Scientific Papers. Series A. Agronomy, Vol. LXVI, No. 1, 2023
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

BENEFITS OF ORGANIC FERTILIZERS RESULTED FROM DIFFERENT ORGANIC WASTE CO-COMPOSTING: A REVIEW

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Abstract

Considering the increasing demography and the diversity of human activities, the quantity of waste is also increasing around the world, and the quantity of organic waste too. Therefore, the nature cannot deal with all waste by itself. Thus, people are looking for the most efficient ways to improve waste management. One of those ways, which is to reintegrate most of the residual materials as resources or as new products and to reduce their environmental impact is the circular economy (CE). Composting is nature's way of dealing with organic waste to turn it into simple components which will be able to integrate the natural cycles. So, composting is a part of CE that can transform organic waste into new products such as compost. This paper will explore the methods of composting, from traditional composting to the involvement of artificial intelligence (AI) in this process and will analyse the benefits of the organic fertilizers resulted from composting and co-composting of different materials. From this perspective, the most well-known composting systems will be addressed (home composting, on-farm composting, and industrial composting).

Key words: *co-composting, organic waste, circular economy, benefits, new products.*

INTRODUCTION

There are many different types of waste generated around the world and the organic waste is a big part of it. Organic waste generally refers to any material which is biodegradable, compostable, mainly produced by living organisms, such as animals and plants, classified as: garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises and comparable waste from food processing plants; animal by-products used in a biogas or composting plant (Directive 2008/98/EU).

It cannot be traced back in time to the moment when the idea of the CE appeared, however, the concept becomes more popular as the need to reduce the impact of human activity on the environment increases. European Union (EU) aims to transit from a traditional linear economy to a circular economy, and to achieve this target, the European Commission (EC) adopted its first circular economy action plan in 2015 with 54 concrete actions which covered the whole life cycle of the products (EC, 2015). Only 40% of the waste produced by EU households is recycled, with a wide variation between Member States (MS) and regions (above 80% recycling rate in some areas and below 5% in other) (EC, 2015). Forward, in 2018 it was revised the legislative framework (Directive 2008/98/EU) on waste which provides a hierarchy of waste and defines the types of waste and by-products, giving directions to MS on how to address the issue of waste management and sets the target for waste-recycling to 60% by 2030 and 65% by 2035 (Directive 2018/851/EU). Statistical reports showed that the total waste generated in EU by all economic sectors decreased with 0.99% in 2020 compared with 2004. The waste produced only by agriculture sector during 2004-2020 decreased with 0.33% in EU (Table 1).

In 2020 the waste recovery rate was 54.08% in EU (Table 2), from which 39.9% is being recycled, the rest of it goes to landfilling, incineration or it's disposed in other ways, and a smaller percentage is used for energy recovery (Eurostat, 2023). Even if the treatment of the waste overall has a descending trend, the recycling of the waste produced by agriculture sector has increased (Table 3).

Wanting to become the first climate-neutral continent by 2050, in 2019 EC adopted European Green Deal (EGD) which has a focus on reducing the greenhouse gas emissions (GHG) with 55% by 2030, compared to 1990 levels (EC, 2019).

According to the Fifth Biennial Report from the European Union under the UNFCCC (2022), in 2020, the total GHG emissions in the EU was 3700 million tonnes CO_2 equivalents, which means 34.3% below 1990 levels. Agriculture is the second largest sector that produces GHG emissions in EU (11% of the total GHG). The main sources of GHG emissions from agriculture comes from application of fertilizers and manure management, and enteric fermentation (including methane emissions).

The reports submitted by the EU and MS show a decrease of 31% in 2020 compared with 1990 in the use of inorganic fertilizers and a decrease of 4% in the use of nitrogen from organic fertilizers (EEA, 2022).

In accordance with the European Green Deal, EC published Farm to Fork strategy, a 10-year plan which aims to accelerate the transition to a sustainable food system and to reduce the impact on the environment of the food supply chain. Besides that, in 2022 through the proposal of a new Regulation on the Sustainable Use of Plant Protection Products (EC, 2022), EC decided to reduce with 50% the use of chemical pesticides and 50% the use of more hazardous pesticides by 2030, in line with the EU's Farm to Fork and Biodiversity strategies.

The reports from 2020 presents a decrease of 14% in the use of chemical pesticides, and 26% in the use of more hazardous pesticides, compared to 2015-2017 (Eurostat, 2022).

