmental impact (Ertani et al., 2017).

Phenol-rich fruit residues are known for their biostimulative effects on crop plants. For instance, an experiment conducted on maize shown that fruit pomace hydrolysates resulted in significant increases in protein content and in various classes of phenolic compounds, although mixed results were obtained for sugars: sucrose, glucose and fructose, with major decreases in the former (Ertani et al., 2017).

More specifically, red grape skin residue extract (produced by cool extraction) applied on *Habanero pepper* plants (*Capsicum chinense*) led to an up to 80% increase in average leaf and fruit numbers and total fresh biomass. The treatment also increased the concentrations of fructose, glucose, ascorbic acid, dihydrocapsaicin, epicatechin, quercetin, chlorogenic acid and ferulic acid in leaves and that of capsaicin, glucose, ascorbate, fumarate, thymidine, chlorogenic acid, *p*-

coumaric acid, *p*-hydroxybenzoic acid, NADP<sup>+</sup>, and featured a higher antioxidant activity (Ertani et al., 2014).

Combined with other organic mixtures (algal residues, chopped vine shoots), grape pomace was found to help increase total biomass in several culture plants: grapevine, mustard, white clover – *Trifolium repens* (a forage plant) and ryegrass – *Lolium perenne* (a turf grass). In this experiment, both fermented and unfermented grape pomace and vine shoots were proven to be the most effective ingredients. Only part of this effect can be attributed to direct fertilization, humus enhancement or phosphorus and iron mobilization, bioactive growth-regulating compounds playing a similarly important role (Artem et al., 2021).

On citrus plants, on the other hand, application of grape pomace amendments was not found to bring significant benefits in terms of fruit size and total yield (Falivene, 2016).

Apart from direct or indirect plant growth enhancement, pomace is also useful against pests and pathogens. Alcoholic extracts of grape seeds added to soil release large quantities of free gallic acid and condensed tannins, which have nematicidal or nematostatic and antimicrobial properties (Lucarini et al., 2018).

White grape pomace extracts (using organic, environmentally-friendly solvents) were also successfully tested against *Phytophthora cinnamomi* (a parasitic oomycete causing chestnut ink disease, difficult to fight

against, since fungicide do not easily affect oomycetes), with inhibitory concentrations (IC<sub>50</sub>) as low as 3.17 % (Rama et al., 2020).

## **5.2. Grape Pomace As Ecological Fertilizer**

The aforementioned methods used for the recovery and recycling of grape pomace included using it as a fertilizer. Numerous times, research has shown that organic wastes can be turned into fertilizers, provided they are transformed in an appropriate way (Galanakis, 2017).

The organic cultivation system has become more and more prevalent nowadays, implying the use of fertilizers of natural origin instead of the synthetic ones (Arvanitoyannis & Varzakas, 2008). Graefe has proposed in 1982 a method of grape pomace recovery which involves using it as a high-grade organic fertilizer, also capitalizing on the heat and carbon dioxide produced.

The composting process has the aim of producing a homogenous, aerated, and reproducible fertilizing product, in well maintained conditions (Arvanitoyannis et al., 2006). Optimal thermal, pH, aeration and humidity conditions must be maintained in order to have a successful composting procedure (Dobrei et al., 2016).

Because of the potential presence of pathogens, long decomposing time, accompanied by the release of catabolites with an inhibitory action of the root growth and seed germination, it is not recommended to apply grape pomace as a fertilizer directly, without treating it properly (Owen, 2015). By decomposing, the unstable chemical compounds and the

activity of pathogenic microorganisms is reduced, thus making grape marc an adequate fertilizer (Dobrei et al., 2016).

Winemaking produces annually millions of tons of grape pomace as a byproduct, a revaluable resource with many potential uses, including a nutrient-rich organic soil amendment, but its application as untreated raw material can damage crops owing to the release of phytotoxic polyphenols, problem which can be minimized by vermicomposting process, as earthworms can partly digest polyphenols. The procedure is effective, simple, environmental-friendly and economical, and can easily be scaled up for industrial application yielding a variety of added-value products from the grape pomace (Domínguez et al., 2016).

