

Enzyme Synthesis from Kitchen By-Products: A Pathway to Sustainable Bio-Shampoos

Ngo BaoKhoa

baokhoa0905@gmail.com

VNU-HCM High School for the Gifted <https://orcid.org/0009-0007-0409-1391>

Research Article

Keywords: Environmental Engineering, Recycling and Waste Management, Garbage Enzyme, Bioshampoo

Posted Date: September 8th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10935319/v1>

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Additional Declarations: The authors declare no competing interests.

Abstract

This study addresses the pressing global issues of untreated organic waste accumulation and greenhouse gas emissions by exploring the valorization of kitchen by-products through enzyme fermentation. Garbage enzyme (GE), a biologically active solution produced under anaerobic conditions from organic waste, sugar, and water, has been previously reported to contain hydrolytic enzymes such as protease, amylase, and lipase, along with organic acids like acetic acid (1, 2). In this work, two experiments and eight survey samples were conducted to determine the optimal fermentation conditions. The results showed that the most effective ratio consisted of 25 mL molasses, 75 g diced organic waste, and 250 mL water, supplemented with 0.2 g Emzeo. The GE solution demonstrated significant cleaning efficiency across three types of stains and three material surfaces. Building on this outcome, GE was incorporated into the formulation of a herbal-based, sulfate-free bio-shampoo. The final product exhibited a stable pH of 5.5, satisfied bonding standards in Vietnam, and demonstrated mild yet effective cleansing performance, highlighting its potential application in eco-friendly personal care products.

Introduction

In recent decades, anthropogenic pressures have accelerated the Earth's progression toward unsustainable conditions. Population growth is a primary driver of this trajectory, with nearly 80 million individuals added annually; projections suggest that the global population will surpass 9 billion by 2050 (3). This demographic expansion has contributed to a fivefold increase in global energy demand since 1950 and nearly a tenfold rise in natural resource extraction (4). Current estimates indicate that humanity consumes resources at approximately twice the planet's annual regenerative capacity, resulting in ecological overshoot and widespread environmental degradation (5).

Organic solid waste mismanagement constitutes one of the most pressing consequences of this imbalance. Improper disposal leads to odor pollution, aquatic contamination, and elevated greenhouse gas concentrations. Methane (CH_4), produced through anaerobic decomposition of organic matter, accounts for roughly 20% of total anthropogenic emissions and possesses a global warming potential approximately 25 times greater than carbon dioxide, thereby intensifying climate change impacts (6, 7). The reduction and valorization of organic waste streams are thus critical strategies for mitigating environmental risks.

A promising biotechnological solution is Garbage Enzyme (GE), a fermentation-based product introduced by Dr. Rosukon Poompanvong (Thailand) more than three decades ago (8). Produced under anaerobic conditions from organic kitchen waste, sugar, and water, GE contains hydrolytic enzymes, peptides, organic acids, and mineral salts (1, 2, 9, 10). Previous studies have reported its capacity to reduce methane emissions, enhance waste degradation, improve air quality, and remediate pollutant parameters in domestic and industrial effluents (9). Additionally, GE exhibits detergent-like properties, including cleansing, deodorization, and antimicrobial activities (10).

These multifunctional attributes position GE as a potential replacement for chemical detergents. Its application in bio-shampoos—herbal, sulfate-free formulations certified under organic standards such as those of the U.S. Department of Agriculture (USDA)—provides an eco-friendly alternative for the personal care sector. Such products combine environmental sustainability with consumer health benefits and economic accessibility (11).

Methods

1. Equipments and chemicals

1.1. Equipment

The experimental procedures were carried out using standard laboratory equipment, including analytical laboratory scales, centrifuges, glass beakers, pH indicator paper, heating pots, and micropipettes.

1.2. Chemicals

The following chemicals and reagents were used in the study: white granulated sugar (analytical grade), molasses, Emzeo microbial preparations, PQ10 enzyme preparation, and sodium chloride (NaCl). All chemicals were of commercial grade and were used without further purification.

2. Survey of Garbage Enzyme (GE) Synthesis Composition

The baseline GE fermentation was prepared at a fixed substrate ratio of 1:3:10 (sugar : organic waste : water). Each batch consisted of 25 mL of molasses (or 25 g of white sugar), 75 g of biodegradable kitchen waste, and 250 mL of distilled water. The mixture was thoroughly homogenized in a sealed glass container and incubated under ambient laboratory conditions. Observations were performed periodically to monitor changes in pH, odor, foaming activity, and visual indicators of fermentation progress.

