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Introduction

Nowadays, synthetic chemicals are used in most farming practices. For the environment and society, it has steadily acted as a "slow poison." Both industrialized and developing countries have about 3 million people who suffer from "acute pesticide poisoning," and 10-20,000 people die from it each year, according to the United Nations Environment Programme (UNEP) and the World Health Organization (WHO) (Sinha *et al*., 2011). Farmers and policymakers in India face tremendous challenges as a result of the enormous volumes of agricultural waste that are created after harvest. The incorrect disposal of these crop wastes has a substantial impact on both human and animal health as well as climate change, environmental pollution, and the emission of greenhouse gases (Sadh *et al*., 2018 and Bharathiraja *et al*., 2017).

Our air, land and water are polluted due to the farmers improper use of excessive quantities of pesticides and lack of adherence to proper safety procedures while applying pesticides. This has resulted in various human health diseases. Organic farming is a long-established method of production. Using organic fertilizers is a crucial component of organic farming. Since the majority of prehistoric civilizations began cultivating crops, organic farming approaches have been used. In 1940, Lord Northbourne coined the phrase "organic agriculture" by relying on natural cycles, ecological processes, biodiversity, and flexibility to the varied agro-climatic conditions of the regions, the organic production approach protects the health of the environment, people, and soil rather than requiring chemical inputs with adverse impacts (Archana, 2013).

350 million tonnes of agricultural waste are produced in India each year. There are around 44,926 farms in India that are classified as organic farms. About 0.3% of all agricultural land consists of them. The organic agricultural market in India mostly consists of exports, with a total market value of around 78 million dollars. A nodal organization (APEDA), which supports organic farming in India, reports that 585,970 tonnes of organic products are exported from the nation. Over the past two years, the certified area has increased by more than 200% as a result of expanding institutional support and market demand (Ramesh *et al*., 2010).

The agro-industry creates significant volumes of garbage with a different range of characteristics. The global production of agricultural waste exceeds 2 billion tonnes. In many nations, improper treatment of these substances has detrimental environmental and economic impacts. These solutions must successfully convert wastes into value-added by-products while maintaining reasonable treatment costs before taking into account the influence on the productivity and condition of the land. Agroindustrial wastes have improved resource efficiency, sustainable production, and safe disposal (Singh *et al.,* 2021).

` India with diverse agro-climatic conditions allows the cultivation of a variety of organic products. Agriculture, although the primary business in India, harms the environment because of the vast quantities of chemical fertilizers and pesticides needed to improve crop yields. Nitrogenous fertilizers shouldn't be applied consistently since they reduce soil fertility, crop productivity and increases the cost of fertilizer compared to organic fertilizers (Amanullah and Khalid, 2020).

Organically cultivated edible foods are regarded as being more wholesome and secure than nonorganic food products. Artificial fertilizers and pesticides are not used to cultivate these foods. The demand for organic foods has been overtaken by the public's preference for consuming nutritious meals and engaging in ecologically friendly activities (Mastura *et al*., 2017). The application of organic manures immediately helps plant development and improves the physico-chemical properties of the soil since they are the source of all necessary macro and micronutrients in forms that are available during mineralization (Ganiger *et al*., 2012).

The biological process of composting involves the sanitary transformation of organic wastes into a homogenous and plant-available material under aerobic circumstances (the presence of oxygen), with appropriate moisture and temperature. In the presence of oxygen, nitrogen (N), and carbon throughout the composting process, diverse microbes carried out intricate metabolic activities to build their microbial biomass (C). Based on the fluctuations in temperature, three primary stages of composting, together with a maturation stage, have been identified in this process i) Mesophilic phase (Moderate-temperature phase) ii) Thermophilic (high-temperature phase) iii) Cooling and Maturation phase.

The Mesophilic phase, which normally lasts for a short while, causes the temperature to rise to 40–45°C due to the microbes' metabolic activities. The temperature then climbs to

the more active "hot" thermophilic stage, which typically lasts a few weeks and reaches over 45 °C. The longest stage is the cooling and maturation stage, during which the temperature drops to 40–45^{o}C as activity slows and the composting ingredients mature. An abundant substance resembling humus is produced through the controlled aerobic bio-degradation of organic materials, known as "biocomposting." It utilizes a mixture of degraded organic material that it offers to enhance soil structure and transmit nutrients.

