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7. Vermicomposting: for Better Food and Nutritional Security

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Abstract:

The use of sustainable farming practices has significantly increased in recent years due to growing consumer awareness about matters including food quality, environmental safety, and soil conservation. Globally, roughly one-third of the food produced for human consumption is lost or wasted, which amounts to about 1.3 billion tons per year. Vermicomposting is one of the most sustainable methods of handling food waste and is a completely environmentally friendly technology that is a viable method of diverting the organic portion of waste streams, avoiding the costs of disposal, and converting it to value-added vermicomposting. Vermicomposting produced by the activity of earthworms is rich in macro and micro-nutrients, vitamins, growth hormones, enzymes such as proteases, amylases, lipase, cellulose and chitinase and immobilized microflora. The enzymes continue to disintegrate organic matter even after they have been ejected from the worms. Vermicomposting is a low- cost organic amendment known for its effectiveness on agricultural productivity increase but little is diffused about its efficacy on nutritional quality. Vermicomposting is one of the most sustainable methods of handling food waste and is a completely environmentally friendly technology that is a viable method of diverting the organic portion of waste streams, avoiding the costs of disposal, and converting it to value-added vermicomposting. This chapter examines vermicomposting for better food and nutritional security, Composition and quality of vermicomposting and role of vermicomposting.

Keywords:

Vermicomposting, Food security, Nutritional security, Waste, Quality

7.1 Introduction:

Since the “Green Revolution” in the 1960s, intensive use of chemical fertilizers significantly increased food production to meet the demands of the growing population.

The food requirements of 50% of the population are met using chemical fertilizers for crop production. However, this has led to environmental pollution and health issues due to agrochemical residues in food commodities. The harmful effects of chemical fertilizers have moved scientists' focus toward "green substitutes" with low environmental impact. Among these, vermicomposting is an appealing alternative to conventional chemical fertilizers.

Vermicomposting is a non-thermophilic process that transforms organic waste materials into valuable fertilizer through the combined action of worms and mesophilic microbes **(Rahman et al., 2023).**

7.2 Vermicomposting:

Vermicomposting is generally defined as the solid phase decomposition of organic residues in the aerobic environment by exploiting the optimum biological activity of earthworms and microorganisms **(Garg and Gupta, 2009).**

Vermicomposting is the scientific method of making compost, by using earthworms. They are commonly found living in soil, feeding on biomass and excreting it in a digested form. Vermiculture means "worm-farming". Earthworms feed on the organic waste materials and give out excreta in the form of "vermicasts" that are rich in nitrates and minerals such as phosphorus, magnesium, calcium and potassium. These are used as fertilizers and enhance soil quality.

7.2.1 Processes undergone during vermicomposting:

There science of vermicomposting can be divided in to two types namely:

- Mechanical and Physical
- Bio-chemical and Ecological

The mechanical and physical process involves the aeration of the organic matter followed by mixing of both organic material and earthworms. The bio-chemical and ecological process exhibit the inter relation of both the earthworms and microorganism. The interaction between earthworms and microorganisms takes place in three stages micro stage, meso stage, and macro stage. The macro stage interactions are not that prominent and hence importance was given to micro and meso stages of interactions **(Ganti,2018).**

Vermicomposting technology is a biotechnological process of converting organic waste into compost using specialized earthworms. Earthworms in recent times have become very beneficial following several kinds of research concerning their ability to efficiently convert organic waste into nutrient-rich compost known as vermicast. The vermicast is proven to increase crop growth and yield substantially compared to conventional compost and chemical fertilizers because the product is nutrient-rich and also contains high-quality humus, plant growth hormones, enzymes, and substances that can protect plants against pests and diseases. There are three basic types of vermicomposting systems of interest to farmers which are windrows, beds or bins, and flow-through reactors.

Each type has several variants. Windrows and bins can be batch or continuous-flow systems, while all flow-through systems, as the name suggests, are of the continuous-flow variety **(Fudzagbo and Iderawumi., 2020).** Vermicomposting is described as "bioxidation and stabilization of organic material involved by the joint action of earthworms and mesophilic micro-orga-nisms".

