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Impact of Waste Coffee Residue Disposal on the Environment and Anti-microbic Activity of Oyster Shell Waste

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Abstract

The objective of this research paper is to discuss the waste coffee residue disposal and its environmental effects on the environment. As we know, coffee is one of the most demand and swallowed beverages in the world, which leads to large quantities of solid waste. Which can be toxic and a lot of environmental problems occur. In developing countries, there is a lack of proper coffee waste residue management. The coffee beans and residues contain several organic compounds. The wastewater from coffee industry emitted several pollutants (highly concentrated) and it contaminates the soil, ground waters, aquatic life, and also human health. Hence it is essential to treat the coffee waste residues. Mean while, oyster shell waste and its disposal also a big environmental challenge in the coastal regions of southeast Korea. In this paper, we focused the treatment of coffee waste residue with oyster shell waste powder. Primarily, oyster shells are calcinated at higher temperatures and investigated the calcined CaO powder as an anti microbic agent to the bacteria presented in coffee waste residues. We successfully applied calcium oxide from oyster shell waste, as an antimicrobic agent.

Key words : Coffee Waste, Calcium oxide, Oyster Shell Waste, Anti microbic activity.

1. Introduction

Coffee is one of the liquid refereshment which were used throughout the globe and the commercial importance was gradually increased during the last 150 years [1]. The word Coffee has originated from the Quahweh an Arabic word. During the 13th century, the roasted coffee has an effective stimulator and Arabs brought the coffee seeds from Ethiopia and established the first plantation in Yemen (Arabian Peninsula) [2]. In Ethiopia, the coffee was considered to be the original habitat of Arabica coffee and robusta coffee is cultivated in central Africa and it species cultivation throughout the world. Currently, Brazil is the largest producer and also exporter of coffee in the world.

The raw coffee powder is mixed with hot water, which releases some aroma compounds and other constituents of coffee beans into the liquid [3]. Its' chemical composition (Table 1), reveals a product rich in sugars, proteins, oil, lignin and polyphenols [4] components.

Coffee grounds contain organic compounds and which are highly pollutant. For the coffee grounds degradation, a larger quantity of oxygen required. There are several ways to coffee waste management other than disposal, first stock pile, then fermented, and under spontaneous combustion process [6-7].

Coffee industry emitted larger quantities of coffee byproducts which contains bioactive compounds like polyphenols, carbohydrates, pectins, and proteins. Which

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Table. 1. The composition of coffee waste ground [4-5].

Chemical composition	Content (wt %)	Chemical composition	Content (wt%)
Cellulose	8.6-13.3	Arabinose	1.7
Hemicellulose	30-40	Galactose	13.8
Proteins	6.7-13.6	Mannose	21.2
Oil	10-20	Ashes	1.6
Lignin	25-33	Organic matter	90.5
Polyphenols	2.5	Nitrogen	2.3
Caffeine	0.02	Carbon/nitrogen ratio	22/1

can be considered as low cost renewable resources [8]. In the near future, there could be a chance to grow coffee production, and need to be balanced with the proper utilization and coffee by-products industrial applications for nutraceuticals development. The major concern of this paper is during coffee processing lot of coffee by-products emitted the bioactive molecules. Coffee waste management is very significant to explore the integrated technologies for the sake of the environment and economy growth.

The effluents from coffee industry are being directly discharged. Which leads to the water contamination, soil contamination and thus causing many health problems like breathing problem, nausea, skin irritation, ear, eye, spinning sensation, and stomach pain etc.

Recently, In Korea, seafood consumption was increased. The waste oyster shells and shellfish cause' marine pollution and it became one of the most serious problems to the environment. Among the various waste shells of shellfish such as short-necked clam, clam mussel, and oyster etc, the most predominant waste is oyster shells. Almost more than 50～70 % oyster-shells waste was produced, most of them were discharged into nearby waters and recycled lands, causing a foul odor from the decomposition of left over flesh attached to the oysters [9-10].

This paper reveals that an effective approach for the treatment of waste coffee and oyster shell waste. This research investigation results represents an alternative approach to coffee waste management practices for waste coffee grounds and inhibits the bacterial growth by the treatment of oyster shell waste powder.

