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Eco-enzyme as disinfectant: a systematic literature review

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ABSTRACT

COVID-19 increases the awareness of cleanliness and sanitation in society. Trends in launching sanitizer and disinfectant products have risen significantly to meet customer demand. However, the existing commercial sanitizer products are mostly chemical-based and may cause adverse effects. Therefore, eco-enzyme is a perfect bio-waste utilization for nonchemical-based sanitization products. The authors investigated eco-enzymes' effectiveness in an aerosol spray from fruit waste for a pleasant natural disinfectant. This review aimed to compile results from previous studies on fruit waste by systematically reviewing empirical studies on household waste practices to develop an eco-enzyme following the PRISMA guidelines. A digital search in five databases from Google Scholar, PubMed, Garuda, Sinta, and Open Alex resulted in 24 relevant journals, considering keywords such as eco-enzyme, disinfectant, and organic waste. The mapping results show that eco-enzyme is feasible and economical for disinfecting and sanitizing surfaces due to its antimicrobial activity. The presence of acetic acids and enzymes (i.e., lipases and amylases) can inhibit specific strains of microorganisms, namely *Escherichia coli* and *Enterococcus* sp.

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1. INTRODUCTION

Until now, waste has been becoming a public concern. Waste means the useless, unwanted, and discarded material or product. Despite being unwanted material, it still can be utilized when humans reuse and recycle it for another product, such as eco-enzyme [1]. Nevertheless, according to the Waste4Change [2], the waste accumulation in Indonesia within 2021 was 24 million tons and dominated by household waste (41.1%). The elevated waste accumulation pushes the application of waste management practices to reduce the negative impact on society [3].

Many works of literature have tried to develop ideas to reduce household food waste. Either by composting it and turning the waste into soil fertilizer full of good organic matter [4], processing it into animal feed [5], or utilizing it as biofuel to replace fossil fuel [6]. However, because those solutions still require energy and resources, recent studies started leaning towards an easier, environmentally friendly, and zero-waste approach in turning the waste into eco-enzyme. Eco-enzyme is easy to produce and is useful as an all-purpose cleaner and disinfectant [7]. Findings represented that eco-enzyme is frequently employed in agriculture (as liquid organic fertilizer and pesticides), health (as disinfectant and cleanser), and household (as a soap and mouthwash substitution). Nevertheless, the existing articles did not discuss the development of eco-enzyme as a potential sanitizer aerosol spray when in fact, eco-enzyme can destroy germs, bacteria, and viruses, including COVID-19. The presence of acetic acid and enzymes (i.e., protease, lipase, amylase) in eco-enzyme led to the ability of eco-enzyme to act as a natural disinfectant, making it useful during the pandemic era [8], [9].

We should consider eco-enzyme's effectiveness in an aerosol spray despite its functionality. Studies have shown that eco-enzyme is suitable for sanitizing and disinfecting surfaces. Disinfectant is needed to prevent us from diseases caused by microorganisms in the hands, the surface of objects, smartphones, and other things that allow bacteria to stick. Diseases caused by bacteria lead people to be infected with mild to severe flu such as COVID-19, or even could attack our digestive organs such as diarrhea. Therefore, the use of eco-enzymes as disinfectants can be utilized to maintain the health of our bodies. Although eco-enzyme has drawbacks in aroma, eco-enzyme is a perfect bio-waste utilization for nonchemical-based sanitization products. Through a systematic review study, we filled the current gap to know the potential of eco-enzyme as an eco-friendly air disinfectant spray. The waste around us has become a public concern. Reducing a large amount of organic waste is possible by transforming it into an eco-enzyme [10]. This defines the aim of this paper, which is to compile results from previous studies on fruit waste by systematically reviewing empirical studies on household waste practices to develop an eco-enzyme.

2. METHOD

The authors conducted a systematic review to identify eco-enzyme's effectiveness as an eco-friendly air disinfectant spray. This systematic review was performed based on the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines, which shown in Figure 1. The authors used five databases, such as Google Scholar, PubMed, and Open Alex, for the English language. In contrast, Garuda and Sinta were also used to discover the published studies for the Indonesian language. The five databases above are chosen due to their relevance to the subject area. An advanced search in five databases from 2012 until 17 March 2022 used eco-enzyme, sanitizer, organic waste, and air-purifier keywords. A limit of 10 years of publication is because food waste has been a significant problem for the last ten years. Recycling waste trends increase where COVID-19 and food waste have been a global problem nowadays. Therefore, the authors use the database with this time span. Moreover, the authors also used synonyms of the listed keywords, as outlined in Table 1. Due to the limited sources of unpublished studies, the authors decided not to include them in this review.