Rich in macro and micronutrients, vitamins, growth hormones, and enzymes including proteases, amylases, lipase, cellulose, and chitin and immobilize microorganisms, vermicomposting is produced by earthworm activity. The enzymes continue to disintegrate organic matter even after they have been ejected from the worms **(Barik et al., 2011)**. Vermicomposting is the process of using earthworm activity to decompose organic waste. It has proven successful in processing sewage sludge and solids from wastewater, materials from breweries, paper waste,urban residues, food and animal wastes, as well as horticultural residues from processed potatoes, dead plants and the mushroom industry **(Domingue and Edwards, 2004).**

Vermicomposting is a decomposition process where microorganisms and earthworms work together to break down materials. Earthworms are important catalysts for the biochemical breakdown of organic materials because they breakage, condition, and drastically change the biological activity of the substrate a procedure that is ultimately carried out by microorganisms. As mechanical blenders, earthworms alter the physical and chemical condition of organic matter by gradually decreasing its carbon-to-nitrogen ratio, increasing the surface area exposed to microorganisms, and creating an environment that is much more conducive to microbial activity and breakdown. They homogenize the organic material by moving particles of excrement rich in bacteria during their journey through the earthworm's gut. The final product, also called vermicomposting, is a finely divided substance that resembles peat and has a high porosity and water-holding capacity. Most of the nutrients are present in this material in forms that the plants can easily absorb. These earthworm casts are rich in organic matter and have high rates of mineralization that implicates greatly enhanced plant availability of nutrients, particularly ammonium and nitrate **(Dominguez and Edwars, 2004).**

7.3 History:

Earthworm has caught imagination of philosophers like Pascal and Thoreau **(Adhikary, 2012).** Earthworms were revered for their role in the soil by several civilizations, such as Greece and Egypt. The first people to realize that earthworms were beneficial were the ancient Egyptians. As said by the 69–30 B.C. Egyptian Pharaoh Cleopatra, "Earthworms are sacred." She saw that the worms were crucial to the fertility of the agricultural land in the Nile Valley following the yearly floods. The extermination of earthworms from Egypt was a capital offense. For fear of angering the God of Fertility, Egyptian farmers were prohibited from touching earthworms in any way. The earthworm was seen by the ancient Greeks as being crucial to raising the soil's quality. The Greek philosopher Aristotle (384–322 B.C.) referred to worms as the intestines of the earth **(Medany, 2011)**. Sir Surpala (10 Cent. A.D., the ancient Indian scientist) recommended to addearthworms to the soil to receive sufficient yield of fruits as pomegranates **(Sinha, 2014)**. Earthworms are truly justifying the beliefs and full-filling the dreams of Sir Charles Darwin who called them as unheralded soldiers of humankind and friends of farmers and said that theremay not be any other creature in world that has played so important a role in the history of lifeon earth. They are also justifying the beliefs of great Russian Scientist Dr. Anatoly Igonin. whosaid: Nobody and nothing can be compared with earthworms and their positive influence on the whole living Nature; they create soil and improve soils fertility and provide critical biospheres functions: disinfecting, neutralizing, protective and productive **(Sinha et al., 2014).**

7.4 Qualitative Characteristics of Vermicomposting:

The disposal of agro-industrial wastes results in the final loss of valuable material, despite the wastes being a major source of plant nutrients. The following are some agricultural and industrial processing wastes that have been investigated for vermicomposting. Wastes from agriculture: include rice husk, cereal leftovers, millet straw, and wheat bran.

Food processing waste includes garbage from breweries, canneries, dairy businesses, sugar companies, wineries, and the oil and wine industries (such as non-edible oil seed cake, coffee pulp, cotton waste, etc.). Food processing waste includes garbage from breweries, canneries, dairy businesses, sugar companies, wineries, and the oil and wine industries (such as non-edible oil seed cake, coffee pulp, cotton waste, etc.). Waste from wood processing: sawdust, wood chips, and wood shavings. Additional industrial wastes include waste from fermentation, waste from paper and cellulose materials, and waste from vegetative tanneries.Locally grown organic products: rice hulls, tea leftovers, coco fiber dust, etc.

Vermicomposting produces a material that resembles peat and is mostly composed of nutrients that are available to plants, including calcium, potassium, magnesium, phosphates, and nitrates. Its high surface area, high porosity, and ability to hold water all contribute to an abundance of sites for microbial activity and nutrient retention. Vermicompost includes plant growth regulators and other components that influence plant growth, such as cytokines, auxins, and humic compounds, amongst others, which are produced by microbes.

