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Spent Coffee Grounds, Plant Growth Promoting Bacteria, and Medicinal Plant Waste: The Biofertilizing Effect of High-Value Compost

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Abstract: Composting of mixed medicinal plant waste was performed with the addition of mixture of plant growth promoting bacteria (PGPB), including *Streptomyces* sp., *Paenybacillus* sp., *Bacillus* sp., and *Hymenobacter* sp., and portions of spent coffee grounds (SCG). To assess the maturity and quality parameters of the compost, chemical and biological parameters (C/N ratio, loss of organic matter, CO_2 production, dehydrogenase activity (DHA), and phytotoxicity) were evaluated during the three months of the composting process. The results revealed that the control sample (without the addition of SCG and PGPB) had evidently lower values of DHA during the entire monitoring period in comparison to other samples, indicating lower microbial activity in the compost mixture. Also, according to the released CO_2, the composting process was accelerated in all samples where the SCG and PGPB were added, enabling a reduction in time needed for mixed plant waste to decompose. The germination index (GI) of the tested seeds indicated that the produced compost was acceptable and safe, with regard to all of the evaluated samples. However, at the end of the process the samples contained SCG and PGPB, which caused an increase of more than 50% of the GI in comparison to the control sample, expressing a high phyto-stimulant effect and improving the biofertilization impact.

Keywords: compost; herbs waste; spent coffee grounds; PGPB; germination index; phytotoxicity

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1. Introduction

To provide eco-friendly solutions, a circular economy-based strategy would appear to afford the best use of biological resources, including composting and biorefineries. The biological conversion of agricultural waste into a product with added value, such as compost, is a promising solution contributing greatly to the zero waste concept [1]. During the composting process, microorganisms convert organic matter into biomass, thermoenergy, carbon dioxide, and ammonia, while odor gas emissions and considerable nitrogen losses also occur [2–4]. Upon achieving the physical and biological properties that ensure the stability of the material and most optimal plant growth, compost is a suitable replacement for peat in the creation of growing media. Even though composting is a naturally occurring microbiological process, inoculating ligno-cellulosic waste materials with specific microbial starters might accelerate the composting and humification processes, thus producing compost of a consistent quality. Furthermore, bacterial strains used for these purposes often have plant growth promoting (PGP) characteristics, which improve

the overall compost quality [5]. This may reduce the amount of synthetic fertilizers utilized in agriculture and make the fertilizer derived from natural waste material more competitive in the market. Also, by varying the composition of the starting mixture, which consists of natural biological material, the final compost material is expected to possess multifunctional biofertilizer properties. Bignami et al. (2023) showed that compost produced from agro–industrial waste from vine pruning residues or hazelnut husks could be used as a partial substitute for peat when growing raspberries and hazelnuts, which helps the vegetative growth and nutritional values of these plants [6]. Also, plants like sage, basil, and rosemary can compost well and produce high-quality compost, whose application may successfully preserve soil fertility [7]. Furthermore, the compost made from the remains of cultivation and processing of medicinal plants can be used as a substitute for other conventional and organic fertilizers and was found to have a positive effect on the morphological and productive characteristics and quality of the marigold flower during cultivation [8].

Accordingly, the use of spent coffee grounds (SCG) in agriculture has attracted much more attention in recent years. Globally, coffee is the second-largest commercially traded good after petroleum [9,10]. According to Atelge et al. (2021) [11], the amount of coffee consumed worldwide is anticipated to reach 12.24 million tons by 2030. One of the most significant by-products generated by this sector of the economy is spent coffee grounds (SCG), which are solid wastes. Spent coffee grounds are currently typically burned, dumped in landfills [12], or composted [13]. More than 1000 organic substances, including minerals, lipids, proteins, peptides, free amino acids, and crude fibers (lignin, hemicellulose, and cellulose), were detected in SCG. Furthermore, bioactive substances with antioxidant, antibacterial, and anticarcinogenic activity, such as alkaloids (caffeine and trigonelline), diterpenes (cafestol and kahweol), and polyphenols (tannins, tocopherols, and anthocyanins), were also detected in SCG [10,14]. In a biorefinery-based process, SCG can be recycled to create new value-added products [15]. Therefore, the comprehensive investigation of the SCG reuse rather than the standard disposal techniques could be a more environmentally friendly alternative [16]. It was also shown that the soil structure may be improved by adding coffee grounds to a compost pile. Cruz et al. (2012) [17] investigated the application of used coffee grounds for the production of lettuce (*Lactuca sativa* L.). Higher levels of xanthophylls, ß-carotene, and chlorophylls were detected in the cultured lettuce leaves when discarded coffee grounds (up to 10%) were present in the growing media. Gomes et al. (2014) [18] made comparable discoveries about the development of lettuce plants and photosynthetic pigments. Used espresso coffee grounds have also been examined for their possible use in agriculture, with promising results on a variety of micronutrients in pot tests employing used coffee grounds both directly and after traditional composting [19,20].