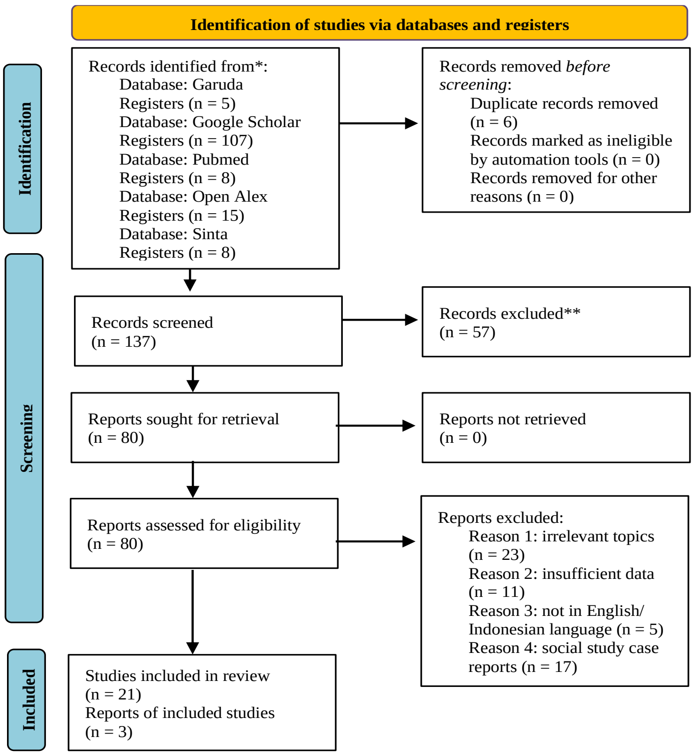

Figure 1. PRISMA diagram

This systematic review will be done by cross reviewing previous experimental results from previous studies to investigate the effectiveness of eco-enzymes in an aerosol spray. The article should meet the following criteria: i) quantitative/qualitative study, ii) primary or secondary research, iii) involved in vitro trials, lab experimentation, and community development as sample characteristics, iv) written in English or Bahasa

Indonesia, v) published within ten years (2012-2022) to ensure the validity of the research. The articles that did not meet the eligibility criteria were excluded, while the rest were retrieved and assessed for their eligibility.

Table 1. Search strings in English and Indonesian

English	Indonesian
"Eco-enzyme as disinfectant" OR "Eco-enzyme as sanitizer" OR "Eco-enzyme as air-purifier" OR "Eco-enzyme" OR "Organic waste" OR "Plant waste" NOT "Inorganic waste"	"*Eko-enzim sebagai disinfektan*" OR "*Eko-enzim sebagai sanitizer*" OR "*Eko-enzim sebagai pembersih udara*" OR "*Eko-enzim*" OR "*Sampah organik*" OR "*Sampah tumbuhan*" NOT "*Sampah inorganic*"

3. RESULTS AND DISCUSSION

A digital search in five databases yielded 143 articles imported to Zotero's bibliography management software for automatic duplication removal (n=6). The rest of the articles (n=137) were screened according to their title and abstract. Not only that, but we also considered the eligibility criteria shown in Table 2.

Table 2. Outcomes of the included articles [11]–[34]

