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Impact of Some Methods on the Production of Organic Fertilizer from Keratin-Based Biomass: A Review

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Abstract: Nowadays, the utilization of synthetic fertilizer has significant adverse effects on the soil, ecosystem, and human health. To evade the use of synthetic fertilizers, the production of organic fertilizer from organic matter particularly from keratin-based materials, has become more popular as a way to solve the problems related to soil conditioning and human health. In addition, the impact of different methods on the extraction of organic fertilizer from keratin-based materials is discussed. Hence, the review was conducted to assess the effect of different methods like acid hydrolysis, base hydrolysis, and hydrothermal treatment on organic fertilizer extraction from keratin materials. Therefore, this revised seminar currently, as it deters the environmental pollution caused by chemical hydrolysis and hydrothermal treatment, the microbial fermentation by immobilized cell for organic fertilizer production is essential to enhancing a green environment and avoiding the risks related to human health.

Keywords: Fertilizer, Microbial Fermentation, Hydrolysis, Synthetic

1. Introduction

According to [1] reports, fertilizer is a material that adds one more nutrient to the soil in order to support the physical and chemical characteristics of the soil or to increase the amount of nutrients available to crop plants. This can be done by either directly or indirectly enhancing plant growth, yield, or products. Fertilizers are categorized as organic or inorganic based on the origin and nature of their chemical compounds [2]. Also referred to as mineral or chemical fertilizers, inorganic fertilizers are made from nonrenewable resources like coal and natural and rock minerals [3]. On the other hand, mineral salts included in inorganic fertilizer acidify the soil to keep microbes away and prevent them from finding a food supply Fertilizer is a substance that contains one more nutrient for the nutrition of crop plants to progress the level of available plant nutrients or to sustain the physical and chemical properties of the soil, by directly or indirectly improving plant growth, yield, and products [1]. Depending on the chemical compound composition and origin, the fertilizer is classified as organic and inorganic fertilizer. Inorganic fertilizers are produced from nonrenewable resources such as coal, and natural and rock minerals, and are also known as mineral or chemical fertilizers [3]. However, inorganic fertilizer contains mineral salts that acidify the soil to repel and do not deliver a food source for microorganisms. The habit of Chemical fertilizers has greatly affected the environment, and health of people [4]. Organic fertilizer, which is made up of various waste materials and by-products such animal manure, municipal soil, waste compost, and sewage sludge, is currently utilized in agricultural and crop production to reduce the need of chemical fertilizer [5]. Because they contain a high concentration of organic matter [6], organic fertilizers improve the physical, chemical, and biological conditions of soil to promote soil health [7]. Organic fertilizers are derived from organic material [6]. Additionally, sulfur-containing amino acids—which are abundant in keratin materiaare used to make organic fertilizers [8, 9]. One of the most prevalent biopolymers, keratin serves as the outer layer of both human and animal organs to reduce fluid loss [4]. To minimize the use of chemical fertilizer, organic fertilizer which is comprised of several waste materials and by-products such as animal manure, municipal soil, waste compost, and sewage sludge is presently being used in agriculture and crop production [5]. Organic fertilizers are derived from organic material, and enhance the physical, chemical, and biological condition of soil to improve soil health because they contain a high amount of organic matter [7].

Organic fertilizers are also produced from sulfur-containing amino acids which are highly available in keratin material [8]. Keratin is one of the most abundant biopolymers that helps as an outer coat of human and animal organs, to minimize the loss of body fluids. According to [10], and it is mostly present in the tissues of mammals, birds, amphibians, and reptiles.

Keratins are categorized α-keratin and β-keratin, encompass a great number of disulfide bonds, hydrogen bonds, and hydrophobic interactions, which are problematic to degrade [11]. Mammal hair, wool, horns, nails, claws, and hooves are common places to find alpha keratin, or soft keratin, whereas bird feathers, beaks, and claws are common places to find hard (-keratin) [12, 13]. Many researchers have sought to turn these waste materials into useful and sustainable goods in order to stop the environment and human health from suffering grave consequences. Using various hydrolysis techniques, including hydrothermal and chemical hydrolysis (acid and base) [14-18], waste keratin is recovered and used to create environmentally friendly products for medical usage, tissue engineering, organic fertilizer, biomaterials, drug permeation, bio composite, Nano fibers, and bio plastic.