To the best of our knowledge, for the first time, this study aimed to examine a real industrial mixture as a starting composting material, consisting of the medicinal plants remains waste, whereby the addition of SCG and mesophilic bacterial cultures (with plant growth promoting properties) affected the speed of the composting process and the quality of the final product. In addition to medicinal plant waste, spent coffee grounds were used as another type of waste during composting, as a valuable source of energy for the growth of bacterial cultures that were added to the compost due to their high total nitrogen and carbon content.

2. Materials and Methods

2.1. Material for Decomposition

The mixed plant waste produced during the cultivation and processing of medicinal plants at the Institute of Medicinal Plants Research "Dr Josif Pančić" in Belgrade was one of the materials used in this research. There were more than 80 different plant species in the waste and the institute generates about 40 tons of waste annually during the production and processing of plants in the production of tea. The waste was composed of both dried root and above-ground parts of the plant (leaves, flowers, stems, fruits, and seeds) and

different granulations from the smallest powdery particle (0.15 mm) to larger crushed parts of the plants (10 cm). Parts of the following medicinal plants were used: German chamomile (*Chamomilae flos*), pot marigold (*Calendulae flos*), mint (*Menthae folium*), horsetail (*Equiseti herba*), rosemary (*Rosmarini herba*), valerian (*Valeriane radix*), artichoke (*Cynarae folium*), parsley (*Petroselini folium*), stinging nettle (*Urticae folium*) etc. Furthermore, the spent coffee grounds collected from local restaurants and cafes were another material used in the research.

2.2. Bacterial Strains

In this study, strains from soil and marine sediments with various hydrolytic potentials were used (*Hymenobacter* sp. CKS3, *Paenibacillus chitinolyticus* CKS1, *Streptomyces spororaveus* CKS2, *Streptomyces microflavus* CKS6, and *Streptomyces fulvissimus* CKS7). They are part of the microbiological laboratory's culture collection at the Department of Biochemical Engineering and Biotechnology at the Faculty of Technology and Metallurgy at the University of Belgrade and were identified in previous research through the analysis of morphological features and 16S rRNA gene sequences (gene accession numbers KP715850–KP715856) [21]. Strain CKS3, showing 98% genetic similarity, was closely related to the *Hymenobacter* species. Notable for their UV radiation tolerance and resilience in harsh conditions, *Hymenobacter* species are *psychrotolerant*, capable of growing across a wide temperature spectrum but favoring cooler environments. The strain *Paenibacillus chitinolyticus* CKS1 demonstrates a broad growth temperature range, thriving between 10 °C and 50 °C, with an optimal growth temperature from 30 °C to 37 °C. This aerobic bacterium adapts well to various growth media. The strains *Streptomyces spororaveus* CKS2, *Streptomyces microflavus* CKS6, and *Streptomyces fulvissimus* CKS7 belong to the *Streptomyces* genus, which flourishes in aerobic conditions and prefers moderate temperatures. *Bacillus amyloliquefaciens* ssp. *plantarum* PPM3 and *Bacillus altitudinis* PPT1, identified in this study, are well-known for their roles in biocontrol and plant growth promotion. As mesophilic organisms, these *Bacillus* species best grow at temperatures ranging from 25 °C to 35 °C and can adapt to various pH levels in oxygen-rich environments. With the exception of *B. amyloliquefaciens* ssp. *plantarum* PPM 3, all of the investigated strains have antibacterial and antifungal properties. The strain's compatibility was revealed on the agar plates with 1%, 5%, and 10% of mixed plant waste, where all of the chosen bacteria were able to thrive. When 10% of mixed plant waste was added, a growth-stimulating impact was observed, particularly on *P. chitinolyticus* CKS1, *B. amyloliquefaciens ssp. plantarum* PPM3, and *B. altitudinis* PPT1 [21]. For experimental purposes, these cultures were grown in ISP1 broth (containing pancreatic digest of casein and yeast extract) to achieve a density of 10^6–10^7 CFU mL^{-1}. These cultures were then mixed in equal volumes in ISP medium to create a combined population, which was used to inoculate medicinal plant waste for composting.