2. EXPERIMENTAL PROCEDURE

Coffee waste was collected from Deete espresso Coffee shop, Daejeon, South Korea, Oyster shell waste was collected from Namhae, South Korea, 3M Petri films were used for the measuring bacterial content by using sodium chloride (Junsei Company, Japan).

Coffee waste was stored at room temperature with different time durations. This aging coffee waste samples are divided into four groups such as fresh coffee waste, Three days after coffee waste, Five days after coffee waste and one week after coffee waste was used to analyze the total bacterial content and E-coli bacterial count by using 3M Petri films method.

The primary step of this research work is, pretreatment of oyster shell waste with water and alcohol for preventing the impurities hook up on the surfaces. This washed oyster shells was dried at room temperature and calcinated at 1000^{o}C for 2h duration time. The calcinated raw materials were grinded mechanically for 1 h until the particle size was below 100μm. Finally, this fine powder was used as an antimicrobial agent to treat different aging

coffee waste samples.

Oyster shell fine powder (2 wt%) was used to treat the coffee waste samples. In this process, i) raw oyster shells are calcinated at 1000 ^{o}C/2h and after grinding sample was sieving with 100μm mess and collected fine powder, ii) Collected fine calcinated oyster powder was characterized using X-ray Fluorescence spectroscopic (XRF), X-ray diffraction (XRD), iii) these oyster powder was used to treat the different aging coffee waste samples and measure the bacterial content.

The number of bacteria per gram or mL of product was estimated by Bacterial counting by Aerobic Colony Count (ACC) method. Some portion of the product is mixed with an agar medium and incubated under specific optimum conditions of temperature and time. By maintaining the specific conditions, each bacterium will multiply and give rise to a visible colony which can be counted.

In this process, the 5g of coffee waste was transferred to 45 ml of 0.85% NaCl diluents. The density of the product must be known if the transfer is based on weight. Homogenize the dilutions and spread 100 μl of dilutions in duplicate on the surface of the agar coated 3M Petri film. Use the 10^{-1}, 10^{-2} and 10^{-3} dilutions for the bacterial challenges. For subsequent sampling select the dilutions to be analyzed on the basis of the results. In this experiment we measured different aging coffee wastes and treated with oyster shells powder (before and after calcination), to analyze the total number of bacteria also E-Coli bacterial counting present in the samples.

3. RESULTS AND DISCUSSION

In this experimental process, we measure the chemical composition of oyster shells by XRF and characterized by XRD for oyster shells before & after calcination and also used as an antimicrobial agent for coffee wastes treatment.

3.1. Oyster shells characterization by XRF and XRD

Oyster shells major composition is $CaCO_3$ are present, remaining other impurities, are shown by XRF results as shows in Table 2, presents the chemical composition of oyster shells, it consists of CaO (53.66 %) and the Ignition loss (44.56 %) from the decomposition of $CaCO_3$ to release CO_2 gas. Which is more near and comparable to the commercial limestone grade published by Yoon et al. [11], and also CaO content (53.7 wt.%) in the oyster shells [12], and some of the other impurities such as SiO_2 (0.45%), Al_2O_3 (0.12%), Fe_2O_3 (0.06%) MgO (0.26%), K_2O (0.06%), Na_2O (0.55%), P_2O_5 (0.16%) are present.

We investigated the X-ray diffraction analysis of waste raw oyster shells material and calcined waste oyster shells. The XRD analysis results showed oyster shells raw material had $CaCO_3$ as major phases (98.2 %), calcined oyster shells waste contains lime (CaO) (93.46%), at 1000^{o}C calcination. These results indicated that the calcination process to produce pure lime (CaO), and it effectively inhibits the bacterial growth.

3.2. Antimicrobial property of calcinated oyster shell CaO treatment with coffee waste

The different types of coffee waste like aging times such as fresh coffee waste, Three days after coffee waste, Five days after coffee waste and one week after coffee waste was used to analysis the total and E-coli bacterial and treatment with 2wt% of calcinated oyster CaO samples was measured. The results are clearly indicated in Fig. 1 and 2. Total and E-Coli bacteria present in the samples, these results are clearly shown from aging coffee waste up

Table. 2. XRF analysis of oyster shells.