One of the cleaner technologies for waste management and GHG reduction is composting, a process of biological decomposition and stabilization of organic matter with a resulting product (compost) that is stable, free of pathogens and plant seeds, that can be beneficial for soils and plants (Haug, 1993; Martínez-Blanco et al., 2010; Scotti et al., 2016).

The compost can be applied to the soil, with amending and fertilizing purpose (Naeini & Cook, 2000; Scotti et al., 2016) and to recover degraded soils (Scotti et al., 2016); to exert plant disease suppressiveness (Pane et al., 2013; De Corato et al., 2019; Pane et al., 2020); to sequester carbon into the soil thus reducing global warming (Favoino & Hogg, 2008); to reduce production costs and negative impacts of agricultural activities by limiting inputs of fertilizers and pesticides (Martínez-Blanco et al., 2009b; Sánchez et al., 2017; Vázquez & Soto, 2017).

This paper addresses the most used composting methods currently used, the typology of composting materials and the benefits of the composts obtained from them. It also addresses the co-composting of waste from farms with medicinal plants to increase the compost suppressiveness against plant pathogens.

The purpose of this study is to support a series of experimental research on the co-composting of aromatic and medicinal plant residues with different residues from farm to obtain a product (compost) with significant suppressive properties to be used in ecological agriculture.

Table 1. Waste generation excluding major mineral wastes during 2004-2020 period (million tons)

Waste generation excluding major mineral wastes			
Period	2004	2020	2020/2004
Total UE	780.52	775.21	-0.99
Agriculture UE	62.34	20.73	-0.33

Source: Eurostat (env_wasgen)

Table 2. Waste treatment by category in EU during 2004-2020 period (%)

	Recovery (recycling + backfilling + energy recovery)		Disposal (landfilling + incineration + others)	
Time	2004	2020	2004	2020
Total UE	38.70%	54.08%	45.66%	37.45%

Source: Eurostat (env_wastrt)

Table 3. Treatment of waste excluding major mineral wastes in EU during 2010-2020 period (million tons)

Treatment of waste excluding major mineral wastes			
Period	2010	2020	2020/2010(%)
Waste treated UE	638.77	633.80	-0.99
Waste recycled UE	325.37	357.37	1.10
Waste recycled from agriculture UE	53.73	69.36	1.29

Source: Eurostat (env_wasoper)

MATERIALS AND METHODS

This study will review the relevant and current literature regarding composting methods, the material used for composting, and the impact that compost has on plant health, all of this in the context of the current legislation. For this, we pursue two objectives:

1. understanding the targets set by the EU to combat climate change and the actions taken to reach the targets set for the agriculture sector;
2. providing an overview on the benefits of compost, a solution for many difficulties faced by farmers.

To achieve our study objectives, we used the following methodology:

- European directives, regulations and communications related to waste management, circular economy and plant protection were searched and studied, as well as reports submitted by MS;
- a number of 22 keywords were established (“compost”, “co-composting”, “composting”, “bio waste”, “organic waste”, “green waste”, “waste”, “home composting”, “industrial composting”, on farm composting”, “aromatic plants”, “herbs”, “manure”, “lavender”, “*Lavandula*”, “pesticides”, “circular economy”, “greenhouse gas emissions”, “suppressiveness”, “plant pathogens”, “organic fertilizer”, “climate change”), and were used to search for scientific publications (original articles and reviews, as well as books) in international databases (Web of Sciences, Scopus, Google Scholar);
- a series of statistical data were collected from Eurostat databases and public reports;
- other free access papers.

Once the searching process was completed, the documents were screened, and the most relevant ones were selected to be further analyzed and studied, and following this, the information and data that satisfied the proposed objectives were retained.

RESULTS AND DISCUSSIONS

Composting methods

There are many methods of composting which can be applied either at home, in a specialized plant or at farm location. The material and location chosen for the composting dictates the method needed. Ayilara et al. (2020) enumerated some of the most common methods such as: in-vessel composting, window composting, vermicomposting, static composting, Berkley rapid composting, Indian Indore composting.

Home composting is considered the self-composting of the biowaste as well as the use of the compost in a garden belonging to a private household (EC, 2009) and it presents some potential benefits such as: avoiding the collection and transportation of the organic fraction of the municipal solid waste, which is translated in the reduction of economic, material, and energetic investments (McGovern, 1997; Ligon, & Garland, 1998; Boldrin et al., 2009; Storino et al., 2016; Vázquez & Soto, 2017), it allows a direct control of the process and the organic materials input (Martínez-Blanco et al., 2009a; 2010; Barrena et al., 2014) and it helps with the reduction of household waste and resource recovery (Cheng et al., 2022), reduction which is important especially in the countries where the collected organic waste is higher than the treatment capacity (Sulewski et al., 2021).