2.3. Composting Process

For experimental purposes, five small wooden containers (70 cm × 80 cm × 100 cm) with a mobile lid that allowed air exchange were used and they were filled with 10 kg of mixed medicinal plant waste. The containers were marked and their composition is presented in Table 1. The control was a sample of homogenous plant waste, marked as P. The second control was a sample with the same plant waste with the addition of 5% spent coffee grounds, marked as PC5%. Three samples of homogeneous plant waste with spent coffee grounds were inoculated with 2% (v/w) of fresh bacterial cultures (cca 10^7 mL^{-1}), introduced in Section 2.2. These samples were marked as: PBC1%, PBC5%, and PBC10%.

The addition of tap water from the water supply once a week kept the humidity of the composting material at 60% to 70% during the composting process. The composts were mixed by overturning once per week. The decomposition of plant waste and the composting process were monitored for three months in laboratory conditions.

Table 1. Samples for composting process.

Mark	Composition
P	mixed plant waste (control)
PC5%	mixed plant waste + 5% *w*/*w* spent coffee grounds
PBC1%	mixed plant waste + 1% *w*/*w* spent coffee grounds + 2% *v*/*w* of inoculum
PBC5%	mixed plant waste + 5% *w*/*w* spent coffee grounds + 2% *v*/*w* of inoculum
PBC10%	mixed plant waste + 10% *w*/*w* spent coffee grounds + 2% *v*/*w* of inoculum

2.4. Sampling and Analysis

Eight samplings were made throughout the composting process, distributed on the 12th, 19th, 26th, 36th, 43rd, 57th, and 91st days, as well as at the beginning of the process (0 day). A sample was obtained from each container by mixing three subsamples taken from different representative spots of the composting material. Afterward, the results were manifested as mean values ± standard deviation of three independent replications and were statistically defined. Before conducting chemical tests, each of the samples was homogenized by grinding into 0.5–1.0 mm particles in a mill at 80 °C until reaching a consistent weight. The materials were again dried at 80 °C after being ground to a consistent weight. The chemical analysis's findings are shown per gram of dry weight of the item. In a muffle furnace, ash was measured by heating to 550 °C until it reached a constant weight.

2.4.1. Organic Matter Content

According to Tiquia and Tam (1998) [22], the organic matter (OM) of samples was determined as the difference between ash and dry weight and reported as a percentage.

2.4.2. pH Value

The samples were processed into extracts using solid/liquid extraction with distilled water (1:10 *w*/*v*) for the purpose of determining pH. After 4 h of extraction, the samples were centrifuged at 4500 rpm for 10 min, after which the supernatant was used for additional research. In an aqueous extract, pH values were determined using a digital pH meter [23].

2.4.3. Changes in CO_2 Release

The approach described by Iannotti et al. (1993) [24] was used for the determination of the CO_2 content. In brief, 2.5 g of dry compost sample were incubated for three days at room temperature, or 25 °C, in a tightly covered container with a test tube containing 2 mL of 1 M NaOH. The leftover NaOH solution was titrated with 1 M HCl after the incubation to determine the evolved CO_2.