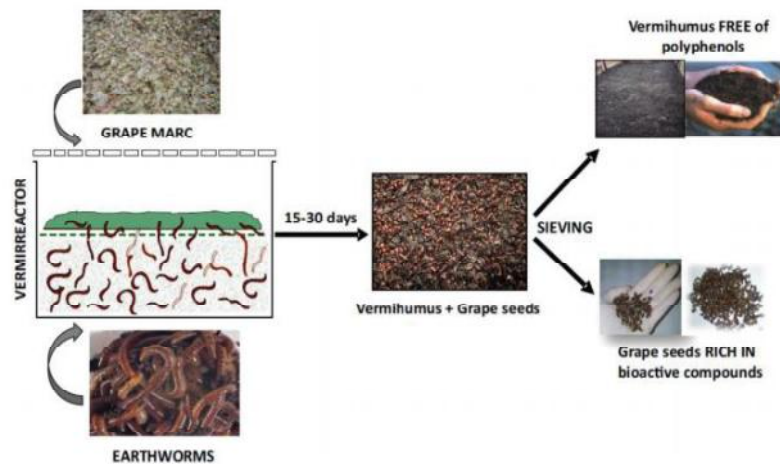
Composting and vermicomposting (Figure 5) are such methods of converting wastes resulted from various domains of agriculture, in order to obtain a satisfactory product for soil fertilization (Arvanitoyannis et al., 2006; Domínguez et al., 2015; Morata & Loira, 2016). Through these processes, the high polyphenolic content of the grape marc constituents is reduced, therefore minimizing their impact on the crops for which the fertilizer is applied (Figure 6) (Morata & Loira, 2016).

Grape pomace has the potential to become a valuable fertilizer, as it has good physicochemical properties and it can return nutrients back into the soil, Lasaridi et al. (2000) stating that this kind of composted material is of the best quality, due to its agronomic value.

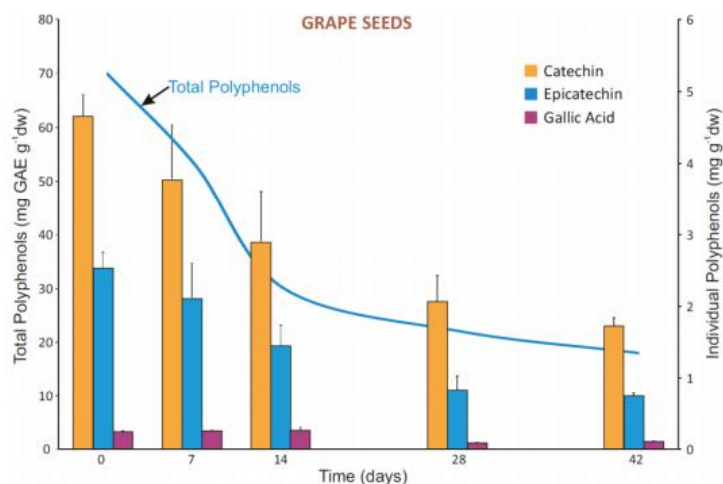
Chemical analyses have shown that grape pomace compost contains 2-3% w/w free potassium, the element present in the most notable amounts (Patti et al., 2009). However, the nitrogen (2.14-3.74%) and phosphorous (0.18-0.52%) contents are not that high (Table 1), and in addition, these nutrients are not found in a form that is available to plants.

Ferrer et al. (2001) recommend that the use of grape pomace compost should be supplemented with phosphorous, in order to satisfy crop needs for this nutrient.

Elements such as calcium, magnesium and sulphur are present in small amounts (Arvanitoyannis et al., 2006). Micronutrients like copper and boron are not present in excessive amounts and can satisfy the soil's needs for these elements.