Considering the environmental aspects, home composting presents some issues: compost obtained is not always homogeneous and its quality cannot be known, odors and other pollutants such as methane, ammonia or nitrous oxide are emitted directly to the atmosphere due to the absence of gas treatment systems. (Amlinger et al., 2008; Martínez-Blanco et al., 2010; Barrena et al., 2014).

Industrial composting is one of the technologies environmentally friendly used mostly for the disposal of the organic fraction of the municipal solid waste (Haug, 1993; Martínez-Blanco et al., 2010; Andersen et al., 2012). It is also the most suitable way to compost polylactic acid (PLA) and polyhydroxy butyrate (PHB), compostable bio-thermoplastic blends which need elevated temperatures maintained for a long timeframe to be properly decomposed (Mistry et al., 2023; Fogašová et al., 2022). In the industrial composting plants the composting parameters (temperature, humidity, and aeration), the quality of the final product and the GHG emissions can be controlled (Peng et al., 2022; Haug, 1993). However, it requires separate collection of the urban waste, it implies energy consumption for transportation and processing (Haug, 1993) and the compost resulted is not always a high-quality product, due to heavy metals content (Barrena et al., 2014; Siles-Castellano et al., 2021).

On-farm composting is an efficient, environmentally safe, and cost-effective technology for recycling and valorization of the agricultural wasted (Scotti et al., 2016). Benefits of these composts could include: their ability to mediate soil-borne plant pathogen suppression (Pane et al., 2013; Scotti et al., 2016), increase the soil fertility (Scotti et al., 2015), and reduce the CO_2 emission (Altieri & Esposito, 2010; Pane et al., 2020).

Authors described on-farm composting as a strategic tool for agriculture solving the issue of disposal of crop residues and livestock waste and serving as an organic amendment which can improve the soil quality and plant health (Scotti et al., 2016; Pergola et al., 2018; De Corato, 2020b).

Preparation procedures and evaluation techniques of the compost

A high-quality compost is critical. Therefore, some authors directed their attention on the evaluation of the compost, others focused on the preparation procedures.

Preparation procedures of compost can affect the properties of compost and its suppressiveness. Research carried out on composts resulted from escarole (*Chicorium endivia* L.) processing mixed with chopped parts of cardoon (*Cynara carduncului* L.), that were used as a bulking agent, show that the composts which were passively aerated and forced ventilated presented higher suppressiveness against *Rhizoctonia solani* and *Sclerotinia minor* than the compost which was turned manually (Pane et al., 2019).

Bedolla-Rivera et al. (2022) directed their attention on the evaluation of the quality of the compost by developing new calculation formulas for the evaluation indexes providing an easy-to-interpret tool to measure the quality of the composts.

Other author studied how using machine learning (ML), a subset of AI can optimize the process, predict missing data, detect non-conformities, and can manage complex variables (Temel et al., 2023). ML can work with complex multivariate data, predict non-linear connections, and process missing data (Manley et al., 2022). Modeling composting process parameters is very significant in generating solutions and decision-making processes. Therefore ML can be used for higher accuracy of optimizing the processing parameters for improving compost quality and maturity (Xue et al., 2019; Dümenci et al., 2021; Ding et al., 2022; Yılmaz et al., 2022; Wan et al., 2022), monitor moisture content in industrial-scale composting systems (Moncks et al., 2022), estimate the enzymatic activity of compost (Chakraborty et al., 2014) and predict CO_2 output from the composting of feedstock manure (Li et al., 2022).

As any new technology, ML and AI algorithms have their challenges which can be studied more in the future.

Suppressive properties of aromatic and medicinal plants

There are very few studies on composts that were made from materials that included aromatic and medicinal plant residues. That is why, in this paper, we have included a chapter on the suppressive properties of the oils extracted from such species.

Considering that the soil-borne pathogens cause plant disease which have a negative impact on the agricultural productivity overall (De Corato, 2020a), some scientists have been focusing on understanding what activates the natural suppressiveness of the soil (Wei et al., 2020; De Corato, 2023; Yang et al., 2023) and how this can be improved throughout organic fertilizers such as composts (Sommermann et al., 2022; De Corato, 2020a; Ayilara et al., 2020), others have explored the possibility of controlling the pathogens using essential oils (EO) from aromatic and medicinal plants (Table 4).