	Subject(s)		Effective	Application
	Criteria	Formulation	(Y/N)	
[11]	Fruit peel (pineapple, citrus)	6:4 of pineapple and citrus peels 30 g molasses, 300 mL of water	Y	Industrial waste treatment
[12]	Fruit or vegetable dregs	1:3:10 of diluent sugar, kitchen waste, and water	Y	Detergent, organic fertilizer, car-care, and fabric softener
[13]	Organic waste (pineapple, orange, tomato, mango)	1:3:10 of organic waste, brown sugar, and water	Y	Aquaculture sludge treatment
[14]	Fruit waste (pineapple, banana, papaya)	1:3:10 of molasses, citrus waste, and water	Y	Antibacterial against *E. coli*
[15]	Fruit or vegetable waste	1:3:10 of molasses, organic waste, and water	Y	Natural disinfectant and Liquid organic fertilizer (LOF) and pesticides
[16]	Citrus waste	1:3:10 of molasses, citrus waste, and water	Y	Fertilizer & wastewater treatment
[17]	Variety of organic waste	1:3:10 of molasses, organic waste, and water	Y	Contaminated water treatment
[18]	Organic waste (orange, papaya, watermelon)	1:3:10 of molasses, organic waste, and water	Y	House cleaner or natural disinfectant and fertilizer
[19]	Fruit waste (orange, apple, peach, pear, watermelon, banana)	1:3:10 of molasses, waste fruits, and water	Y	Antibacterial
[20]	Variety of organic waste (mostly fruit peels)	1:3:10 of molasses, organic waste, and water	Y	Wastewater treatment
[21]	Fruit waste (orange, pineapple, and papaya)	1:3:10 of molasses, organic waste, and water	Y	Antimicrobial against *Enterococcus* sp.
[22]	Fruit peels (orange, pineapple, and papaya)	Not reported	Y	Bar soap
[23]	Fruit peels (oranges)	1:3:10 of sugar, kitchen waste, and water	Y	Natural disinfectant
[24]	Fruit peels (lime, pineapple, pomegranate, and papaya) and vegetable waste	1:3:10 of brown sugar, fruit/vegetable peels, and water	Y	Antibacterial
[25]	Organic waste (rambutan fruit skin, corn cob, and chayote skin)	1:3:10 of molasses, organic waste, and water	Y	Bio-hand sanitizer bio-disinfectant
[26]	Organic waste (citrus peels (orange), marigold flowers, and neem leaves)	1:3:10 of mixing jaggery, wastes, and water	Y	Wastewater treatment
[27]	Domestic organic waste	1:3:10 of sugar, fruit waste, and water	Y	Natural disinfectants
[28]	Fruit peel (pineapple)	1:3:10 of brown sugar, pineapple peel, and water	Y	Antibacterial
[29]	Fruit waste (tomato and orange wastes	1:3:10 of mixture sugar, fruit wastes, and water	Y	Aquaculture sludge treatment
[30]	Fruit peels (orange, pineapple, and papaya)	Not reported	Y	Hand sanitizer
[31]	Fruit peel (sweet lemon)	1:3:5 of jaggery, sweet lemon peel, and water	Y	Antimicrobial
[32]	Fruit peel (orange, pineapple, and papaya)	1:3:10 of brown sugar, fruit peel waste, and water	Y	Natural disinfectant
[33]	Organic waste (pineapple and papaya)	1:3:10 of molasse, organic waste, and water	Y	A natural disinfectant, floor cleaning, and insecticide
[34]	Citrus fruit peels (sweet lime, orange, and lemon)	1:3:10 of brown sugar, fruit peels, and water	Y	Floor cleaning, utensils, gardening, enhanced plant growth

Therefore, we successfully retrieved 24 articles for our systematic review study. Furthermore, we also extracted data from each obtained paper. The authors independently performed the data extraction for 24 accepted papers. Data extraction included i) bibliographic information (author(s) name, publication year, and status), ii) research objectives, iii) origin of the research, iv) subject (samples and criteria), v) study characteristics (formulation, type, design) and vi) result. The formulation of eco-enzyme was extracted to compare the effectiveness and functionality of eco-enzyme made by other researchers. Visualizations of data synthesis are provided in this text in the form of a table and pie chart diagram to summarize the obtained results and recommendations for future study. Table 2 outlined the outcomes of accepted articles related to the subjects, effectiveness, and application of eco-enzyme.

Figure 2. shows that the formulation for making this eco-enzyme has a ratio of 1:3:10 of sugar/brown sugar/jaggery, organic waste, and water, which is the primary ratio used to make eco-enzymes. The percentage of the enzyme is 88% and is the most significant ratio among other formulations. There is 4% in the ratio of making eco-enzyme with a magnitude of 1:3:5 of sugar/brown sugar/jaggery, organic waste, and water, which is eco-enzyme production carried out by Geetha and Kaparapu [31], while the percentage is 8% resulted from not reported formulation of eco-enzyme as shown in Megawati and Nugroho [22], and Rusdianasari *et al.* [30].