**Figure 5:** The Scheme of Grape Pomace Biofertilizer Obtained by Vermicomposting Process to Obtain Simultaneously a High-Quality Biofertilizer Free of Polyphenols and Grape Seeds Rich in Bioactive Compounds (Domínguez et al., 2015; Morata & Loira, 2016)



**Figure 6:** The Effect of Compost Process on the Polyphenol Content of Grape Pomace (Morata & Loira, 2016)

**Table 1:** Chemical Composition of Compost Derived From Winery Waste (Arvanitoyannis & Varzakas, 2008)

ELEMENT	VALUES
<b>N</b>	2.14-3.74%
<b>P</b>	0.18-0.52%
<b>Ca</b>	3.17-14.3%
<b>Mg</b>	0.3-0.61%
<b>Fe</b>	0.5%
<b>Zn</b>	77-109 mg/kg
<b>Cu</b>	30-46 mg/kg
<b>Ni</b>	9.1-17.6 mg/kg
<b>Cr</b>	23.4-147 mg/kg
<b>Pb</b>	8-19 mg/kg
<b>Cd</b>	0.2-0.4 mg/kg

The organic carbon present in grape pomace compost was in the forms of lignin and carbohydrates, studies revealing the presence of the humification process (Patti et al., 2009). The use of this type of compost

implies the gradual release of nutrients, over a long period of time, an increase of the soil's organic matter content, also improving its microbial activity and physical characteristics, such as water-holding capacity and aeration (Ribereau-Gayon et al., 1982). This kind of fertilizer has become more sought after, as it can ameliorate soils characterized by erosion and low humus levels (Vilaseca et al., 1994), as well as having pollutant filtering capacities (Dobrei et al., 2016).

Grape pomace compost can be used on its own as a biofertilizer, as was mentioned before, or along with other components, which lead to a more potent effect. Compost made of freshly obtained grape pomace, combined with hen dropping can represent a higher quality fertilizer, compared with a synthetic product composed of  $P_2O_5$ ,  $K_2O$  and urea (Ferrer et al., 2001). The role of the addition of hen droppings in this case is to aid the aerobic and anaerobic bioconversion processes. This effect was produced due to the fact that the composted biofertilizer contains humic compounds, micronutrients and minerals (Arvanitoyannis & Varzakas, 2008).

In another study from 2004, Bertran et al. used winery sludge and grape stalks, in a ratio of 1:2 as a compost, obtaining a high value biofertilizer. This can be especially used for the vineyard soils, characterized by a low organic matter content, thus closing the cycle.

In a 2021 study on grapevine, Artem et al. have noticed an increase of grape quality, vegetative growth, as well as soil phosphorus and humus contents, after incorporating a mixture of grape pomace, grapevine

canes, *Rapana* sp. shells and green and brown algae into the soil (Negreanu-Pirjol et al., 2019).

The continuous use of grape pomace compost as a fertilizer can induce, however, undesirable effects, such as heavy metals bioaccumulation (Arvanitoyannis & Varzakas, 2008).

The abundance and availability of heavy metals and essential nutrients were evaluated in a comprehensively study by Pérez Cid et al., (2019), on different grape pomace residues from winemaking of different white and red grape varieties, before and after the distillation process and the data emphasize in this chapter, suggest the valuable application of grape pomace as eco-fertilizers for different agricultural soils, without limitations resulting from heavy metal contamination.

## **CONCLUSION**

Grape pomace obtained during the winemaking process, it is a mixture of skins, pulp, seeds, and stems, obtained after pressing of grapes in the winemaking process and represents about 20–30% wt. of processed grapes.

The valorization of grape pomace in circular bioeconomy is important considering the environmental issues or the important potential of its bioactive compounds, but in the last decade only 3% of grape pomace was turned into animal feed, compost, or other applications. In the same time, the grape pomace is an abundant and valuable source of polyphenolic compounds, which present an increased interest due to their health benefits, which involve antioxidant, anti-inflammatory,

antibacterial, anticarcinogenic, antidiabetic, cardioprotective effects and a valuable potential for food and cosmetics industries.

As a promising biostimulant, grape pomace boost crops yield and quality. Also, it improve the soil structure, increase the volume of useful land which give the crops better access to the soil's water and mineral resources, a better resistance and tolerance to water stress, increase the production and offer better crops physiological conditions.

As eco-fertilizer for plant nutrition, grape pomace can help make soils more fertile by restoring a level of organic matter needed for healthy plant growth through the complexed micronutrients content and also, could reduce abiotic stress caused by drought or high soil salinity.