The processing of cocoa and jackfruit generates enormous amounts of waste, including inedible portions like shells and peel (Plate-1&2). Cocoa shells are typically utilized as organic mulch, but they are hazardous to pets, while jackfruit peel is used as animal feed. However, very few researchers have examined the prospect of using bioconversion to transform these wastes into environmentally benign value-added products. Both of these wastes are harming the ecosystem as a result.

Cocoa is a large agricultural product and a lucrative commodity that has a considerable impact on global economic growth. It is a member of the Malvaceae family. Cocoa beans are the primary raw material for the more than $47 billion in food exports that take place annually. The cocoa fruit consists of around 80% left as residual biomass (Pod husks and shells), on the farm. Farmers usually throw away these byproducts and leftovers during the first phases of processing cocoa beans, taking up a lot of space and creating social and environmental problems (Vasquez *et al.,* 2019). Industrial cocoa planting started in the region of India around 1970. This crop is frequently grown in India's gardens alongside coconut and areca nut trees (Praveena *et al*., 2018).

Cocoa is now a vital component of the food, cosmetics, and pharmaceutical sectors. India’s top four cocoa-producing states are Andhra Pradesh, Tamil Nadu, Kerala, and Karnataka. Kerala secured second position with a production of 10,904 tonnes, behind Andhra Pradesh in terms of overall output. The majority of the cocoa grown in the Idukki district produces 40% of cocoa production in Kerala followed by Wayanad and Kannur districts. Every year, the environment and the health of agricultural workers are put at risk by the wasted cocoa shells generated by the chocolate industry.

As a result, recycling waste reduces the harm it does to an ecosystem. Cocoa shells may be used to provide substrates for the growth of plants when combined with other organic materials. Hence, cocoa shells might be used to create soil amendment materials since they

operate as biofertilizers that increase soil fertility and crop productivity (Kuppusamy, 2017 and Sadasivuni *et al.,* 2015).

PLATE -1

Cocoa Tree and Cocoa Shell Waste

In India, jackfruit is popular and extremely remunerative fruit. Kerala, Assam, West Bengal, Chattisgarh, Madhya Pradesh, Tamil Nadu, Tripura, and Karnataka are the top 10 producers in India (Sundarraj and Ranganathan, 2018). In India, jackfruit trees are cultivated on around 1, 02,552 hectares, with an estimated 1.0 million of those trees being planted in backyards (Apaari, 2012).

Indian agriculture has long been primarily reliant on jackfruit, which is said to have originated in India. Jackfruit Peel disposal is not carried out methodically, which is harmful to the environment. However, efficient by-product utilization increases economic value and also reduces disposal expenses. Jackfruit peel is said to contain significant amounts of cellulose, pectin, protein, and carbohydrate. Additionally, Bangladesh, Malaysia, and Indonesia engage in commercial jackfruit cultivation (Sundarraj and Ranganathan, 2017). Jack fruit trees are most commonly seen in every household in Kerala.

Jackfruit, a well-known but underutilized fruit crop, belongs to the moraceae family. India is one of the major producers of fruit, producing 1400 tonnes yearly. Jackfruit is a tropical and subtropical fruit that is native to India and is popular across these regions. Eastern and southern India refer to it as "the poor man's fruit." Between 3000 and 6000 years

ago, it is believed to have started in the Western Ghats jungle of India (Maurya, 2017). When these wastes are managed incorrectly, it causes contamination of the water and air, a rise in pests and diseases, and other environmental problems. Due to the high concentrations of chemical constituents such as lignin, cellulose, hemicellulose, pectin, and calcium, waste from cocoa shells and jack fruit peel does not easily degrade.

PLATE - 2

Jack Fruit Tree and Jack Fruit Peel Waste

Composting is a crucial tactic for the management of organic wastes to produce high-quality refined products with a healthier microbial ecology. Different fungi and bacteria including mushrooms are used for the breakdown of agricultural wastes. More than other microorganisms, mushrooms can decompose organic matter. A favorable environment for the mushroom spawn to prevail is provided by composting (Karpagavalli *et al.*, 2020).

Organic compost not only provides nutrients to the soil but also enhances soil structure, microbial activity, water-holding capacity and carbon sequestration. Pit composting is the biological, aerobic transformation of an organic residue into a new organic product that may be added to the soil without harming crop development. Pit compost creates natural fertilizer while improving the physical, chemical, and biological properties of the soil. These

composts significantly increase the plant's ability to absorb nutrients, provide all elements in forms that are easily accessed, and improve the growth and yield of many field crops.