Experiment 1: Effect of Sugar Source and Waste Preparation on GE Fermentation

To evaluate the influence of sugar type and physical state of the waste substrate on GE fermentation, four treatment groups were prepared without microbial inoculation (Emzeo):

- Sample 1: Whole kitchen waste fermented with white granulated sugar.
- Sample 2: Whole kitchen waste fermented with molasses.
- Sample 3: Diced (chopped) kitchen waste fermented with white granulated sugar.

- Sample 4: Diced (chopped) kitchen waste fermented with molasses.

In all cases, the substrate ratio of sugar: organic waste: water was maintained at 1:3:10, corresponding to 25 g of sugar (or 25 mL of molasses), 75 g of organic waste, and 250 mL of water. Each mixture was placed in a sealed container and incubated under ambient laboratory conditions. Observations were recorded periodically for changes in pH, odor, foam formation, and visual signs of fermentation.

Table 1. Component ratio of experiment 1.

Sample	Size of kitchen waste	Sugar type	Sugar	Waste	Water
1	Leave the pieces as they are	White granulated sugar	25ml	75g	250ml
2	Leave the pieces as they are	Molasses	25g	75g	250ml
3	Cut into medium pieces	White granulated sugar	25ml	75g	250ml
4	Cut into medium pieces	Molasses	25g	75g	250ml

Experiment 2: Use Emzeo microbiological preparations (0.2g) during incubation.

To investigate the role of microbial supplementation, Emzeo (0.2 g per batch) was added during incubation. Three treatment groups were prepared:

- Sample 1: Whole kitchen waste fermented with white granulated sugar and Emzeo.
- Sample 2: Whole kitchen waste fermented with molasses and Emzeo.
- Sample 3: Diced (chopped) kitchen waste fermented with white granulated sugar and Emzeo.
- Sample 4: Kitchen waste that have been diced (chopped) and brewed with molasses.

The substrate ratio was consistent with Experiment 1 (1:3:10), and all mixtures were incubated under the same laboratory conditions. Observations and analyses followed identical procedures as in Experiment 1.

Table 2. Component ratio of experiment 2.

Sample	Size of kitchen waste	Sugar type	Sugar	Waste	Water	Emzeo
1	Leave the pieces as they are	White granulated sugar	25ml	75g	250ml	0.2g
2	Leave the pieces as they are	Molasses	25g	75g	250ml	0.2g
3	Cut into medium pieces	White granulated sugar	25ml	75g	250ml	0.2g
4	Cut into medium pieces	Molasses	25g	75g	250ml	0.2g

3. Preparation of biological shampoos from synthetic GE enzymes

	Sample 1	Sample 2	Sample 3	Sample 4
Size of kitchen waste	Leave the pieces as they are	Leave the pieces as they are	Cut into medium pieces	Cut into medium pieces
Sugar type	White granulated sugar	Molasses	White granulated sugar	Molasses
Incubation period	30 days	30 days	30 days	30 days
Color after incubation	Opaque white to brown	Dark brown	Opaque white	Light brown
Smell	No smell	Light yeast sour smell	Slight sour smell	Strong sweet and sour yeast smell
Thickness of microbial whey layer	Thin	Quite thick	Quite thin	Thick

Results and Discussion

1. Survey of GE enzyme synthesis composition

Experiment 1: Control trial without Emzeo

Throughout the 30-day observation period, no typical indicators of microbial fermentation—such as the appearance of white mycelial patches, production of acidic odor, or noticeable degradation of organic waste—were detected. Consequently, the use of the microbiological preparation *Emzeo* is proposed to accelerate the fermentation process.

Experiment 2:

The results of the four experiments (with the addition of Emzeo) are presented in Table X and illustrated in Figure 3.

Observations:

Among the tested samples, the enzyme solution obtained from Sample 4 (diced organic waste fermented with molasses and Emzeo) exhibited the most favorable characteristics. This sample demonstrated:

- A pronounced sweet–sour yeast-like aroma,
- A dense and uniform white microbial biofilm on the surface,
- Complete decomposition of fruit peels and other substrates, which settled at the bottom,
- Transformation of organic matter into inorganic forms, and
- A final enzyme solution with desirable color and clarity after standard incubation.