2.4.4. Dehydrogenase Activity (DHA)

Dehydrogenase activity (DHA) was measured by reducing triphenyl tetrazolium chloride (TTC) to triphenyl formazan (TPF). This was carried out in accordance with the ISO 23753-1:2011 protocol [25]. Compost samples (5 g) were incubated in 5 mL of a TTC solution (5 g L^{-1} in 0.1 M Tris-HCl buffer, pH = 7.4) for 24 h at 30 °C. To extract TPF, the sample was then combined with 25 mL of acetone, agitated in the dark for two hours at 150 rpm, and then centrifuged for five minutes at 4500 rpm. Using a UV-Vis spectrometer set at 485 nm, the optical density of the extract was measured. The DHA activity was then computed using a standard curve made with TPF and expressed as μg TPF g^{-1} dry compost h^{-1}.

2.4.5. Total Carbon and Nitrogen

A moisture analyzer (MLS 65-3A, KERN & SOHN, Balingen, Germany) was used to automatically measure the moisture content of the source materials and the composting mixtures.

By digesting the samples with concentrated sulfuric acid (H_2SO_4) and a mixture of catalysts (100:1:1000 $CuSO_4 \times 5H_2O/Se/K_2SO_4$), the total nitrogen content (TNC) was calculated [26]. This method involves converting organic N to ammonium (NH^{4+}-N), which is then used to make other elements such as nitrogen (N) and phosphorus (P) into ammonium (NH^{4+}-N). After an alkaline steam distillation, the ammonium in the Kjeldahl digests was measured titrimetrically [27].

Dry ashing was performed in a muffle furnace at temperatures between 500 and 550 °C until reaching constant weight in order to determine the amount of organic carbon. By deducting the weight per cent of ash from the total net material weight before ashing and dividing, the amount of organic carbon was estimated.

2.4.6. Evaluation of Phytotoxicity

According to Qian et al. (2014) [28], the compost extract's seed-germination index (GI) was measured during phytotoxicity testing.

Water extracts of the samples were used to assess the germination of seeds. Fresh samples were diluted 1:10 (*w*/*v*) in distilled water and agitated for an hour at 150 rpm in an orbital shaker. The sterilized Whatman no. 1 filter paper was placed in a glass Petri dish with 3 mL of each extract as the setting solution and 3 mL of distilled water served as the control sample. The 25 seeds of *Fagopyrum esculentum* were used to calculate the germination index (GI):

$$GI\ (\%) = 100 \times G/Gc \times L/Lc \quad (1)$$

where G and L stand for the germination and root length of the samples, respectively, and Gc and Lc stand for the corresponding values for the control (distilled water).

2.5. Statistical Analysis

Statistical analysis was performed with the program Origin Pro 9 (OriginLab, Northampton, MA, USA), within the one-way analysis of variance (ANOVA), accomplished by the Tukey test of multiple comparison, with a significance level of $p < 0.05$. All results are presented as the mean values ± standard deviation of three independent measurements.

3. Results and Discussion

3.1. Monitoring of the Composting Process

The composting process of five examined compost samples (P, PC5%, PBC1%, PBC5%, and PBC10%; Table 1) was monitored within three months, where sampling was distributed in eight time intervals (12th, 19th, 26th, 36th, 43rd, 57th and 91st composting days). Thereby, the main chemical and biological data (dehydrogenase activity, CO_2 production, C/N ratio, pH variations, loss of organic matter, and phytotoxicity) have been obtained for evaluating the effect of SCG and PGPB addition on the quality and maturity of the compost made of mixed medicinal plant waste. In this study, the temperature of the compost material in all samples varied at the beginning of composting from 22–24 °C and at the end from 12–15 °C. The maximum temperature during the process was on the 26th day and was 60–62 °C in samples with bacteria and 55–57 °C in samples without bacteria. The higher temperature in the samples with bacteria was a consequence of the microbial action of the added bacterial inoculum.

3.1.1. Dehydrogenase Activity (DHA)

Dehydrogenase activity is a simple way to evaluate compost maturity and to measure the biological activity in compost [29]. The results of the DHA activity test showed that the activity of the microorganisms in the compost mixture fluctuates significantly throughout the composting process, which was also found to be influenced by the addition of both microbial inoculum (PGPB) and SCG (Figure 1).