Oyster mushrooms, also known as *Pleurotus* species, belong to the family of higher fleshy fungi called Basidiomycetes. The cultivation of saprophytic edible mushrooms, which is currently the most economically viable biotechnology for recycling lignocellulose organic waste, maybe the only way to provide protein-rich food while minimizing environmental pollution. The fungus produced a substance resembling humus produced through the controlled aerobic bio-degradation of organic materials (biocomposting). It utilizes the combination of degraded organic material that enhances soil structure and transmits nutrients. *Pleurotus* efficiently breaks down lignin and may grow on a variety of lignocellulosic substrates. *Pleurotus* species vary in their ability to tolerate a wide range of temperatures, making them ideal for year-round cultivation in tropical countries like India (Ahmed *et al*., 2009).

A direct fertilization-based ecological evaluation is conducted on the adaptable type of anatomically sophisticated earthworms known as *Eudrilus eugeniae* (Kinberg). It is a species native to the soils of the tropical West African savannah, and it prospers on substances with high organic content. It has a brief life cycle, emerging from the cocoon after just around 47 days (Blakemore, 2015). Vermicomposting is a type of microbial composting in which complex organic materials are bio-oxidized and transformed into a stable end product. The robust gizzard of an earthworm acts as a crusher as it consumes organic trash. Vermicompost progressively enhances the soil physical, chemical, and biological qualities as the natural fertility of the soil is restored. Due to their high nutrient content and relatively delayed rate of nutrient release into the soil, organic fertilizers enhance the physical, biological, and quality of the soil as well as the plants (Khan and Ishaq, 2011). Vermicomposting and mixed composting with microorganisms and earthworms are efficient methods for biodegrading. While combined composting also eliminates the indicator pathogens from the finished compost, vermicomposting alone simply reduces the pathogen population (Mupondi *et al.*, 2010).

This study was conducted in accordance with this concept and utilized the biodegrading agents *Pleurotus eous* (APK 1), *Pleurotus florida* and *Eudrilus eugeniae* (Kinberg) for the decomposition of cocoa shell and jack fruit peel wastes.

This study was conducted to produce biocompost from the waste cocoa shell and jack fruit peels as well as to characterize and analyze their effects on the following four test crops.

1. *Vigna unguiculata* (L.) Walp. (Var.Co (CP) 7)

2. *Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdc. (Var. NS-621)

3. *Clitoria ternatea* L.

4. *Amaranthus tricolor* L. (Var. Arun)

India produces majority of pulses in the world, with 25.70% of the total output (Chauhan *et al*., 2016). Pulses are amazing gifts from nature because of their deep root system, biological soil changes, the ability to access insoluble soil nutrients and biological nitrogen fixation capacity that make them renowned as soil nutrient conservators (Kumar *et al*., 2019). In regular meals, pulses provide a source of additional protein to daily meals that are mostly comprised of cereal and starchy carbs for a population that is primarily vegetarian and for persons who cannot afford pricy animal protein. They also include vitamins, essential minerals, nutrients, and some other elements regarded to be beneficial for health. Both in undeveloped and developing countries, pulses are in high demand because they provide the basic protein requirements of a growing population adopting a better lifestyle (Pankaj and Dewangan, 2017).

Vigna unguiculata (L.) Walp. is a member of the family fabaceae and is commonly known as cowpea (Plate-3). Strong roots sustain this annual herbaceous legume, which can be upright, creeping, or climbing depending on the variety. The trifoliate leaves have leaflets that are round, long, and wide. White, yellowish, pale blue, or violet flower clusters can be seen in the axillary clusters. Pods are often pendulous but can stand upright. They are spherical, long, and wide. White, pink, brown, and black seeds could be present. It is indigenous to Africa and is extensively farmed all over the world, mainly in Nigeria, India, Central America, China, and Africa. Cowpea is a vital component of Indian agriculture, and both the seeds and leaves, which are edible, provide significant amounts of plant proteins and vitamins to both people and animals.

PLATE -3

***Vigna unguiculata* (L.) Walp. Var. Co (CP) 7 (Habit)**

Vigna unguiculata (L.) Walp a crucial summer pulse crop, it is used for grain, fodder and green manuring. Because of the crop's vigorous vegetative growth and extensive ground coverage, it minimizes soil degradation in difficult locations and may then be plowed under to produce green manure. It is very promising as a replacement for pulse crops.