7.5 Vermicomposting Chemical Composition:

These are following chemical composition of vermicomposting. Characteristics Value Organic carbon, % 9.15 to 17.88 Total Nitrogen, % 0.5 to 0.9 Phosphorus, % 0.1 to 0.26

Potassium % 0.15 to 0.256 Sodium % 0.055 to 0.3 Calcium & magnesium (Meq/100 g) 22.67 to 47.6 Copper; mg kg^{-1} 2.0 to 9.5 Iron, mg kg^{-1} 2.0 to 9.3 Zinc, mg kg^{-1} 5.7 to 9.3 Sulphur, mg kg^{-1} 128.0to 548.0 **(Garg and Gupta, 2009)**. Vermicomposting technology is a suitable tool for efficient conversion of agro-industrial processing wastes, which serves as a rich source of plant nutrients. These waste materials are packed with a tremendous source of energy, protein and nutrients, which would otherwise be lost if they are disposed as such in the open dumps and landfills. Moreover, with the use of vermicomposting as organic amendments in the agriculture, recycling of the nutrients back to the soil takes place, in turn, maintaining the sustainability of the ecosystem **(Garg and Gupta, 2009).**

7.6 Roles of Vermicomposting:

- A significant amount of humus is present in red worm castings. Humus facilitates the formation of soil particle clusters, which improves the soil's ability to retain water and opens up air channels.
- It is thought that humus can help keep bacteria, nematodes, fungi, and dangerous plant pathogens as away.
- A worm casting, sometimes referred to as a vermicast or worm cast, is a biologically active mound that contains plant remnants that the worms did not digest along with thousands of bacteria and enzymes.
- Plants can easily access the nutrients found in castings.
- The worm stomach functions similarly to a little composting tube, combining the ingredients and inoculating the waste.
- Worm castings are the finest potting soil available for gardening, farming, and greenhouses or houseplants.
- Plant Growth Regulating Activity: According to some research, the high nutrient, humic acid, and hamate contents of vermicompost may have caused the plants' growth responses to resemble "hormone-induced activity."
- Capacity for Plants to Develop Biological Resistance: Actinomycetes and some antibiotics found in vermicomposting aid with boosting crop plants' "power of biological resistance" against pests and illnesses. When earthworms and vermicomposting were utilized in agriculture, the number of chemical pesticides sprayed was drastically decreased—by more than 75%.
- Capacity to Reduce Pest Attack: There seems to be substantial proof that worm castings can occasionally ward off hard-bodied bugs.
- Capacity to Suppress Plant Disease: Studies reported that vermicomposting application suppressed 20%–40% infection of insect pests i.e. aphids (Myzus persicae), mearly bugs (Pseudococcus spp.) and cabbage white caterpillars (Peiris brassicae) on pepper (Capsicum annuum), cabbage (Brassica oleracea) and tomato (Lycopersicum esculentum).
- Vermimeal Production: With the increasing demand for animal feed protein bolstered bythe continuing growth of human population and food source, the production of vermimeal be considered as the most economically feasible application of vermiculture (Adhikary, 2012).

7.7 The Advantages of Vermicomposting for Soil:

- Improve the soil's structure, "Soil Organic Matter" (SOM), and prevent erosion of the soil.
- Enhance the amount of nutrients, microbial activity, and essential soil bacteria.
- Increase the ability to exchange cations.
- Lowers the bulk density of the soil and guards against erosion and compaction.
- Prevention of diseases of plants borne in soil.
- Improve the soil's ability to retain water. 7.Reduce sodicity and salt from the soil.
- Maintain optimal pH value of soil (Sinha, 2014).

For several reasons, vermicomposting is the best organic manure for improving plant development and productivity.

- Compared to conventional composts, vermicomposting offers a higher nutritional value.
- The activity of earthworms is to blame for the increased rate of mineralization and degree of humidification.
- The porosity, aeration, drainage, and water-holding capacity of vermicomposting are high.
- The presence of microbiota, specifically actinomycetes, bacteria, and fungi, renders the environment favorable for plant growth. Vermicomposting contains nutrients in plant-available forms, including nitrates, phosphates, exchange-able calcium, and soluble potassium.
- Vermicomposting also contains other plant development-influencing substances made by microorganisms, such as plant growth regulators.
- Earthworm processing of organic wastes revealed the production of auxins and cytokines.
- Earthworms release certain metabolites, such as vitamin B, vitamin D and similar substances into the soil **(Joshi et al., 2015).**

Particularly in the last few decades have the role of vermicomposting in agricultural fields' nutrition come to the attention of researchers worldwide. Since waste management is seen as a crucial component of a sustainable society, it is necessary to divert biodegradable portions of that waste from landfills and into alternative waste management techniques like vermicomposting.