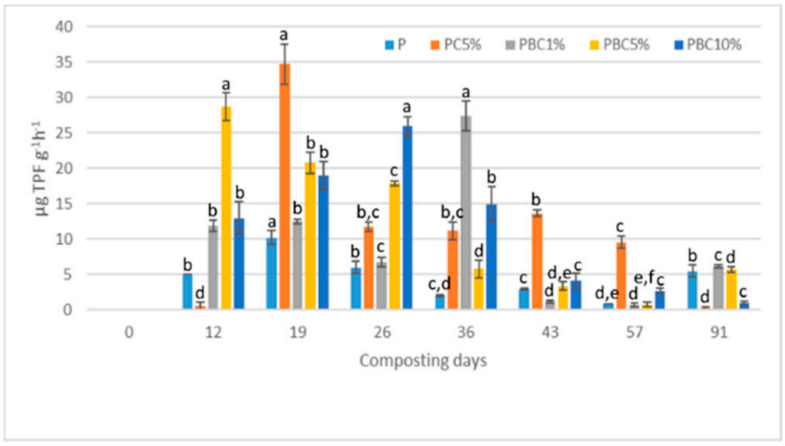

Figure 1. Changes of DHA activity of compost samples during the composting period (different letters within each sample individually per composting day indicate statistically significant difference ($p < 0.05$)).

The statistical analysis has been performed for each compost sample individually to observe the differences in DHA variations per composting days (during the composting process). The control sample P (without the addition of SCG and PGPB) evidently had lower values of DHA activity during the entire monitoring period of the composting process in comparison to other samples. A slight increase in DHA activity (up to 10.22 ± 0.95 μg g^{-1} h^{-1}) was evident only on the 19th day of the process, afterward, in all the rest of the measurements, the value ranged between 0.83 and 5.98 μg g^{-1} h^{-1}. These values indicated a very low level of microbial activity in the control sample. In all samples with addition of PGPB (PBC1%, PBC5%, and PBC10%), the value of DHA increased considerably immediately at the beginning of the composting process from the 12th day of sampling, indicating that the additional microorganisms are most active at the beginning of the process. Compared to the control without the influence of PGPB, the value of DHA was up to 5 times higher in the PBC5% sample (28.7 ± 1.95 μg g^{-1} h^{-1}). During the composting period, the sample containing SCG (PC5%) was mostly found to possess higher DHA in comparison to the control sample. However, the samples per se expressed a significant statistical difference with regard to the composting days. At the end of the monitored period, the lowest DHA activity was noted in the PC5% and PBC10% samples, which indicates the completion of the process and the weakening of microbial activity, being around five times lower than the other samples.

3.1.2. Changes in CO_2 Release

The content of the released carbon dioxide during the composting process indicates the intensity of microbiological activity. The bacterial inoculum has the efficiency to initiate and accelerate the composting process, where the mineralization of total organic matter in the plant waste, such as proteins, amino acids and peptides, is also accelerated.

Bacteria have the ability to hydrolyze a wide range of carbohydrates such as chitin, starch, and xylan [30]. *Paenibacillus chitinolyticus* CKS1 produces different types of cellulases (endoglucanases and exoglucanases), xylanases, chitinases, proteases, and β-amylases. Representatives of the genus *Bacillus*, *Paenibacillus* produce phytohormones auxin, gibberellin, cytokinin, abscisic acid, and ethylene, which play a major role in plant development [31].

Namely, many bacteria have the ability to produce a wide variety of secondary metabolites which can exhibit antimicrobial and antifungal effects against numerous plant pathogens. Antibiosis is one of the most common biocontrol mechanisms. Also, these strains have the ability to biologically fix nitrogen and dissolve phosphate [31].

Streptomyces strains are also known for their ability to produce extracellular enzymes and have chitinolytic, cellulolytic, and proteolytic activity.