Color	Identical
Smell	Nature, pleasant herbs

Based on these results, Sample 4 was selected for subsequent studies.

2. *Petition:*

Within the scope of this research, we have not yet conducted testing on the storage conditions and shelf life of the product. Further work is also needed to diversify the types of stains used to evaluate the cleansing capacity of the GE enzyme, as well as to expand studies on mixing ratios and the development of shampoo formulations.

The results obtained so far indicate that the optimal incubation rate for GE enzyme production is 25 ml of molasses, 75 g of diced organic waste, and 250 ml of water, with the addition of 0.2 g of Emzeo. The synthesized GE enzyme solution demonstrates effective cleaning ability across three different materials and three types of stains, showing complete stain removal. Furthermore, the bio-shampoo derived from GE enzyme exhibits gentle cleansing and satisfactory foaming capacity. Composed entirely of natural herbs and free from toxic sulfate-based chemicals, this shampoo not only provides a safe and suitable hair care option but also introduces a sustainable solution that contributes to addressing global warming and climate change.

Conclusion

The optimized conditions for garbage enzyme (GE) fermentation were identified as 25 mL of molasses, 75 g of diced organic waste, and 250 mL of water supplemented with 0.2 g of Emzeo inoculum. Under these parameters, the GE solution exhibited effective cleaning properties, demonstrating complete

removal of stains across three types of substrates. Furthermore, a bio-shampoo formulated with the synthesized GE enzyme showed mild cleansing ability and stable foaming characteristics. Owing to its composition of entirely natural herbal ingredients and the exclusion of sulfate-based surfactants, the product offers a non-toxic and environmentally benign alternative to conventional shampoos. Beyond personal care applications, this work highlights the potential of GE-based products to contribute toward sustainable solutions in mitigating the impacts of global warming and climate change.

Declarations

Acknowledgements

The author gratefully acknowledges Ms. Pham Thi Quynh Anh, M.Sc., for her invaluable assistance in writing, editing, revising the manuscript, and updating the research methodologies. Special thanks are also extended to VNU-HCM High School for the Gifted for providing laboratory facilities and financial support that enabled the successful completion of this study.

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Figures

The substrate ratio was consistent with Experiment 1 (1:3:10), and all mixtures were incubated under the same laboratory conditions. Observations and analyses followed identical procedures as in Experiment 1.