Vigna unguiculata subsp. *sesquipedalis* (L.) Verdc (Plate - 4) is one of the preferred and well-known types of cowpea and is commonly known as yardlong bean, belongs to the family Fabaceae. The perennial climber plant's stem has a thin rib and a twining growth form. The trifoliate leaves are arranged alternately along the stem, with the terminal leaflet having an oval shape and symmetry, as opposed to the first two leaflets having an asymmetrical shape. On axillary racemes, the flowers are blue, white, or yellowish. The fruit is a hanging pod that is elongated, pale green, and impressively long. When it is young, the pod is inflated and succulent, and as it ages, it becomes dry and constrained. The ancient vernaculars Achingapayar, Kurutholapayar, Vallipayar, Pathinettumaniyan, Asparagus bean, and Chinese long bean. Yardlong beans are a staple vegetable that grows in Kerala. It is both affordable and widely available as a source of plant protein. It makes the soil more fertile by storing

nitrogen in the atmosphere. Due to its propensity for rapid development, tropical marginal soils require it as a crucial part of sustainable agriculture (Varghese and Celine, 2015).

PLATE - 4

***Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdc. Var. NS-621 (Habit)**

The world greatest producer of medicinal plants is India, sometimes known as the "botanical garden of the globe. Over 3000 plant species have been officially recognized as having medicinal value in India. There are several native plant species that are frequently used for their therapeutic potential.

Clitoria ternatea L. a medicinal plant of the fabaceae (Plate-5) family, is also known as Shankhpushpi, butterfly pea, Asian pigeon wings, bluebell vine, blue pea, cordofan pea, and Darwin pea. The stem of this little climbing legume is covered with minuscule, fine hairs. It grows as a vine or creeper. The leaves are stalked, alternately arranged, pinnate, and include elliptic or oval leaflets. The most distinctive feature of this plant is its single or double funnel-shaped blooms, which can be pale or dark blue or blue with a yellow base. It is a well-known plant that bears fruits that are long, pointed pods that are linear-oblong in shape. It is indigenous to Madagascar, the Philippines, India and China, and has also been

introduced to Africa, Australia, and North America. The extracts of *Clitoria ternatea* L have been utilized as a component of "Medhya Rasayana," a revitalizing herbal remedy, to treat a variety of neurological conditions and boost mental capacity.

PLATE - 5

***Clitoria ternatea* L. (Habit)**

The plant treats various conditions in traditional medicine, including jaundice, migraine, throat infections, skin diseases, asthma, swollen joints, ear aches, fever, urinary tract infections, constipation, snakebites, indigestion, leprosy, and disorders of the central nervous system. It has a long history of usage as a nootropic, antistress drug, anxiolytic, antidepressant, anticonvulsant, tranquilizer, and sedative. Neurological conditions can also be helped by their use (Gupta *et al*., 2010). Every part of the plant, including the leaves, seeds, bark, fruits, sprouts, and stems has medicinal properties. When developing drugs and treatments, their biological, pharmacological, therapeutic, and safety values are all highly beneficial (Karel *et al*., 2018).

Amaranthus tricolor (Red amaranth) is a member of the Amaranthaceae family and commonly known as Red spinach (Plate-6), Chinese Spinach, Callaloo, Joseph Coat and

Fountain Plant, and is widely cultivated as a vegetable around the world, both in tropical and subtropical climates. It may be grown all year long and is fast-ready for harvest. For the production of seeds and vegetables, red amaranth grows best in the winter. Since it is one of the healthiest and tastiest vegetables, red amaranth is a favorite in Bangladesh. It grows fast and has superior output potential. Therefore, red amaranth is crucial for both food security and nutrition (BARC, 2012).

PLATE - 6

***Amaranthus tricolor* L. Var. Arun (Habit)**

Red amaranth (*Amaranthus tricolor* L.), an herbaceous shrub, typically grows up to 1.2 meters tall and 1.0 meters wide. The fully expanded leaves are a vibrant shade of scarlet and crimson red. A spike-like inflorescence of scarlet blooms develops. It is a substantial leafy vegetable that has earned the nickname "poor man's spinach" for its high nutrient content, which includes vitamins and minerals (Sherinlincy *et al.*,2020).

In Kerala, it is cultivated for commercial purposes across a space of around 1035 hectares, red amaranthus is the most well-liked and frequently used leafy vegetable. It is a favourite crop of farmers due to its short duration, quick response to manures and fertilizers, high yield, simplicity of cultivation, and broad adaptation to a variety of agro-climatic conditions (Agey and Suma, 2012).

