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# Biopesticides and their type of formulations

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## Abstract

Biopesticides, derived from natural sources such as microorganisms, plants, and minerals, have emerged as a sustainable alternative to conventional chemical pesticides in modern agriculture. They offer a safer, environmentally friendly solution to pest management by targeting specific pests while preserving beneficial organisms and reducing chemical residues in ecosystems. Biopesticides can be broadly classified into three categories: microbial, biochemical, and plant-incorporated protectants (PIPs). These are available in various formulations designed to optimize their efficacy, stability, and application. Common formulations include wettable powders, liquid concentrates, granules, and encapsulated products, each tailored to specific pest control scenarios and environmental conditions. With advancements in formulation technology, biopesticides hold great potential for enhancing agricultural productivity while ensuring environmental sustainability.

## I. Introduction

Modern agricultural production technologies, which rely heavily on the use of pesticides and mineral fertilizers, have significantly addressed the issue of food supply for the population. However, these technologies have also led to numerous environmental and health problems. Currently, there is a priority focus on developing and applying new plant protection products that are non-toxic to humans, animals, and the environment. Biopesticides, a specific type of pesticide, are derived from natural substances and materials, such as those from animals, plants, or minerals. Biopesticides fall into three main categories: biochemical, microbial, and plant-incorporated protectants. They are used to control and combat diseases in crops and to protect against pests.

The United States Environmental Protection Agency (EPA) defines biopesticides as pesticides derived from natural materials such as animals, plants, bacteria, and certain minerals. These biopesticides pose less risk to the environment and human health. The most commonly used biopesticides are living organisms that are pathogenic to the targeted pests, including biofungicides like *Trichoderma*, bioherbicides like *Phytopthera*, and bioinsecticides like *Bacillus thuringiensis*. Additionally, there are plant products that can serve as major sources of biopesticides. Plant-incorporated protectants are substances naturally produced through the genetic modification of plants. Examples include the incorporation of the Bt gene, protease inhibitors, lectins, and chitinase into the plant genome, enabling transgenic plants to synthesize substances that destroy specific pests. The potential benefits of using biopesticides in agriculture and public health programs are considerable (Bharti and Ibrahim, 2020) The growing interest in biopesticides is due to their inherent advantages, such as being less harmful and environmental friendly. They are designed to target specific pests or a few target organisms, are effective in small quantities, and decompose quickly, which reduces exposure and pollution problems. When integrated into Integrated Pest Management (IPM) programs, biopesticides can greatly contribute to pest control efforts (Kandar, 2021).

Biological products are highly target-specific and highly desirable for use, but developing acceptable formulations is challenging. This difficulty arises because, in addition to needing good physical properties and ease of use, the formulated product must maintain the functionality of its biological agent throughout storage and application (Woods, 2003). Commercial biopesticides should be cost-effective to produce, possess stable storage properties, have high residual activity, be easy to handle, mix, and apply, and consistently provide effective control of target pests. To address issues related to their efficacy and degradation, and to ensure convenience during handling and application, various formulations of biopesticides should be developed (Boyetechko, 1999). Bioformulation is crucial for maximizing the bioactivities of biopesticides, ensuring their effectiveness, safety, and practicality in agricultural practices. There is a need for increasing bioactivities of pesticides in terms of stability, efficacy, target specific, ease of application, Consistent Performance, Environmental Safety, Cost effective and

Resistance Management.

**II. Formulation of Biopesticides:**

Formulation involves preparation of a product from an active ingredient by adding specific active (functional) and inactive (inert) substances (Grewal, 2005).

**Priniciples of bioformulation**

Formulated organisms are suspended in an appropriate carrier and supplemented with additives to enhance their survival during storage, optimize their application to the target, and protect them after application. Unlike chemical active ingredients, these organisms are particulate and either living or protein-based, making them relatively sensitive to storage conditions and environmental factors. Several amendments are used in the preparation of these formulations.

**Basic functions of formulations**

**1. Stabilizing Organisms**: Ensuring stability during distribution and storage.

**2. Facilitating Handling and Application**: Simplifying delivery to the target in the optimal manner and form.

**3. Protecting from Environmental Factors**: Shielding agents from adverse conditions at the target site to prolong effectiveness.

**4. Enhancing Activity**: Increasing organism activity, reproduction, and interaction with target pests or disease organisms.

**Regarding their physical state, biopesticide formulations are categorized into two main types:**

**1. Liquid Formulations**: These can be water-based, oil-based, polymer-based, or combinations thereof. Water-based formulations like concentrates, suspo-emulsions (such as suspension concentrate and capsule suspension), require the addition of inert ingredients such as stabilizers, stickers, surfactants, coloring agents, antifreeze compounds, and additional nutrients (Knowles, 2008).