Types of waste and by-products

Many authors have studied various recipes of composts trying to reintegrate in the economy different types of waste and by-products, while analyzing the benefits of the composts on the environment, soil, and plant health (Table 5).

Most of the waste produced buy agriculture is compostable waste, with animal or plant origin, such as: livestock manure, slaughtered animals, residues from plant processing, pruning biomasses, residues from distilled plants, or waste from biogas.

Considering the variety of residues available nowadays, the scientists are trying to learn more about the agricultural potential of each type of waste while using different composting methodologies.

Table 4. Properties of aromatic and medicinal plants extracts and essential oils against soil-borne organisms

Target Organism	Plant	Effect	Reference
Fusarium oxysporum f. sp. *ciceris* Padwick	*Thymus pallescens*, *Artemisia herba-alba*, *Laurus nobilis*, *Cymbopogon citratus* (de Candolle ex Nees) Stapf.	Inhibition of mycelial growth, sporulation, and spore germination	Moutassem et al., 2019
Verticillium dahlia Kleb.	*Mentha piperita* L., *Thymus vulgaris* L., *Lavandula angustifolia* Mill.	Inhibition of mycelial growth	Erdogan et al., 2016
Meloidogyne incognita, *Meloidogyne javanica*	*Orginum vulgare*, *Thymus citriodorus*	Nematostatic/nematicidal activity (paralysis of second-stage juveniles)	Ntalli et al., 2020
Penicillium citrinum	*Satureja thymbra*, *Rosmarinus officinalis*	Suppression of spore germination	Vokou et al., 1984
Mucor hiemalis	*Satureja thymbra*	Complete inhibition of mycelial growth	Vokou et al., 1984
Penicillium expansum	*Mentha spp.*	Inhibition of mycelial growth	Benomari et al., 2018
Alternaria alternata, *Aspergillus* spp., *Penicillium* spp., *Trichoderma viride*, *Cladosporium cladosporioides*, *Phomopsis helianthi*	*Origanum onites* L., *Salvia thymbra* L.	Strong antifungal activity against the microorganisms tested	Sokovic et al., 2002
Verticillium dahliae, *Fusarium oxysporum* f. sp. *lycopersici*, *Sclerotinia sclerotiorum*, *Pythium* spp.	*Origanum* spp.	Inhibition of mycelial growth	Wogiatzi et al., 2009
Phytophthora spp.	*Rosmarinus officinalis*, *Lavandula angustifolia*, *Lavandula spicata*, *Salvia officinalis*	Control of zoospore germination	Widmer et al., 2006
Fusarium oxysporum f. sp. *Cyclaminis*	*Salvia officinalis* L.	Suppression of fungal pathogen, reduction of disease indices in cyclamen roots and shoots	Ahmad et al., 2020

Table 5. The benefits of different composts

Composted materials	Purpose	Benefits	Reference
Steam distilled pruning residues from *Ocimum basilicum* L., *Rosmarinus officinalis* L., *Salvia officinalis* L. and old commercial urban-waste compost	Improving sustainability	Improve plant production	Zaccardelli et al., 2021
Gentamicin mycelial residue (GMR) and rice chaff	Recycling the residue of GMR	Improve plant growth	Bu et al., 2022
Biosolids resulted from urban wastewater treatment, bovine manure, and rice husks	Disposal of the biosolids resulted from urban wastewater treatment	Restoration of degraded soils	Bedolla-Rivera et al., 2022