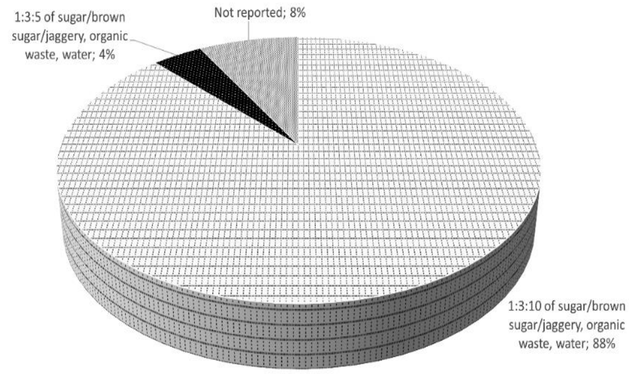

Figure 2. Formulation of eco-enzyme

Through Figure 3, it can be seen that the application of eco-enzyme can be used as a natural disinfectant by 25% and is the most preferred choice for people to use eco-enzyme in their daily life. In addition, eco-enzyme is also an option for people for wastewater treatment with a percentage of 13%. Aquaculture sludge treatment is also the center of attention for managers so as not to cause contamination that can affect the environment with a percentage of 8%. Moreover, 8% of eco-enzyme applications can also be applied as antibacterial and antimicrobial, in which eco-enzymes can be used to prevent exposure to microbes such as *Enterococcus sp.* 46% of other eco-enzyme applications are used by people as hand sanitizer, bar soap, fertilizer and wastewater treatment, floor cleaning, utensils, gardening, enhanced plant growth, insecticide, detergent, car care, and fabric softener.

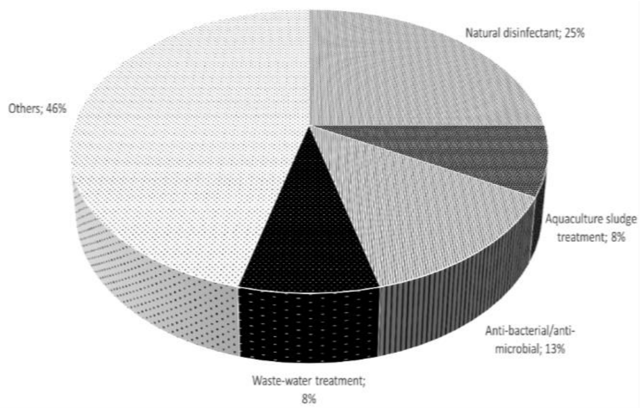

Figure 3. Applications of eco-enzyme

3.1. Chemical disinfectant compared to natural disinfectant on health problems

Nowadays, it is essential to do disinfection practices to reduce the potential COVID-19 virus contamination in every setting, such as homes, schools, gyms, offices, and other public places. However, disinfectants use chemicals to kill germs on surfaces and objects. Some common disinfectants are bleach and alcohol solutions. We usually need to leave the disinfectant on the surfaces and objects for a particular time to kill the germs. Disinfectants that contain strong chemicals and disinfectants have health risks for people and pets. When they are washed down the drain, they contaminate our waterways and soil as we can smell the chemicals whenever we use these cleaning products, and the labels even warn us to wear gloves, avoid contact with skin and eyes, and not to breathe in the fumes. Thus, even though chemical-based disinfectants can sanitize and disinfect surfaces, reducing the likelihood of spreading illness-causing bacteria and viruses, they can also cause allergic reactions, skin irritations, respiratory issues, and other health problems. Using all-natural disinfectants like eco enzyme is a far healthier and safer choice as it avoids breathing in the harsh chemicals in toxic cleaning products, reducing the chance of skin conditions such as eczema and respiratory infections [27].

3.2. Definition and procedure of making eco-enzyme

From all 24 studies, 20 studies' results show formulation of eco-enzyme with the ratio of sugar, organic waste, and water (1:3:10) being effective for applications such as cleaning agents, disinfectants, insecticides, aquaculture sludge treatment agents, wastewater treatment agents, hand sanitizer, fertilizer, and even solution for specific for combatting *E. coli* strain. The reason bio- enzyme with the formulation of 1:3:10 is effective for those purposes, especially as fertilizer, is that the formulation of 1:3:10 could produce bio-enzyme with pH above four, which is slightly acidic than the base is due to the high water dilution. Thus preventing plants from experiencing acid burn when the bio-enzyme is used as a fertilizer. Bio-enzyme could also be an effective fertilizer since bio-enzyme could not deactivate soil biology and other beneficial bacteria [34]. Other formulations besides 1:3:10, such as bio-enzyme made from formulation 1:3:5 (sugar, organic waste, and water) and other unreported formulations, were also effective to be used for sanitation and water treatment purposes due to less water-diluted bio-enzyme would be more acidic than higher diluted bio-enzyme such as formulation of 1:3:10 which is still effective for sanitization, water treatment, cleaning agent purposes but not suitable as fertilizer. Thus, all 24 studies were effective for each application (Y).