#### **ACKNOWLEDGEMENTS**

The authors would like to express appreciation for the financial support of the Romanian Ministry of Research - UEFISCDI, for Complex Project no. 85PCCDI / 2018, Acronym INOBIOMAR, Project code PN-III-P1-1.2-PCCDI-2017-0701.

## REFERENCES

- Abduraman, A., Brezoiu, A.M., Tatia, R., Deaconu, M., Lincu, D., Minea, S., Artem, V., Matei, C., Moldovan, L., Pirjol Negreanu, T., & Berger, D. (2020). Properties of free and embedded extracts from different grape pomace into mesoporous inorganic matrices. *Proceedings (MDPI)*, 57(1): 78.
- Artem, V., Negreanu-Pirjol, T., Ranca, A., Ciobanu, C., Abduraman, A., Coroiu, V., & Negreanu-Pirjol, B.S. (2021). Experimental studies on the residual marine and viticultural bioresources valorization for new organic fertilizers. *U.P.B. Scientific Bulletin, Series B: Chemistry and Materials Science*, 83(2): 65-76.
- Arvanitoyannis, I.S. & Varzakas, T.H. (2008). Vegetable waste treatment: comparison and critical presentation of methodologies. *Critical Reviews in Food Science and Nutrition*, 48(3): 205-247.
- Arvanitoyannis, I.S., Ladas, D., & Mavromatis, A. (2006). Potential uses and applications of treated wine waste: a review. *International Journal of Food Science & Technology*, 41(5): 475-487.
- Barba, F.J., Zhu, Z., Koubaa, M., Sant'Ana, A.S., & Orlie, V. (2016). Green alternative methods for the extraction of antioxidant bioactive compounds from winery wastes and by-products: A review. *Trends in Food Science & Technology*, 49: 96-109.
- Benmeziane, F., Cadot, Y., Djamai, R., & Djermoun, L. (2016). Determination of major anthocyanin pigments and flavonols in red grape skin of some table grape varieties (*Vitis vinifera* sp.) by high-performance liquid chromatography–photodiode array detection (HPLC-DAD). *Oeno One*, 50(3): 125-135.
- Beres, C., Simas-Tosin, F.F., Cabezudo, I., Freitas, S.P., Iacomini, M., Mellinger-Silva, C., & Cabral, L.M. (2016). Antioxidant dietary fibre recovery from Brazilian Pinot noir grape pomace. *Food Chemistry*, 201: 145-152.
- Bertran, E., Sort, X., Soliva, M., & Trillas, I. (2004). Composting winery waste: sludges and grape stalks. *Bioresource Technology*, 95(2), 203-208.

- Bordiga, M., Travaglia, F., Locatelli, M., Arlorio, M., & Coisson, J.D. (2015). Spent grape pomace as a still potential by-product. *International Journal of Food Science & Technology*, 50(9): 2022-2031.
- Brezoiu, A.M., Bajenaru, L., Berger, D., Mitran, R.A., Deaconu, M., Lincu, D., Stoica Guzun, A., Matei, C., Moisescu, M. G., & Negreanu-Pirjol, T. (2020). Effect of nanoconfinement of polyphenolic extract from grape pomace into functionalized mesoporous silica on its biocompatibility and radical scavenging activity. *Antioxidants*. (MDPI), 9(8): 696.
- Chedea, V.S., & Pop, R.M. (2019). Total polyphenols content and antioxidant DPPH assays on biological samples. In *Polyphenols in Plants*, Academic Press, pp. 169-183.
- Choi, Y.S., Choi, J.H., Han, D.J., Kim, H.Y., Lee, M.A., Kim, H.W., & Kim, C.J. (2010). Optimization of replacing pork back fat with grape seed oil and rice bran fiber for reduced-fat meat emulsion systems. *Meat Science*, 84(1): 212-218.
- Dobrei, A., Posta, G., Danci, M., Nistor, E., Camen, D., Mălăescu, M., & Sala, F. (2016). Research concerning the correlation between crop load, leaf area and grape yield in few grapevine varieties. *Agriculture and Agricultural Science Procedia*, 10: 222-232.
- Domínguez, J., Martínez-Cordeiro, H., & Lores, M. (2016). Earthworms And Grape Marc: Simultaneous Production Of A High-Quality Biofertilizer And Bioactive-Rich Seeds, *Grape And Wine Biotechnology*, Chapter 8, IntechOpen Ed., 167-183, <http://dx.doi.org/10.5772/64751>.
- Domínguez, J., Lores M, Álvarez Casas M, & Martínez-Cordeiro H. (2015). Procedimiento para la obtención y aislamiento de un fertilizante orgánico y de semillas de uva a partir de residuos de uva. Patent number: ES2533501. 30/11/2015. Universidade de Vigo y Universidade de Santiago de Compostela. Spain.
- Ertani, A., Francioso, O., & Nardi, S. (2017). Mini review: fruit residues as plant biostimulants for bio-based product recovery. *AIMS Agriculture and Food*, 2(3): 251-257.