Composted materials	Purpose	Benefits	Reference
Fresh sheep manure and cornstalks	Reduce gas emissions	Reducing the gas emissions	Li et al., 2022
Olive mill waste, wool waste, and wheat straw	Recycling the olive mill waste	Improve plant production	Altieri & Esposito, 2010
Swine manure and rice straw	Disposal of livestock manure	Improve plant growth	Qian et al., 2014
Dairy manure and rice straw	Disposal of livestock manure	Improve plant growth	Qian et al., 2014
Chinese medicinal herbal residues, food waste, and sawdust	Suppression of plant pathogens	Suppressiveness against *Alternaria solani* and *Fusarium oxysporum*	Zhou et al., 2016
Agricultural residues and pruning biomasses from leafy vegetables, fennel, and woodchips	Suppression of plant pathogens	High suppressiveness against *Rhizoctonia solani* and *Sclerotinia minor*	Pane et al., 2020
Agricultural residues and pruning biomasses from leafy vegetables, basil, tomato, watermelon, and woodchips	Suppression of plant pathogens	High suppressiveness against *Rhizoctonia solani* and *Sclerotinia minor*	Pane et al., 2020
Agricultural residues and pruning biomasses from leafy vegetables, basil, watermelon, and woodchips	Suppression of plant pathogens	High suppressiveness against *Rhizoctonia solani* and *Sclerotinia minor*	Pane et al., 2020
Agricultural residues and pruning biomasses from leafy vegetables, basil, watermelon, and woodchips	Suppression of plant pathogens	Suppressiveness against *Rhizoctonia solani*	Pane et al., 2020
Agricultural residues and pruning biomasses from leafy vegetables, basil, and woodchips	Suppression of plant pathogens	High suppressiveness against *Rhizoctonia solani* and *Sclerotinia minor*	Pane et al., 2020
Agricultural residues and pruning biomasses from leafy vegetables, basil, and woodchips	Suppression of plant pathogens	Suppressiveness against *Rhizoctonia solani*	Pane et al., 2020
Agricultural residues and pruning biomasses from leafy vegetables, artichoke, and woodchips	Suppression of plant pathogens	High suppressiveness against *Rhizoctonia solani* and *Sclerotinia minor*	Pane et al., 2020
Agricultural residues and pruning biomasses from leafy vegetables, cabbage, walnut husk, and woodchips	Suppression of plant pathogens	High suppressiveness against *Rhizoctonia solani* and *Sclerotinia minor*	Pane et al., 2020
Agricultural residues and pruning biomasses from leafy vegetables, basil, sorghum, tomato, pumpkin, and woodchips	Suppression of plant pathogens	High suppressiveness against *Rhizoctonia solani* and *Sclerotinia minor*	Pane et al., 2020
Processing leftovers and unmarketable biomaterials of escarole (*Chicorium endivia* L.), chipped aboveground parts energy cardoon (*Cynara cardunculus* L.), and mature compost	Suppression of plant pathogens	High suppressiveness against *Rhizoctonia solani* and *Sclerotinia minor*	Pane et al., 2019
C1 = composted 17.5% tomato residues, 15.5% escarole residues, 65% woodchips and 2% mature compost starter	Suppression of plant pathogens	High suppressiveness against *Rhizoctonia solani* and *Sclerotinia minor*	Pane et al., 2013
C2 = composted 50.0% tomato residues, 48% woodchips and 2% mature compost starter	Suppression of plant pathogens	High suppressiveness against *Rhizoctonia solani* and *Sclerotinia minor*	Pane et al., 2013
C3 = 78.0% artichoke residues, 20% woodchips and 2% mature compost starter	Suppression of plant pathogens	High suppressiveness against *Rhizoctonia solani* and *Sclerotinia minor*	Pane et al., 2013
C4 = composted 43.5% artichoke residues, 23.5% fennel residues, 11.0% escarole residues, 20% woodchips and 2% mature compost starter	Suppression of plant pathogens	High suppressiveness against *Rhizoctonia solani* and *Sclerotinia minor*	Pane et al., 2013
Peat and compost (a mixture of lignocellulosic tree and grass cuttings and the	Suppression of plant pathogens	Suppressiveness against *Pythium ultimum* and	Loffredo & Senesi, 2009

Composted materials	Purpose	Benefits	Reference
organic fraction of municipal solid wastes)		*Fusarium oxysporum* f. sp. *callistephi*	
Coconut fiber and compost (a mixture of lignocellulosic tree and grass cuttings and the organic fraction of municipal solid wastes)	Suppression of plant pathogens	Suppressiveness against *Pythium ultimum* and *Fusarium oxysporum* f. sp. *callistephi*	Loffredo & Senesi, 2009
Composted defatted olive marc and fennel green waste	Suppression of plant pathogens	Suppressiveness against *Verticillium dahliae*	De Corato et al., 2019
Composted un-defatted olive marc and artichoke green-waste	Suppression of plant pathogens	Suppressiveness against *Verticillium dahliae*	De Corato et al., 2019
Composted spent coffee ground with green wastes of celery and carrot	Suppression of plant pathogens	Suppressiveness against *Verticillium dahliae*	De Corato et al., 2019
Composted spent tea bags with green wastes of tomato and lettuce	Suppression of plant pathogens	Suppressiveness against *Verticillium dahliae*	De Corato et al., 2019
Composted wood chips with green wastes of tomato and escarole	Suppression of plant pathogens	Suppressiveness against *Verticillium dahliae*	De Corato et al., 2019
Composted aspen chips with green wastes of artichoke and fennel	Suppression of plant pathogens	Suppressiveness against *Verticillium dahliae*	De Corato et al., 2019
Composted vineyard pruning wastes, vinery residues and wheat straw with green wastes of potato and pepper	Suppression of plant pathogens	Suppressiveness against *Verticillium dahliae*	De Corato et al., 2019
Composted tomato-waste	Suppression of plant pathogens	Suppressiveness against *Verticillium dahliae*	De Corato et al., 2019
Vermicompost produced from wastes of menthol mint (*Mentha arvensis*), chamomile (*Matricaria recutita*), geranium (*Pelargonium graveolens*), qinghao (*Artemisia annua*) followed by pyrethrum (*Chrysanthemum cinerariaefolium*), isabgol (*Plantago ovata*), African marigold (*Tagetes minuta*), Boerhavia (*Boerhavia diffusa*), mustard (*Brassica compestris*), lemongrass (*Cymbopogon flexuosus*) and garden mint (*Mentha viridis*)	Suppression of plant parasites	Inhibition in hatching of eggs of *Meloidogyne incognita* (root-knot nematode) and root-knot disease development	Pandey & Kalra, 2010