Vermicast, or earthworm excrement, is a nutritious organic fertilizer that is high in humus, NPK, micronutrients, and helpful soil microorganisms, including bacteria that fix nitrogen, phosphate, and dissolve phosphate, actinomycete growth hormones, auxins, gibberellins, and cytokinins. Both vermicompostingand its body liquid (vermiwash) are proven as both growth promoters and protectors for crop plants **(Adhikary, 2012).**

Plant nutrients such as N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, and B can be obtained from vermicomposting. The high percent-age of humic acids in vermicomposting contributes to plant health, as it promotes the synthesis of phenolic compounds such as anthocyanins and flavonoids which mayimprove the plant quality and act as a deterrent to pests and diseases **(Theusnissen et al., 2010).**

The primary elements of vermicomposting are C, H, and O. It also contains micronutrients and nutrients like N, P, Ca, K, Mg, and S that have an impact on plant growth and production that is comparable to that of inorganic fertilizers put to soil. Similarly, vermicomposting contains a high proportion of humic substances, which provide numerous sites for chemical reaction; microbial components knownto enhance plant growth and disease suppression through the activities of bacteria (Bacillus), yeasts (Sporobolo-myces and Cryptococcus) and fungi (Trichoderma), as well as chemical antagonists such as phenols and amino acids **(Theunissen et al., 2010).**

Without the need for agrochemicals, vermicomposting, and earthworms can increase horticulture output. Producing "chemical-free," safe, "nutritive and health protective" (rich in minerals and antioxidants) foods for people (even against certain forms of cancer), will benefit humanity in several social, economic, and environmental ways. It will also save human waste and eliminate harmful "agrochemicals" from the environment.

The use of vermicomposting in farms also 'sequester' huge amounts of atmospheric carbon (assimilated by green plants during photosynthesis) and bury them back into the soil improving the soil fertility, preventing erosion or compaction and also reducing greenhouse gas and mitigating global warming **(Sinha et al., 2013)**.

7.8 Effect of Vermicomposting on Agricultural Crop Performance:

Yield: Studies on the production of important vege-table crops like tomato (Lycopersicon esculentum), eggplant (Solanum melongena) has yielded very good results **(Adhikary, 2012).** In the same way, when vermicomposting was done at a rate of roughly 6 tons/ha, the overall output of potatoes was considerably higher than that of the control. Vermicast produced higher garden pea green pod plants, higher green grain weight per plant, and higher green pod yield as compared to chemical fertilizer **(Adhikary, 2012).** Analyzing the data showed that applying "Parthenium Vermicomposting" at a rate of 5 t/ha improved eggplant (Solanum melongena) production. Farmers around the nation are increasingly turning to vermicomposting as a source of organic manure to supplement chemical fertilizers. Vermicomposting increases in crop yield probably because of higher nutrient uptake **(Seethalakshmi, 2011)**.

Growth: Worms and vermicomposting promoted excel-lent growth in the vegetable crop with more flowers and fruits development **(Adhikary, 2012)**. Vermicomposting can have dramatic effects upon the germination, growth, flowering, fruiting and yields of crops **(Mistry, 2015).** Tomato transplant growth was boosted by vermicomposting; shoot biomass increased by up to 2.2 times. Differences in growth were attributed mainly to differences in nutrient content of the potting mixtures, but some changes in physical and biological propertiesof the substrate could also be responsible (Tringovska and Dintcheva, 2012). Application of vermicomposting increased seed germination, stem height, number of leaves, leaf area, leaf dry weight, root length, root number, total yield, number of fruits/plant **(Joshi et al., 2015).**

Nutrient content: Vermicast produced higher percentage of protein content and carbohydrates in garden pea as compared to chemical fertilizer (Adhikary, 2012). Application of vermicomposting increased chlorophyll content, pH of juice, total soluble solids of juice, micro and macronutrients, carbohydrate % and protein (%) content and improved the quality of the fruits and seeds. Studies suggested that treatments of humic acids, plant growth promoting bacteria and vermicomposts could be used for a sustainable agriculture discouraging the use of chemical fertilizers (Joshi et al., 2015).