Red amaranthus is a particularly nutrient-rich food since it contains beta-carotene, ascorbic acid, moisture, and carbohydrates. It also contains vitamins A, B, C, and K, lutein, flavonoids, and alkaloids all have medicinal benefits for human health. The pigment's reddish-purple colour is a result of the antioxidant anthocyanin. Major nutrients including K, Ca, Mg, Fe and P are among the important components of spinach's nutritional worth (Shariff *et al.,* 2020).

The traditional medical system in India is among the most developed, comprehensive, and diverse in the whole globe. The use of herbs to cure disease has been practiced since antiquity. Production of locally available medicinal plants continues to be a vital aspect of human healthcare, especially for those living in rural areas where people lack access to modern medical facilities and cannot afford to purchase synthetic medications due to their high cost (Kumar *et al.,* 2011).

The medicinal value of plants is found in certain chemical substances known as phytochemicals that have a particular physiological effect on people. They possess antioxidant qualities that lessen the effects of oxidative stress, according to many phytochemical studies. Additionally, they affect the detoxification of enzymes, the immune system and hormones have an antibacterial and antiviral effect. In their overlapping and complementary modes of biological activity, the most important phytochemicals present are alkaloids, flavonoids, tannins, and phenolic compounds (Balakumar *et al.,* 2011).

Fruit shells, peel, and seeds are among the organic waste that may be recycled extensively to make valuable products like agricultural compost. This study demonstrated how adding nutrients are improving the soil's physical attributes, which support crop development, and may help recover overworked soil using biocompost generated from leftover cocoa shells and jackfruit peel.

There will be 32.41 million tonnes of usable organic resources with a total nutritional potential by 2025. Promoting organic farming across the country will not be feasible. It is anticipated that 15 million tonnes of nutrients might be shared using organic manures and other sources (Ravisankar *et al*., 2021).

The current study describes and investigates the use of biocomposted cocoa shells and jack fruit peel trash. Therefore, the current study analyses microbial population,

physicochemical parameters, FTIR and SEM of raw and composted cocoa shells and jack fruit peel, biometric characteristics, biochemical components, pre and post-harvest soil status, antibacterial, antioxidant and mineral composition of four plants, as well as selected plants phytochemical analyses also. The major goal of the study is to collect, treat, and dispose of the two agroindustrial wastes using the least expensive techniques available. If the idea is successful, it will not only provide a different way to dispose of waste made from cocoa shell and jackfruit peels, but it will also encourage organic farming and minimize the application of synthetic fertilisers to crops. The current study, "Effect of Biocomposted Cocoa Shell and Jack Fruit Peel Waste on Certain Crop Plants and Soil Fertility" was carried out to convert the waste from cocoa shells (CS) and jack fruit peels (JFP) into a useful and nutrient-rich biocompost.

In light of the aforementioned details, the following objectives were successfully examined.

- To prepare biocompost from Cocoa shells and Jack fruit peel wastes using *Pleurotus eous, Pleurotus florida* and *Eudrilus eugeniae.*
- To count and evaluate the microflora present in biocompost during the 30^{th}, 60^{th} and 90^{th} days.
- To analyze the physico-chemical parameters of raw and biocomposted Cocoa shell (CS) and Jack fruit peel (JFP).
- To investigate the functional groups of raw and biocomposted Cocoa shell (CS) and Jack fruit peel (JFP) using Fourier Transform Infrared Spectroscopy (FT-IR)
- To assess raw and composted Cocoa shell (CS) and Jack fruit peel (JFP) using scanning electron microscopy (SEM).
- To evaluate the role of different biocomposted treatments on the growth and yield of *Vigna unguiculata* (L.) Walp., *Vigna unguiculata* subsp.*sesquipedalis* (L.) Verdc, *Clitoria ternatea* L. and *Amaranthus tricolor* L.
- To study the protein and carbohydrate content in leaves and seeds of selected plants.
- To evaluate the crude protein content in seeds of selected plants.

- ❖ To determine chlorophyll ‘a’, chlorophyll ‘b’ and ‘total’ chlorophyll content in leaves of selected plants.
- ❖ To determine the leghaemoglobin content in nodules of selected plants.
- ❖ To analyze the pre and post-harvesting soil.
- ❖ To study the antioxidant and antibacterial activity of the selected plants.
- ❖ To analyze the phytochemical constituents present in two medicinal plants (*Clitoria ternatea* L and *Amaranthus tricolor* L).
- ❖ To determine the mineral composition of test plant leaves.