**2**. **Dry Formulations**: These can be produced using various technologies such as spray drying, freeze drying, or air drying, with or without the use of a fluidized bed. They are created by incorporating binders, dispersants, wetting agents, and other additives (Knowles, 2008).

Biopesticides are typically formulated as follows:

- ✓ **Dry Formulations for Direct Application**: Dusts (DP), powders for seed dressing (DS), granules (GR), micro granules (MG).
- ✓ Dry **Formulations for Dilution in Water**: Water dispersible granules (WG), wettable powders (WP).
- ✓ **Liquid Formulations for Dilution in Water**: Emulsions, Suspension Concentrates (SC), Oil Dispersions (OD), Suspo-Emulsions (SE), Capsule Suspensions (CS).
- ✓ **Ultra Low Volume Formulations**

**Dusts:** Dusts are formulated by adsorbing an active ingredient onto finely ground solid mineral powders like talc or clay, typically with particle sizes ranging from 50-100 µm. These formulations are applied directly to targets either mechanically or manually. Inert ingredients such as anticaking agents, UV protectants, and adhesives are added to enhance adsorption. Dust formulations usually contain around 10% active ingredient (organisms). While effective under certain conditions, they pose inhalation hazards for users and have been restricted due to health concerns, although they are still used in many regions (Knowles, 2005).

**Powders for Seed Treatment (DS):** These formulations involve mixing an active ingredient with a powder carrier and inert additives to facilitate adherence to seed coats. Applied by tumbling seeds with the product, powders for seed treatment are an older formulation type traditionally used for seed coating. They often include a red pigment as a safety marker for treated seeds (Woods, 2003).

**Granules (GR):** Granules are similar to dust formulations but with larger, heavier particles ranging in size from 100-1000 microns for granules and 100-600 microns for micro granules. They are made from mineral materials like kaolin, attapulgite, silica, starch, polymers, dry fertilizers, or ground plant residues. Active ingredient concentrations range from 5-20%, either coating the outside of the granules or absorbed within them. Granules are manufactured by mixing a powder blend with water to form a paste, which is extruded and dried, or by applying a liquid active ingredient to absorptive material. Some granules are coated with resins or polymers to control the release rate of the active ingredient after application. They are mainly used for soil application to control pests like weeds, nematodes, and soil insects, gradually releasing their active ingredient with soil moisture (Knowles, 2005).

**Wettable Powders (WP):** WP formulations are dry, finely ground products that are suspended in water before application. They are produced by blending an active ingredient with surfactants, wetting agents, dispersing agents, and inert fillers, followed by grinding to achieve a particle size of about 5 microns. WP formulations can pose health and safety risks during manufacturing and application due to their dustiness, which can cause inhalation and irritation issues for workers if safety precautions are not strictly followed (Knowles, 2005).

**Water Dispersible Granules (WG):** Water dispersible granules are designed to be easily suspended in water, breaking up to form a uniform suspension similar to wettable powders but with less dust and better storage stability. Various processing techniques like extrusion granulation, fluid bed granulation, and spray drying can be used to formulate them. While generally more expensive than older formulations like dusts and wettable powders, their safety and ease of application make them preferred by many users (Knowles, 2008).

**Emulsions:** Emulsions consist of liquid droplets dispersed in another immiscible liquid, with droplet sizes ranging from 0.1 to 10 µm. They can be either oil in water (EW) or water in oil (EO) emulsions, both requiring mixing with water before use. Stabilizing emulsifiers are crucial to prevent instability. In EO emulsions, where oil is the external phase, losses due to evaporation and spray drift are minimal, although shelf stability and occasional phytotoxicity issues can affect performance. Ongoing research aims to optimize EO emulsions for biopesticide applications by exploring various oils and emulsifying agents (Brar *et al*., 2006).

**Suspension Concentrate (SC):** Suspension concentrates (SC) are mixtures where finely ground solid active ingredients are dispersed in a liquid phase, typically water. These formulations require agitation before application to maintain even distribution of solid particles. They include a complex composition with wetting agents, dispersing agents, thickening agents, and antifoaming agents to ensure stability. Produced through wet grinding, SCs have particle sizes ranging from 1-10 µm (Woods, 2003; Knowles, 2005).

**Oil Dispersions (OD):**

Oil dispersions are formulations where solid active ingredients are dispersed in a non-aqueous liquid, typically a plant oil, which enhances retention, spreading, and penetration capabilities. This formulation is advantageous for delivering water-sensitive active ingredients and using oil-based adjuvants instead of water, thereby potentially broadening and enhancing pest control capabilities. Production methods for oil dispersions are similar to suspension concentrates, requiring careful selection of inert ingredients to prevent instability issues (Verner and Bauer, 2007).