Additionally, sulfur amino acids were used to create organic fertilizer, which aided in the development of plant growth [19, 20]. Although they can be prepared by plants from the soil, this requires a lot of energy. Thus, plants can boost their development and conserve energy through the ingestion of amino acids [4].

Table 1. *Types of amino acids and their function on plant growth* [4].

Function in plant growth	Amino acid
Anti-stress agent Chelating	Proline
Chelating agent	Cystine, Glutamic acid, Glycine, Histidine, Lysine
Cold weather resistance	Alanine, Arginine
Development of plants and improvement of pollen fertility	Proline
Growth stimulator	Glutamic acid
Precursor of auxin Precursor	Serine, Tryptophan, Valine
Precursor of chlorophyll	Glycine
Precursor of polyamines: necessary to start the cell division	Arginine
Precursor to the formation of lignin and woody tissues	Phenylalanine
Regulation of the water balance	Proline, Serine
Reserve nitrogen for the synthesis of amino acids and proteins	Glutamic acid
Stimulation of the chlorophyll synthesis	Alanine, Lysine, Serine
Stimulation of the ethylene synthesis Stimulation	Methionine
Stimulation of the germination	Aspartic acid, Glutamic Methionine acid, Lysine,
Stimulation of the hormone metabolism	Alanine
Stimulation of the resistance mechanism to viruses	Alanine

2. Objective

To review the production methods of organic fertilizer from keratin waste biomass.

3. Literature Review

3.1. Alkali Hydrolysis

Currently, agricultural practices use protein hydrolysate fertilizers as an alternative to chemical fertilizers. Different protein waste materials and by-products, including animal hair, bristles, horns, feathers, hoof kinds of blood, and human hair, are used to make the protein of hydrolysate fertilizers. Barbershop waste, which includes human hair waste, is disposed of at waste sites, landfilled, and composted with other municipal solid wastes. A lengthy chain of amino acids that could be used as a source of nitrogen makes up between 65% and 95% of the weight of hair, with up to 17% of that weight being included inside the complicated structure. However, because of its rich composition, human hair is an organic resource that has been employed as a nutrition source and soil amendment and nutrition supply because of its high nitrogen and other element content [4].

The other study was carried out by using the alkali hydrolysis method in order to convert tannery hair waste into liquid fertilizer by alkali hydrolysis offers an opportunity to handle waste eco-friendly and viable economically.

Potassium hydroxide and tetramethylammonium hydroxide in water were used to form concentrations of different solution for hydrolysis of hair. The composition of collected human hair was analyzed by using an elemental analyzer. Finally, the hair sample contains 46.3% carbon, 6.7% hydrogen, 14.8% nitrogen, and 3.1% Sulphur. The potential of the two solvents was explored. Tetramethylammonium hydroxide denotes the total nitrogen gratified by the liquid fertilizer. The time used to achieve hydrolysis is not directly proportional to the concentration of the solution. For 10% KOH and 10% TMAH, the solution ends up at 1 and 1.5 hrs. Respectively. The densities of the produced fertilizer solutions were 2097 and a748kg/m^3 for KOH and TMAH respectively and the PH value of the final fertilizer was between 7.5 and 8 [21].

3.2. Hydrothermal Treatment

Feathers contain renewable sources of N up to 15%, which means they are a good source of plant nutrition. It is composed of greater than 90% keratin, a fibrous and structural protein that has a high degree of cross-linking of the polypeptide chain caused by disulfide bonds that causes keratin unsolvable and not degradable by most proteolytic enzymes [16]. The chicken feather wastes were collected and converted to liquid fertilizer at the hydrothermal temperature of (140 – 200) °C and pressure of (0.36 – 1.53) MPa. The studies were carried out to examine the effect of hydrothermal treatment on feather solubilization rate, total organic carbon, and total nitrogen. The chicken feather was collected, washed, and dried at an ambient temperature o at75°C for 3 days. The effect of reaction temperature on solubilization and liquid product composition was determined at (140 – 200) °C with 30min. The water desorption process at 40°C-160°C and degradation of chicken feather fertilizer at 220°C – 250°C were analyzed by using a differential scanning calorimeter. The hydrolysis of biomass by hydrothermal treatment expresses lower activation energy than the decomposition reaction under inert conditions.