During the aerobic composting process, a large fraction of carbon is consumed by microorganisms and is released as carbon dioxide. According to the results shown in Figure 2, it can be seen that in all samples the concentration of released CO_2 is increasing (above 0.2 mg CO_2 g^{-1} day^{-1}) during the first 19 days of composting, except for the control sample, where it was 0.095 ± 0.01 mg CO_2 g^{-1} day^{-1}

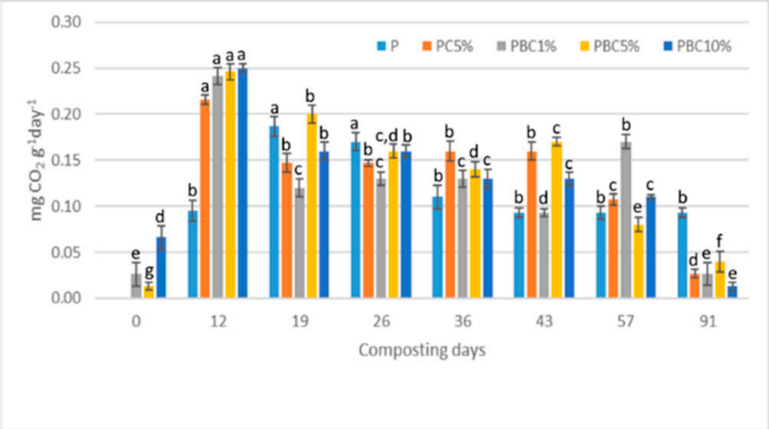

Figure 2. Changes of CO_2 release activity of the compost samples during the composting period (different letters within each sample individually per composting day indicate statistically significant difference ($p < 0.05$)).

This indicates an increase in the number, as well as the activity, of microorganisms in the samples. After that, the concentration of CO_2 was decreasing gradually, with certain statistically significant variations, until the end of the composting period, to the value below 0.04 mg CO_2 g^{-1} day^{-1} for all samples except for the control sample. This can be interpreted as the composting process being nearly finished or even completely finished in all samples where the PGPB was added, as well as in the sample with addition of SCG (PC5%). In contrast, in the control sample P, certain microbial activity can still be expected for the purpose of maturing of the compost mass.

3.1.3. Total Carbon and Nitrogen (C/N) Ratio

Medicinal plant waste is a substrate that generally decomposes more slowly with regard to other plant waste because it is high in cellulose, hemicellulose, and lignin, but low in total nitrogen content (TNC). Contrary to the medicinal plant waste (1.32 ± 0.24% of TNC), the TNC of SCG was almost twice as high (2.38 ± 0.17%), while the total carbon content (TCC) in the SCG was approximately 54.7%, which was close to the TCC of the control sample initially (50.25 ± 0.98%). During the composting period, all of the examined samples revealed a very similar trend, where TCC decreased rapidly while the TNC increased and, accordingly, the C/N ratio decreased (TCC and TNC sample values are presented in Supplementary Materials, while the sample's C/N ratio has been calculated from the relation of TCC and TNC mean values and is presented in Table 2).

Table 2. Changes in the main chemical parameters during the composting period: C/N ratio for the compost samples.

Composting Days	Sample				
	P	**PC5%**	**PBC1%**	**PBC5%**	**PBC10%**
0	38.07	34.56	37.71	34.92	33.16
26	20.56	19.45	20.34	19.77	20.87
57	17.50	16.08	16.72	17.08	16.64
91	14.92	14.59	14.77	14.34	13.36

The changes in the C/N ratios reflect compost stabilization [32] and this value is often used as a relative indicator of the compost maturity. Within this study, the sample's initial C/N ratio was in the range of 33–38, while the final C/N ratio reached values near 15, revealing their maturity. The results were in accordance with the literature reports; according to Hube et al. (2010) [32], lignocellulosic plant material typically has a C/N ratio of about 38, while the composts reached maturity when the C/N ratio of mature compost reaches values between 15 and 25 [33].

3.1.4. pH Value

The pH of the control material at the beginning of the composting process was about 5.5. The initial pH value of the samples is connected to the formation of organic acids in the initial stage of the composting process. After that, pH value increased each week until the 45th day of composting, when it reached the highest value of over 9.0 in all samples (Figure 3).