Co-composting of lavender with manure

A large quantity of bio waste consists in residual biomass resulted from the agricultural and industrial processes. The sector of aromatic and medicinal plants generates various kinds of residues like residual biomasses from distillation of aromatic herbs and non-utilized parts of medicinal plants (Santana-Meridas et al., 2012; Zhang et al., 2017; Saha & Basak, 2020; Wang et al., 2021; Zaccardelli et al., 2021; Li et al., 2022). Many of these residues are considered environmental liabilities if they are not ecologically recycled (Liang et al., 2011; Saha & Basak, 2020), but left on the field or incinerated (Lesage-Meessen et al., 2018). These residues still contain great nutrients and natural bioactive compounds such as cellulose, proteins, flavonoids, polysaccharides, organic acids (Su et al., 2018; Ni et al., 2020; Li et al., 2022), since the efficiency of the extraction of the EO is around 50% (Zhou et al., 2016; Greff et al., 2021b). Therefore, Lesage-Meessen et al. (2018) have studied the distilled straws of lavender and lavandin which proved to contain volatile molecules, usually found in the EO, and non-volatile phenolic compounds and flavonoids, as well as fungal enzymes involved in the degradation of lignocellulosic biomass.

Studies regarding the antifungal activity of lavender extracts and EO, proved that it can inhibit the mycelial growth of the fungus *Verticillium dahliae* Kleb. (Erdogan et al., 2016), or it can control of zoospore germination of *Phytophthora* spp. (Widmer et al., 2006).

Considering the previews scientific acquisitions, distilled straws of lavender might be a valuable component for co-composting, since plenty of fungal plant pathogens can survive during composting process by prolifically producing spores (Greff et al., 2021b; Chen et al., 2022; Liu, 2023), even though during composting most of the pathogens can be eliminated due to higher temperature through the decomposition (Wichuk et al., 2011; Liu, 2023).

Greff et al. (2021a) investigated the composability of post-extraction lavender waste by co-composting lavender with cattle manure, and González-Moreno et al. (2022) used a compost made of mature horse manure and lavender waste to create good quality vermicompost. Up to now, little information can be found about the benefits of co-composting lavender with sheep manure.

In the last 10 years, in Romania, the interest of small farmers for the cultivation of lavender in the "bio" system as well as for lavender oil production increased. Also, considering that sheep manure is a valuable resource of nutrients, and it is rich in organic matter, nitrogen, and phosphorus and it can be transformed into high-quality organic fertilizer (Ravindran et al., 2019; Li et al., 2022). In addition, since there is no other option for the elimination of lavender residues resulting from its processing to obtain the oil, our future research will focus on co-composting lavender residues with sheep manure. Besides the composting process, the quality of the compost, its agronomic value, etc., its antipathogenic effect will represent an objective to be studied.

CONCLUSIONS

The composting process is a complex process which can be the solution for many environmental issues we are facing nowadays. Our study showed that disposal of organic waste through composting it's a good strategy because of its low investment and operation costs, high benefits socially and environmentally and generation of a final product which can be used as fertilizer.

Even though there are studies which demonstrate the suppressive character of the compost, the use of compost as a suppressive agent has not been extended due to its complexity which was not entirely understood, therefore more studies should be conducted in this direction.

There are various materials that can be composted (co-composted), however less authors directed their attention on lavender waste and the benefits which this might bring.

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