- Ertani, A., Pizzeghello, D., Francioso, O., Sambo, P., Sanchez-Cortes, S., & Nardi, S. (2014). *Capsicum chinensis* L. growth and nutraceutical properties are enhanced by biostimulants in a long-term period: chemical and metabolomic approaches. *Frontiers in Plant Science*, 5.
- Falivene, S. (2016). Extension of Citrus Practices to Maximise Marketable Fruit Size and Economic Returns through on-Farm Trials. Horticulture Innovation Australia Limited, Sydney, Australia. pp: 76-78.
- Ferrer, J., Páez, G., Mármol, Z., Ramones, E., Chandler, C., Marin, M., & Ferrer, A. (2001). Agronomic use of biotechnologically processed grape wastes. *Bioresource Technology*, 76(1): 39-44.
- Galanakis, C.M. (2017). *Handbook of Grape Processing By-Products: Sustainable Solutions*. Academic Press, Elsevier, 125 London Wall, London EC2Y 5AS, United Kingdom. pp: 20-23.
- García-Lomillo, J., Gonzalez-SanJose, M. L., Del Pino-García, R., Ortega-Heras, M., & Muñiz-Rodríguez, P. (2017). Antioxidant effect of seasonings derived from wine pomace on lipid oxidation in refrigerated and frozen beef patties. *LWT*, 77: 85-91.
- Górnaś, P. & Rudzińska, M. (2016). Seeds recovered from industry by-products of nine fruit species with a high potential utility as a source of unconventional oil for biodiesel and cosmetic and pharmaceutical sectors. *Industrial Crops and Products*, 83: 329-338.
- Graefe, G. (1982). U.S. Patent No. 4,311,510. Washington, DC: U.S. Patent and Trademark Office.
- Kokkinomagoulos, E. & Kandyli, P. (2020). Sustainable exploitation of by-products of vitivincultural origin in winemaking. *Proceedings*, 67(5): 1-5.
- Kosseva, M.R. & Webb, C. (2020). *Food Industry Wastes: Assessment and Recuperation of Commodities*. Academic Press, Elsevier, London. pp: 46-48.
- Lasaridi, K.E., Stentiford, E.I., & Evans, T. (2000). Windrow composting of wastewater biosolids: Process performance and product stability assessment. *Water Science and Technology*, 42(9): 217-226.