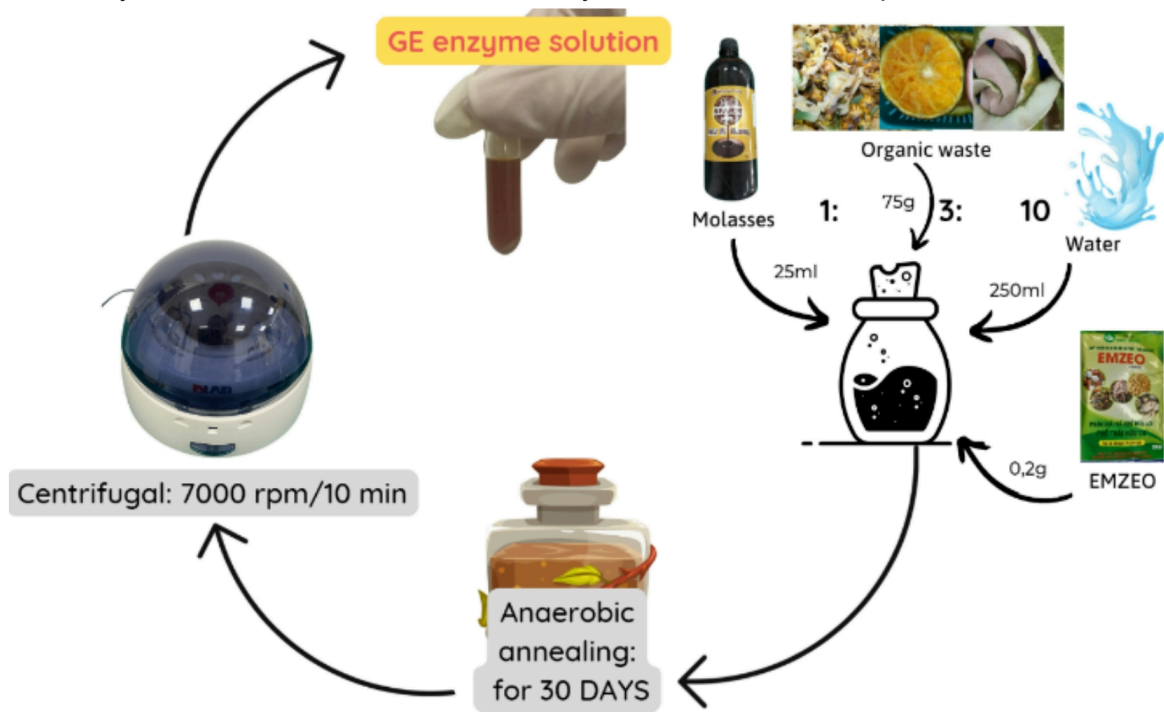


Figure 1

The procedure for performing GE enzyme synthesis with molasses with the addition of Emzeo.

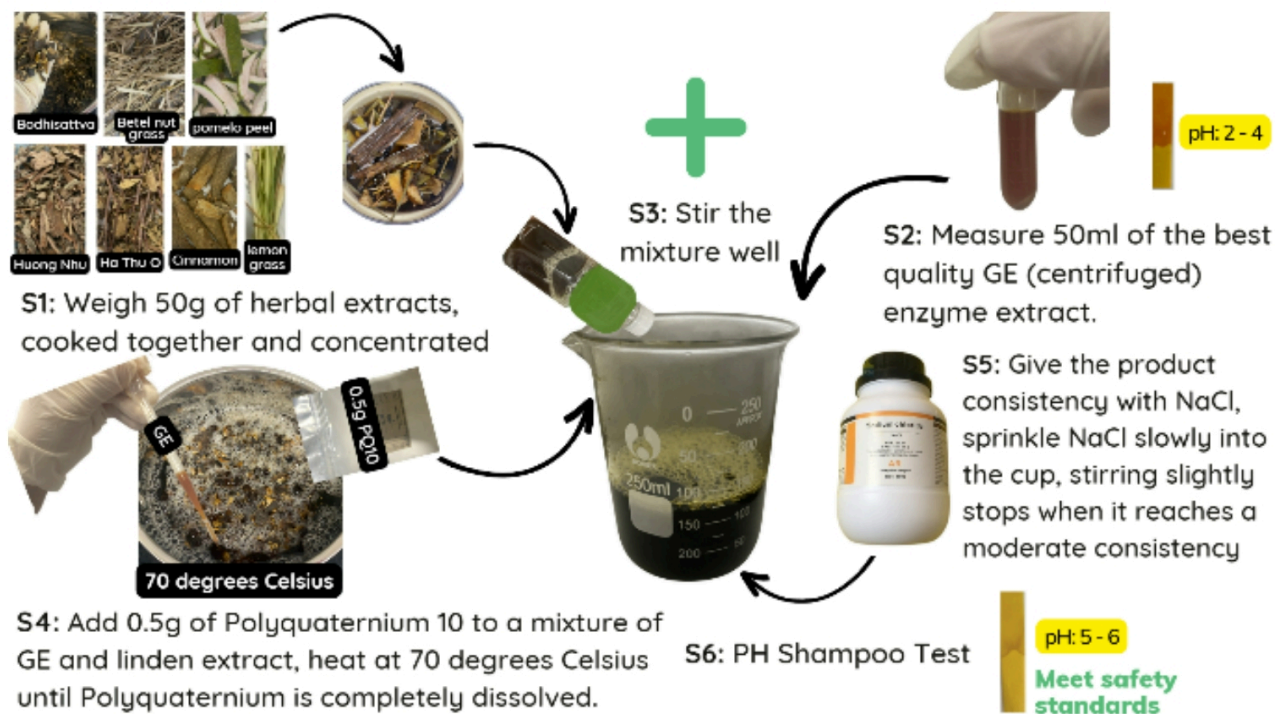


Figure 2

The procedure for preparing bioshampoo from synthetic GE.