**Suspo-Emulsions (SE):**

Suspo-emulsions combine characteristics of suspension concentrates and emulsions. Formulating suspo-emulsions is challenging because it requires achieving a stable emulsion component simultaneously with a stable particle suspension component. Selection of appropriate dispersing and emulsifying agents is crucial to prevent heteroflocculation between solid particles and oil droplets. Extensive stability testing is necessary due to the complexity of this formulation, but suspo-emulsions have gained significance and are expected to continue growing in importance (Knowles, 2008).

**Capsule Suspension (CS):**

Capsule suspension is a stable formulation where micro-encapsulated active ingredients are suspended in an aqueous continuous phase, intended for dilution before use. The active bio-agent is encapsulated within capsules made from materials like gelatin, starch, cellulose, or other polymers, providing protection against environmental conditions and enhancing residual stability through controlled release. Surfactants and thickeners are used to stabilize microcapsule suspensions, similar to suspension concentrates. Despite the benefits of controlled release, commercial development of capsule suspensions is slow due to formulation complexity and high production costs (Chen *et al*., 2013).

**Ultra low Volume Liquids (UL):**

Ultra-low volume liquids are formulations with very high concentrations of active ingredients that are extremely soluble in crop-compatible liquids. These products do not require dilution before use and often contain surface-active agents and drift control additives. Ultra-low volume liquid biopesticides can be formulated similarly to suspended biocontrol agents as active ingredients, offering ease of transportation and application (Woods, 2003). Various ammendments and examples of materials for formulation is given in figure 1.

| Amendment type | Examples |
|---|---|
| Liquid carriers | Vegetable oil |
| Mineral carriers | Kaolinite clay, diatomaceous earth. |
| Organic carriers | Grain flours |
| Stabilizers | Lactose ,sodium benzoate |
| Nutrients | Molasses ,peptone |
| Binders | Gum Arabic, carboxymethy cellulose |
| Desiccants | Silica gel, anhydrous salts |
| Thickeners | Xanthan gum |
| Surfactants | Tween 80 |
| Dispersants | Microcrystalline cellulose |
| UV protectants  sunscreens | Oxybenzone |
| Light blockers | Lignin (PC 1307) |
| Stickers | Pregelatinized corn flour |

**Figure 1. Different Ammendments and example materials for formulation**

## Conclusion

Biopesticide formulations play a crucial role in enhancing bioactivity and effectiveness in pest management strategies. **Optimized Formulation Techniques, Enhanced Target Specificity, Increased Persistence and Efficacy, Integration with IPM Programs will tend to increase its activities**. Effective formulations increase the persistence of biopesticides on plant surfaces or in soil, improving their efficacy over time and under varying environmental conditions. Biopesticide formulations offer safe alternatives to synthetic pesticides, contributing to sustainable agricultural practices by minimizing chemical residues and environmental impact. In conclusion, advancing biopesticide formulations through innovative techniques and strategic integration within IPM frameworks holds promise for achieving effective pest management while promoting environmental sustainability in agriculture.

## References

- Bharti, V., & Ibrahim, S. (2020). Biopesticides: Production, formulation and application systems. *International Journal of Current Microbiology and Applied Science*, *9*(10), 3931-3946.
- Boyetchko, S., Pedersen, E., Punja, Z., & Reddy, M. (1999). Formulations of biopesticides. *Biopesticides: Use and delivery*, 487-508.
- Brar, S. K., Verma, M., Tyagi, R. D., & Valéro, J. R. (2006). Recent advances in downstream processing and formulations of Bacillus thuringiensis based biopesticides. *Process biochemistry*, *41*(2), 323-342.
- Chen, K. N., Chen, C. Y., Lin, Y. C., & Chen, M. J. (2013). Formulation of a novel antagonistic bacterium based biopesticide for fungal disease control using microencapsulation techniques. *Journal of Agricultural Science*, *5*(3), 153.

- Grewal, P. S. (2005). Formulations and quality control of entomopathogenic nematodes. *Department of entomology, Ohio-state-university Wooster*.
- Kandar, P. (2021). Phytochemicals and biopesticides: Development, current challenges and effects on human health and diseases. *J. Biomed. Res*, *2*(1), 3-15.
- Knowles, A. (2005). New developments in crop protection product formulation. *T&F Informa UK Ltd*, 23-343.
- Knowles, A. (2008). Recent developments of safer formulations of agrochemicals. *The Environmentalist*, *28*(1), 35-44.
- Vernner, R., & Bauer, P. (2007). Q-TEO, a formulation concept that overcomes the incompability between water and oil. *Pfalzenschutz-Nachrichten Bayer*, *60*(1), 7-26.
- Woods, T. S. (2003). Pesticide formulations. *Encyclopedia of Agrochemicals*.