- Lucarini, M., Durazzo, A., Romani, A., Campo, M., Lombardi-Boccia, G., & Cecchini, F. (2018). Bio-based compounds from grape seeds: A biorefinery approach. *Molecules*, 23.
- Mendes, J.A., Xavier, A.M., Evtuguin, D.V., & Lopes, L.P. (2013). Integrated utilization of grape skins from white grape pomaces. *Industrial Crops and Products*, 49: 286-291.
- Minjares-Fuentes, R., Femenia, A., Garau, M.C., Meza-Velázquez, J.A., Simal, S., & Rosselló, C. (2014). Ultrasound-assisted extraction of pectins from grape pomace using citric acid: A response surface methodology approach. *Carbohydrate polymers*, 106: 179-189.
- Morata, A. & Loira, I. (2016). *Grape and Wine Biotechnology*. IntechOpen, Rijeka. pp: 167-178.
- Muñoz, P., Morales, M.P., Mendivil, M.A., Juárez, M.C., & Muñoz, L. (2014). Using of waste pomace from winery industry to improve thermal insulation of fired clay bricks. Eco-friendly way of building construction. *Construction and Building Materials*, 71: 181-187.
- Negreanu-Pirjol T., Negreanu-Pirjol, B.S., Popoviciu, D.R., Mirea, M., & Vasile, M. (2019). Micro-macroelements and heavy metals in the algae component of a new biostimulator-regenerator for grapevine soils. 19<sup>th</sup> International Multidisciplinary Scientific GeoConferences–SGEM 2019, 9–11 December 2019, Vienna, Austria, Conference Proceedings, Nano, Bio, Green and Space: Technologies for a Sustainable Future, Section „Advances in Biotechnology”, 19(6.3): 141-148.
- OIV, (2020). State of the World Vitivinicultural Sector in 2019.
- Oliveira, M. & Duarte, E. (2016). Integrated approach to winery waste: waste generation and data consolidation. *Frontiers of Environmental Science & Engineering*, 10(1): 168-176.
- Owen, J.P. (2015). *Fruit and Pomace Extracts*. Food and Beverage Consumption and Health Series. Nova Science Publishers, New York. pp: 69-76.
- Patti, A.F., Issa, G., Smernik, R., & Wilkinson, K. (2009). Chemical composition of composted grape marc. *Water Science and Technology*, 60(5): 1265-1271.

- Pérez Cid, B., Martínez, M.M., Vázquez, F.A., & Río Segade, S. (2019). Content and bioavailability of trace elements and nutrients in grape pomace. *Journal of the Science of Food and Agriculture*, 99(15): 6713-6721.
- Pinelo, M., Arnous, A., & Meyer, A.S. (2006). Upgrading of grape skins: Significance of plant cell-wall structural components and extraction techniques for phenol release. *Trends in Food Science & Technology*, 17(11): 579-590.
- Prozil, S., Evtuguin, D.V., Lopes, S.M., Cruz Lopes, L.P., Arshanitsa, A.S., Solodovnik, V.P., & Telysheva, G.M. (2014). Evaluation of grape stalks as a feedstock for pellets production. In *Proceedings of the 13th European Workshop on Lignocellulosics and Pulp (EWLP2014)*, Seville, Spain, pp: 24-27.
- Rama, J.L.R., Mallo, N., Biddau, M., Fernandes, F., de Miguel, T., Sheiner, L., Choupina, A., & Lores, M. (2020). Exploring the powerful phytoarsenal of white grape marc against bacteria and parasites causing significant diseases. *Environmental Science and Pollution Research*, 28(19): 24270-24278.
- Ribéreau-Gayon, J., Peynaud, É., & Sudraud, P. (1982). *Sciences et techniques du vin: traité d'oenologie. Analyse et contrôle des vins*. Bordas.
- Rockenbach, I.I., Jungfer, E., Ritter, C., Santiago-Schübel, B., Thiele, B., Fett, R., & Galensa, R. (2012). Characterization of flavan-3-ols in seeds of grape pomace by CE, HPLC-DAD-MSn and LC-ESI-FTICR-MS. *Food Research International*, 48(2): 848-855.
- Salgado, M.M.M., Blu, R.O., Janssens, M., & Fincheira, P. (2019). Grape pomace compost as a source of organic matter: Evolution of quality parameters to evaluate maturity and stability. *Journal of Cleaner Production*, 216: 56-63.
- Sirbu, R., Negreanu-Pirjol, T., Negreanu-Pirjol, B.S., & Cadar, E. (2021). Important properties of grapes and wine from the Dobrogea area for therapeutic use. *European Journal of Medicine and Natural Sciences*, 5(1): 17-26.
- Souquet, J.M., Labarbe, B., Le Guernevé, C., Cheynier, V., & Moutounet, M. (2000). Phenolic composition of grape stems. *Journal of Agricultural and Food Chemistry*, 48(4): 1076-1080.

Vilaseca, J.S., Martí, T.B., de la Peña Kruter, M., & Tardiu, M.L.G. (1994).  
Utilizacion de compost de residuos solidos urbanos en un viñedo del Penedes.  
Viticultura Enología Profesional, (31): 20-25.