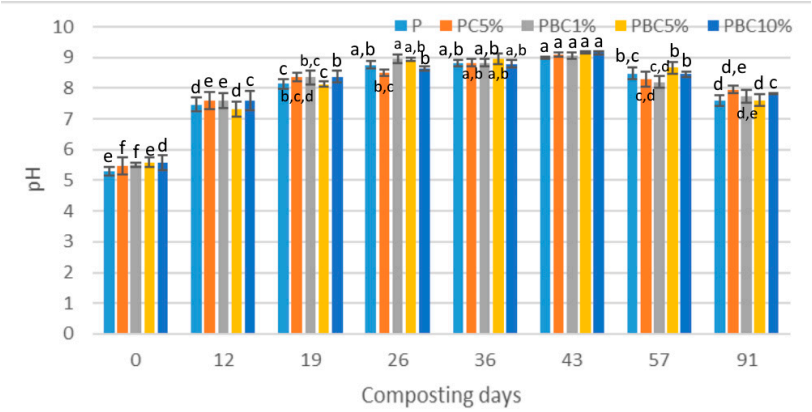

Figure 3. Changes of pH of the compost samples aqueous extract during the composting period (different letters within each sample individually per composting day indicate statistically significant difference ($p < 0.05$)).

Later, it slowly decreased until the end of the process, when it was around 7.5–8.0. In all samples with the addition of SCG, pH had a greater value at the end of the process than in the control sample. Although it is clear that the samples among each other possess close pH values in the observed composting days, statistical analysis revealed that the results of each sample per se showed a statistically significant difference at a significance level of 0.05, taking into consideration the middle of the process (especially the 43rd day), in relation to both the beginning and the end of the process. According to general observation, a pH value above 8.0 from the 19th to the 56th day of composting is considered to be the consequence of the liberation of ammonia and other alkaline compounds. Khan et al. (2009) [34] obtained similar results during the composting of green tea and rice bran.

3.1.5. Organic Matter (OM)

According to the obtained results, the content of organic matter in all samples is slowly decreasing during the composting process (Figure 4).

The initial content of organic matter in the composting mixtures was in the range of 85–89% and, after 91 days, it reached the lowest value of 73.41 ± 0.86% in the sample PC5%. The sample with the highest content of organic matter at the end of the process possessed PBC10% (78.66 ± 1.18%), probably due to the highest content of SCG. The results of statistical analysis revealed a similar trend as in the case of pH variations. The samples had similar OM content in the observed composting days. However, each sample per se

(with the exception of control sample P) showed a statistically significant difference, taking into account the beginning of the process in relation to the second half and, particularly, the end of the process.

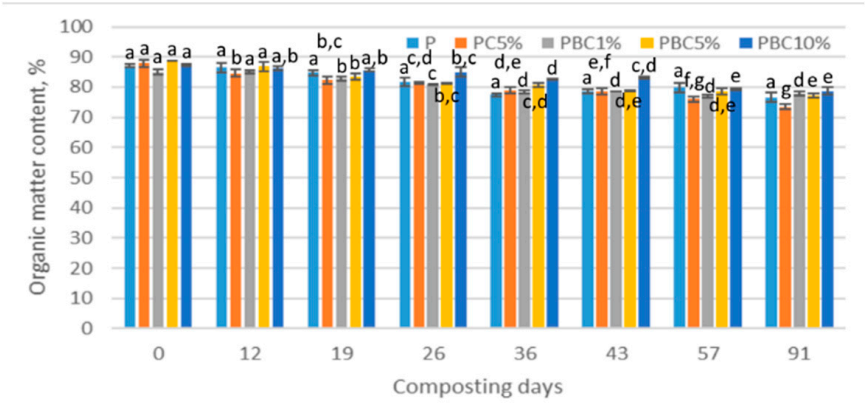

Figure 4. Changes of organic matter content of the compost samples during the composting period (different letters within each sample individually per composting day indicate statistically significant difference ($p < 0.05$)).