3.3. Acid Hydrolysis

The main aim of this study was to extract amino acids from human waste for natural fertilizer by using the acid hydrolysis method. Waste human hair was collected and washed by using distilled water. The washed hair was dried and dissolved in 0.05 N HCl in the beaker and mixed by using a manual string for 15 minutes. After 15 min, 0.1N NaOH was added drop wise and the solid residues were washed with 20ml of distilled water, and the washing residue was dissolved in 20ml of ethanol and heated for 10min, the existence of amino acids in the residue was tested after drying it. Finally, the presence of various amino acids that were used for plant growth was detected depending on the colour that they were indicated in the different solutions of the amino acid test [18].

The studies of [22], also declare that with the valuation of the environmental guard and the large cost of discarding and as well as the anticipation of the byproduct of valuable organic materials, it is essential to progress effective waste management that is not unsafe for the environment and economically feasible. The study was carried out by the acid hydrolysis method. The chicken feathers were washed by deionized water and hydrolyzed by 30% of sulphuric acid. The pH value of the hydrolysate fertilizer was adjusted by magnesium oxide, potassium sulfate, and urea. The amino acid composition in the hydrolysate of keratin gained from digestion feather chromatographic analysis was carried out. In pot experiments, the mass of fresh and dry plants was performed and the examination of macro-and micronutrients in the biomass was achieved. Furthermore, the nitrogen content in the plants was evaluated by the colorimetric method after mineralization in sulphuric acid. As a result of performing hydrolysis of a waste feather by 30% of sulphuric acid was contained, which was the base of the fertilizer, which contained numerous amounts of amino acids that include: - proline, serine, glycine, leucine, glutamic acid, aspartic acid, valine and arginine [22].

4. Conclusion

Thanks to researchers as they study the valuable conversion of this waste keratin-based material into Eco friend products to sustain a green environment. However, no one has answered the problem related to the methodology of keratin extraction from waste biomass for organic fertilizer production. All methodologies that they followed to prepare the fertilizer were not eco-friendly for the environment, and there was a loss of amino acids used for the nutritional value of the plant. In the case of using alkali, the hydrolysis process causes an emission of certain gases like CO and SO_2 into the environment, which is responsible for causing cancer and various respiratory diseases. Although certain amino acids like arginine, serine, threonine, and cysteine are lost in the process, and the product obtained will have low nutritional value due to essential amounts of amino acids being lost. Additionally, during the preparation of fertilizer by acid hydrolysis, there is an emission of certain gases CO and SO_2 into the environment that causes severe diseases and loss of amino acids such as tryptophan. Furthermore, hydrothermal hydrolysis requires thermal energy, large pressure, and temperature to eliminate keratinous biomass and harsh environment, as the operating temperature increases, certain amino acid which is used for plant nutrients are destroyed. Nowadays, to evade the use of chemical fertilizers in agriculture production, different scholars have tried work on the production of non-chemical fertilizers known as organic fertilizers from different keratin waste materials by using different degradation methods such as alkali, acid, and hydrothermal methods. However, using those methods will causes serious injuries to the environment and to human health, as well as the nutritional value of the plant can be reduced due to the loss of certain amino acids during hydr olysis. To overcome the problem that comes from those methods, it is better to use the green eco-friendly method, like microbial fermentation by immobilized cell methods. Microbial fermentation by immobilized cell is eco-friendly and safe as it has no impact on nutrient loss human health, and environments, and can increase the protein in the hydrolysate product.

Conflicts of Interest

The authors have not declared any conflict of interest.

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