Oxides	CaO	SiO_2	Al_2O_3	Fe_2O_3	MgO	K_2O	Na_2O	P_2O_5	Ig Loss
Oyster (%)	**53.66**	**0.45**	**0.12**	**0.06**	**0.26**	**0.06**	**0.55**	**0.16**	**44.56**

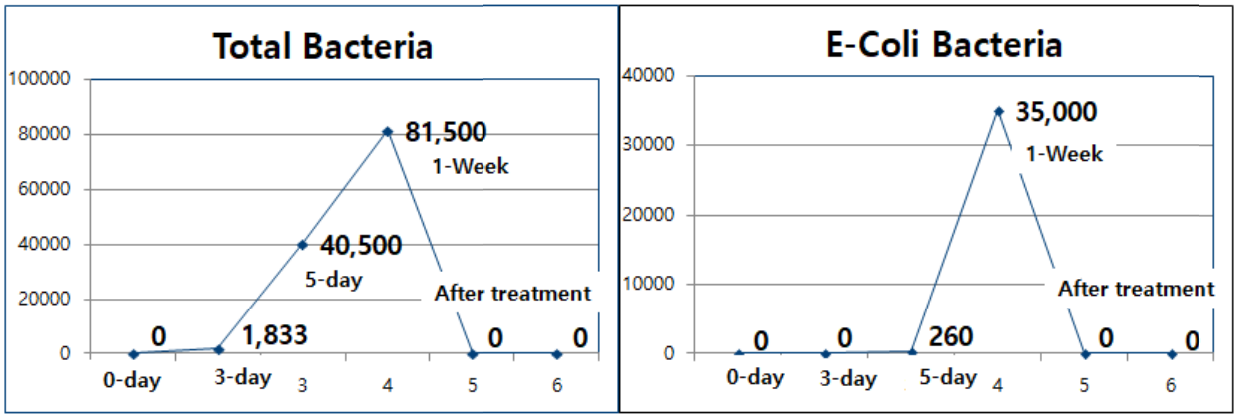

Fig. 1. Total bacteria & E-Coli bacteria present in different aging coffee waste before and after treatment with oyster shell CaO.

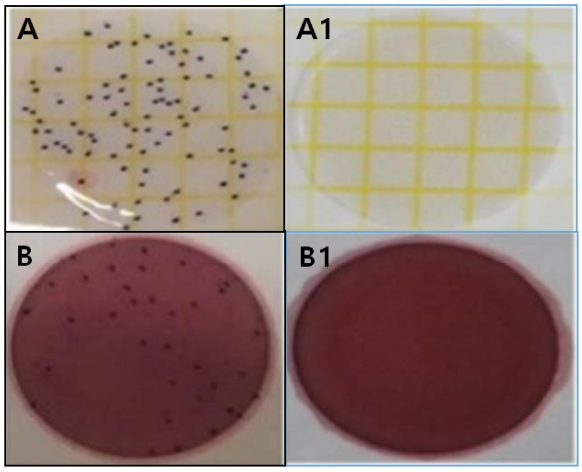

Fig. 2. (A) Total bacteria in coffee waste, (A1) After oyster CaO treatment total bacteria, (B) Total E-Coli Bacteria in Coffee waste and (B1) Total E-Coli in coffee waste after treatment with oyster shell CaO.

to one week duration the total and E-Coli bacteria was gradually increased and after treatment with oyster shell CaO all bacteria were killed due to the anti-microbial activity of CaO from oyster shells.

4. Conclusions

These studies revealed that the calcium carbonate ($CaCO_3$) from oyster shell waste is not a waste material and also it's most beneficial to treat the coffee waste effluents. The present investigations reveal that a waste product of oyster shells has good antibacterial property to treat the coffee waste effluents and it can be effective to control the bacteria in coffee wastewaters. Calcinated oyster shell CaO was reacting with bacterial membrane and prevent the bacterial activity. This coffee waste treatment process is simple with the economic and eco-friendly process and it provides a beneficial and value added products and as well as oyster shell recycling process is beneficial to reduce the environmental effect in coastal regions. The extracted calcium carbonate used as an advanced functional filler to waste water treatment, fertilizer, pathogens removal, coffee waste treatment, water content and simultaneously can use for lightweight plastics.

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