Eco-enzyme is a multi-purpose solution made from the fermentation of organic waste with molasses and water. Previous studies revealed that eco-enzyme has a wide application in our daily life, either in the household or agricultural field. Hence, it is recommended for society to utilize organic waste as an eco-enzyme. Making eco-enzyme is based on anaerobic fermentation with a 1:3:10 ratio of molasses/brown sugars/jaggery, organic waste, and water. Approximately 10 g of molasses, 30 g of organic waste, and 1,000 g of water are necessary for eco-enzyme production. However, the 1:3:10 ratio rule for eco-enzyme production is not mandatory to be followed and may differ from one another. For instance, Saramanda and Kaparapu [31] used the 1:3:5 ratio for eco-enzyme production. The criteria for organic waste selection must be either fresh fruit or vegetable waste or peels and has not spoiled/biologically contaminated. All materials for eco-enzyme production are gathered in one container equipped with a lid for up to three months. Nonetheless, the container should be opened occasionally for the gas release due to microbial activity. In addition, the jar should be narrow enough and provide room for the gas release to avoid explosion. After three months, the eco-enzyme solution is filtrated and mixed with water for future uses, such as house cleaning fluid and pesticides [7]. During the storage period, eco-enzyme must be kept away from the children's reach, Wi-Fi radiation, toilet, and other potential cross-contamination sections and hazards [35].

Eco-enzyme results from the fermentation of organic waste made from fruits/vegetable scraps, molasses, and water. Eco-enzyme typically acts as an all-purpose cleaner and disinfectant; therefore, a few criteria must be met to ensure the enzyme produced is safe to use. The ingredients criteria are raw fruits/vegetable waste and clean water [11]. Using cooked food that has an oil residue, meat scraps, and dirty water will produce rotting liquid trash instead of eco-enzyme. Raw fruits/vegetable scraps naturally contain bacteria that will feed off of the sugar from the molasses and kickstart the fermentation process. Moreover, clean water will ensure that harmful bacteria do not contaminate the eco-enzyme [14].

3.2.1. Pros and cons of eco-enzyme

There are a few pros and cons to using eco-enzyme as an alternative cleaning product like any other product. The pros of the eco-enzyme are that it is cheap because the main ingredients are raw fruits/vegetable scraps, easy to produce, non-toxic because it is made from all-natural ingredients (free of harmful chemicals), and environmentally friendly. Eco-enzyme has been used to treat wastewater [16] and sludge removal from freshwater [29] as a cheaper alternative to regular waste handling procedures [26]. Eco-enzyme can also be used to clean multiple surfaces without any toxic side effects on humans and pets [12]. Moreover, the wastes from making the eco-enzyme can be used as an excellent fertilizer, thereby reducing the amount of garbage in the landfill [15].

The cons to this eco-enzyme are that if the pH of the final product happens to be below 4, it is considered too acidic [27]. If used as pesticides or fertilizer on plants, the eco-enzyme could cause an "acid burn" and kill the plants [34]. Another drawback of eco-enzyme is the time it takes to ferment—the fermentation process of eco-enzymes takes three months to meet the SNI standards as sanitizers [30], [32]. Eco-enzyme's other name is garbage enzymes. True to its name, the odor of the enzyme can be slightly sour (vinegary) and unpleasant to the olfactory. The formulation and types of raw fruits/vegetable scraps used can be slightly trickier to figure out [11].

Because eco-enzyme is also considered garbage enzyme, sometimes the fermentation result can produce a sharp and unpleasant sour odor. Furthermore, since eco-enzyme is often used as a cleaner and even hand soaps, the harsh fermentation smell can deter customers' willingness to try it. However, with the addition of citrus peels, the sharp odor can be masked, producing a fresh citrusy smell associated with regular cleaning products and hand soaps. The desirable color for eco-enzyme is dark brown. The brown color comes from the molasses used during fermentation, indicating a successful fermentation process. If the color of the co-enzyme is black, that means that the enzyme is contaminated and it is unusable [18].