Plant protection: The most significant observation was drastically less incidence of diseases in worm and vermicomposting applied plant **(Adhikary, 2012)**. Accordingly, vermicomposting also protects plants against various pests and diseases either by suppressing or repelling them or by inducing biological resistance in plants **(Sinha et al., 2013)**. Disease resistance is a plus Cornell University lab trials have shown promise for applying the solid vermicomposting and its non-aerated extract as a control for Pythium aphanidermatum, a disease common to many vegetable crops "Garlic doesn't tend to have Pythium problems," points out Fraser.

"So I was looking for how well the compost would support plant growth. We saw a definite impact on leaf growth and weight gain." "The healthier and more vigorous the plants are with the microbiology in their root zone, the more the plants are able to thwart attacks from destructive crop pathogens and insect pests," he elaborates Recent Ohio State University studies also concluded that crops fed with vermicomposting are also more resistant to blight, bacterial wilt, parasitic nematode attacks and powdery mildew than those on synthetic fertilizers **(Dunn, 2011)**.

Human health: Organically grown fruits and vegetables especially on 'earthworms and vermicomposting' have been found to be highly nutritious, rich in 'proteins, minerals and vitamins' and 'antioxidants' than their chemically grown counterparts and can be highly beneficial for human health. They have elevated antioxidants levels in about 85% of the cases studied. They have been found to be protective against several forms of 'cancers' and against 'cardiovascular diseases' **(Sinha, 2012)**.

7.9 Vermicomposting Better for Food and Nutritional Security:

Vermicomposting increases production, nutritional quality, and biochemical components while lowering pest attacks on plants, thus contributing to food security. The application of vermicomposting enhances the retention of carbon in the soil while simultaneously reducing greenhouse gas emissions.

Indeed, vermicomposting is an effective method that improves food security in many ways. How to do it is as the following:

Rich in Nutrients: The final by-product of composting, vermicomposting provides a rich source of nutrients for soil amendment. It improves the structure and fertility of soil when added, which promotes healthy plant growth. Consequently, this raises crop yields and promotes food security.

Low-Cost Method: Vermicomposting is a small-scale process that requires little space and equipment. This makes it feasible for homes, neighborhoods, and even cities where there might not be enough room for conventional composting. In areas with a shortage of resources, its affordability and ease of use make it a desirable alternative for enhancing soil fertility and food production.

Waste Reduction: Vermicomposting diverts organic waste from landfills. Instead of allowing food scraps and other organic materials to degrade in landfills and produce greenhouse gases, vermicomposting converts them into valuable compost that can be used to grow more food. This approach to waste reduction can indirectly contribute to food security by reducing environmental pollution and conserving resources.

Microbial Activity: The procedure of vermicomposting encourages healthy microbial activity in the soil, which supports the cycling of nutrients and soil health. Resilient food systems and sustainable agriculture depend on robust soil ecosystems, especially in the face of environmental challenges like climate change.

Community Involvement: Another way to foster community building is through vermicomposting. Initiatives for community vermicomposting can teach people about methods for sustainable agriculture, waste management, and soil health. Through community participation, these initiatives support regional food security and cultivate a feeling of pride and ownership in protecting the environment.

7.10 Food Security:

Formidable food systems that can curtail hunger and poverty especially among the rural poor will require sustainable inclusion in crop production. Agro-ecosystems should be conditioned to support continued food production to feed the ever-increasing human population. Vermicomposting technology used in urban centers is providing a better alternative soil medium for convenient and cost-effective vegetable crop production.

The fight against the effects of climate change and efforts to cut down greenhouse gas emissions in urban center will demand a 'one household one backyard garden' approach, where vermitech is utilized. By this, households can provide enough to feed themselves and make extra income on the side **(Fudzagbo et al.,2020).**

7.11 Conclusions:

It can be concluded that vermicomposting produced by the activity of earth-worms is rich in macro and micronutrients, vitamins, growth hormones, enzymes such as proteases, amylases, lipase, cellulose and chitinase and immobilized microflora. The application of vermicomposting enhances soil health and crop productivity due to improved nutrient uptake, the presence of humic substances, phytochromes, and enhanced microbial activities in vermicomposting. Vermicomposting a biological process which involves the interaction between earthworms and micro-organisms leading to the formation of earthworm biomass and the vermicomposting. Vermicomposting is optimal organic manure for better growth and yield of many plants. It can increase the production of crops and prevent them from harmful pests without polluting the environment. Application of vermicomposting increased growth, improved plants nutrient content, and improved the quality of the fruits and seeds. This chapter gives an updated perspective on the possible use of vermicomposting to recommended for plant production and food and nutritional security.

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