3.1.6. Phytotoxicity of Composting Material

The seed-germination test is a commonly used method to evaluate the stability and phytotoxicity of compost [35,36]. Within this study, the phytotoxicity of the compost was estimated based on the germination index (GI) of *Fagopyrum esculentum* seeds. The following ranges have been proposed to evaluate the phytotoxicity level: for GI < 25 the substrate is very phytotoxic, for 26 < GI < 65 the substrate is phytotoxic, and for 66 < GI < 100 the substrate is non-phytotoxic and can be used for agricultural purposes [31]. The results have shown that all samples had phytotoxic activity in the first 36 days of composting (Figure 5); however, the GI was higher in the samples that contained both SCG and PGPB, in comparison to the control sample. There was an exception for the PBC10% sample, where it had the lowest GI values on the 26th and 36th days, when its DHA activity values were the highest (particularly on the 26th day).

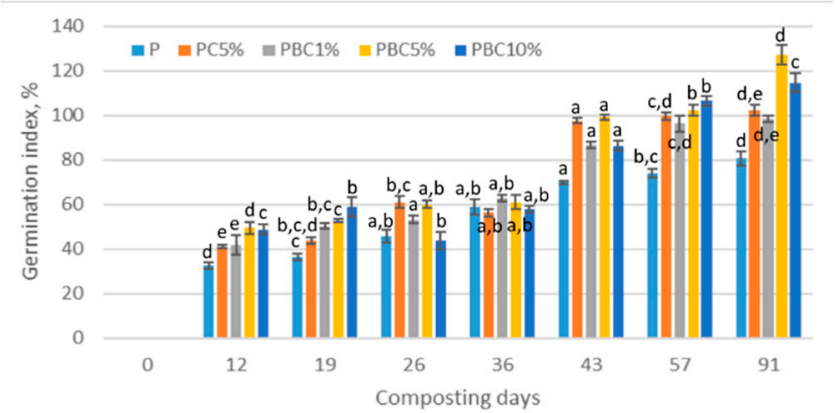

Figure 5. Evolution of germination index (GI) of *Fagopyrum esculentum* seed with regard to the compost samples during the composting period (different letters within each sample individually per composting day indicate statistically significant difference ($p < 0.05$)).

It can be explained that the high microbial activity of the present bacteria has accelerated composting and decomposition of plant material which has caused the release of phytotoxic matter and reduction in GI. Phytotoxicity and immaturity of compost are connected to the presence of organic acids, ethylene oxide, and ammonia, in the earlier stages of the composting process. Pergola et al. (2020) [37] and Sayara and Sánchez (2021) [38] indicated that the four main gases resulting from feedstock decomposition are CO_2, CH_4, N_2O, and NH_3. After the 43rd day, GI in all samples rose over 70% and showed the characteristic of being acceptable and safe compost. At the end of the process, on the 91st day, a biofertilizing effect was achieved in samples PBC5% (GI 127.2 ± 4.2%), PBC10% (GI 114.7 ± 4.3%), and PC5% (GI 102.2 ± 2.5%). When compared to the control compost sample, the germination index of the tested species had an average increase of 58% in sample PBC5%, and 42% in sample PBC10%. If GI > 101, the substrate is characterized as a phytonutrient and a phytostimulant and it can be efficiently used in agriculture as a fertilizer [31].

4. Conclusions

This study showed the composting process of waste derived from the industrial production and processing of more than 80 species of medicinal plants, whereby the addition of spent coffee grounds (SCG) as well as plant growth promoting bacteria (PGPB) were evaluated on the process speed and quality of the resulting compost.

In general, the obtained compost samples were found to be stable in all physical, chemical, and biological parameters. The addition of SCG affected the increase in the value of DHA activity, whereby the biofertilizing effect on the tested herbs was considerably greater in samples with the addition of both SCG and PGPB. Such an approach, the addition of waste SCG in combination with selected PGPB to medicinal plant waste during composting, which is in line with a strategy based on a circular economy, resulted in the production of compost as an innovative product that can be immediately used in agriculture as a high-quality organic fertilizer. It is expected that the application of such product should increase yields in the cultivation of medicinal plants.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su16041632/s1, Table S1: Total carbon content (%) of compost samples during the composting period; Table S2: Total nitrogen content (%) of compost samples during the composting period.

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