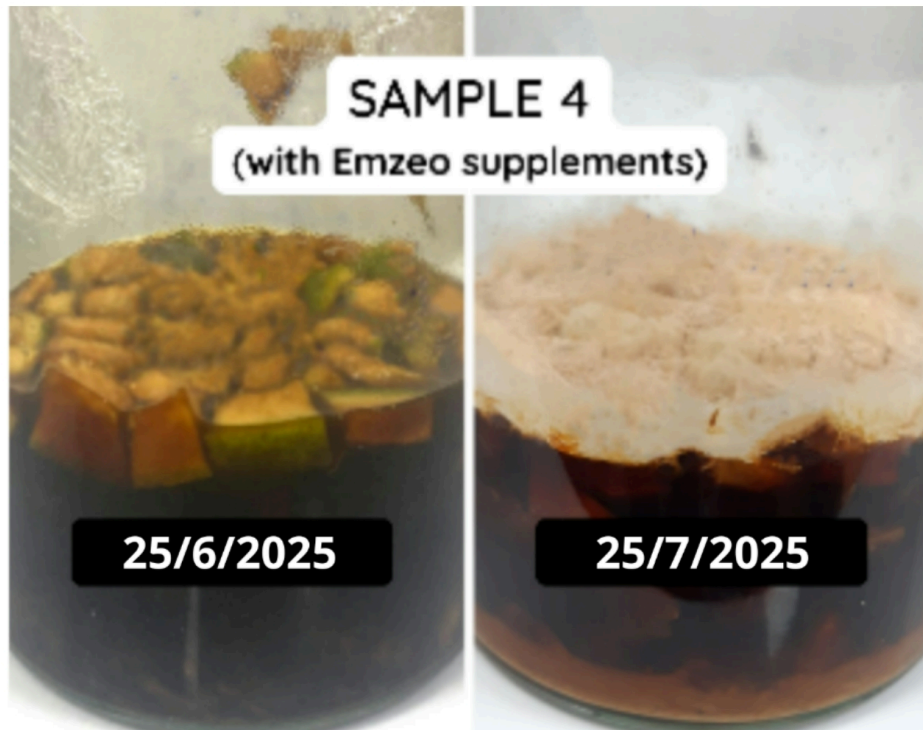


Figure 3

Sample 4 before and after incubation

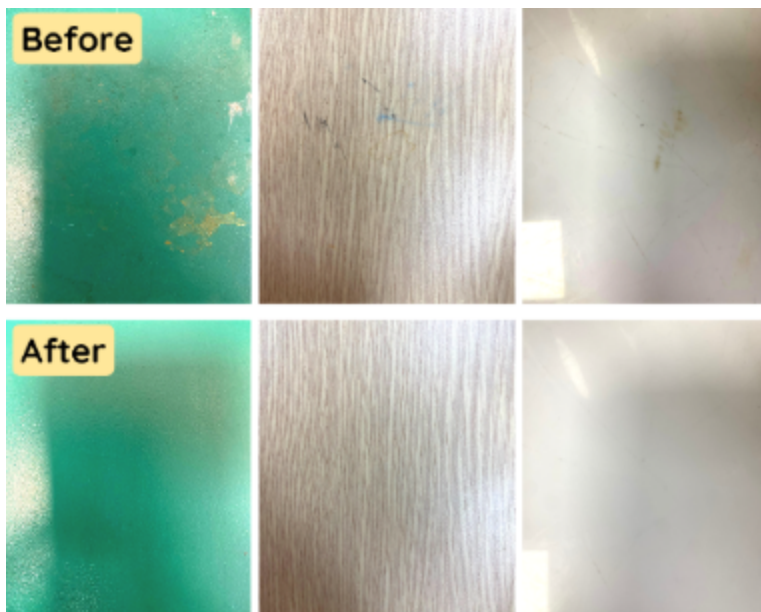


Figure 4

Cleansing capacity of GE enzyme sample 4.



Figure 5

GE enzyme bio-shampoo with PH meets the safety standard for human scalp 5.5

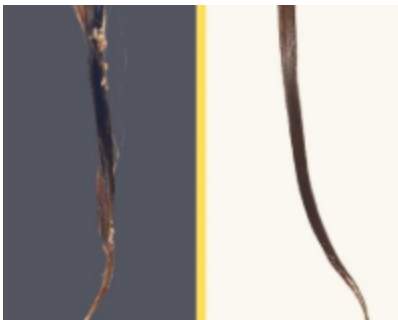


Figure 6

The cleansing power of biological shampoos from synthetic GE enzyme