3.3. The potential and effectiveness of eco-enzyme as a natural disinfectant

The effectiveness of eco-enzyme as cleaner and disinfectant has been proven many times before in numerous works of literature. Galintin *et al.* [13] proved that a concentration of 10% eco-enzyme can treat aqua sludge and reduce total suspended solid (TOD) by 89%, volatile suspended solid (VSS) by 78%, chemical oxygen demand (COD) by 88%, total ammonia nitrogen (TAN) by 94%, and total phosphorus (TP) by 97%. Hemalatha and Visantini [16] proved that wastewater contaminated by heavy metals treated using eco-enzyme reduced biological oxygen demand (BOD) by 70%, total solids (TS) by 32.5%, total dissolved solids (TDS) by 39.5%, and TSS by 33%. Kerkar and Salvi [20] treated wastewater with a concentration of 10% eco-enzyme. They reduced the numbers of TDS, BOD, COD, and most probable number (MPN), increasing the pH of the wastewater to near neutral (6.82) and meeting the irrigation standards in five days. Bharvi *et al.* [26] proved that eco-enzyme could replace expensive wastewater treatment since eco-enzyme TDS and COD. According to the paper, orange peels based eco-enzyme is the most effective eco-enzyme in decreasing TDS from 3,200 to 2,800 mg/L within 50 days period and marigold eco-enzyme was the most effective in reducing chemical oxygen demand in wastewater from 1,920-1,028 mg/L at 30 days period.

Ginting *et al.* [14] did an *in vivo* experiment that proves diluted eco-enzyme at 1:30 can inhibit the growth of *E. coli* in pig pens. Jiang *et al.* [19]; Rochyani *et al.* [33] showed that a low pH eco-enzyme could act as an inhibitor and inhibit the growth of bacterial community and diversity, making it suitable as a disinfectant and cleaner. Eco-enzyme can be an alternative to endodontic irrigants in dentistry. Mavani *et al.* [21] proved that a concentration of 50% eco-enzyme has similar results to the endodontic irrigants inhibiting *Enterococcus faecalis* strain and without the harmful side effect. Neupane and Khadka [24] proved that pomegranate eco-enzyme has the highest enzymatic activity inhibition on all agar media and has the highest effectiveness in inhibiting gram-positive bacteria such as *S. aureus*, *S. aureus* (ATCC 25923), and *Bacillus spp*. In contrast, the pineapple eco-enzyme has the highest antimicrobial properties against gram-negative bacteria.

Megawati and Nugroho [22] showed that eco-enzyme has the possibility as one of the ingredients in creating hand soaps that meet the SNI standards. Mubarok *et al.* [23] and Nurdin *et al.* [25] showed that eco-enzyme is an excellent utilization of bio-waste for producing a safe and sustainable disinfectant/sanitizer because of the presence of acetic acid and naturally occurring enzymes such as lipase, trypsin, and amylase. Rahayu and Situmeang [27]; Ramadani *et al.* [28] showed that a concentration of 50% eco-enzyme with 60-70% alcohol and pH below four infused with frangipani flower extract has strong inhibition power against *Staphylococcus aureus*. Saramanda and Kaparapu [31] proved that a concentration of 15% eco-enzyme works best in inhibiting *E. coli*, *S. aureus*, *Streptococcus*, *Salmonella*, and *Pseudomonas* for bacteria and *Aspergillus niger*, *Fusarium* and *Cladosporium* for fungi.

The fermentation of organic waste into eco-enzyme creates natural chains of proteins, mineral salts, and enzymes. This solution can break down, develop and catalyze functions into an excellent cleaning aid. Regarding eco-enzyme antimicrobial effect and water irrigants, the raw material used for making eco-enzyme also served an important role [7]. Natural plant extracts have been studied as a potential substitute for NaOCl as endodontic irrigants. Ginting *et al*. [14], Jannah *et al*. [18], Jiang *et al*. [19], and Mavani *et al*. [21] reported that fruit peels had displayed antimicrobial activities against various microorganisms, including *Enterococcus faecalis*. Following fermentation, the antibacterial properties of fruit peels are further enhanced as organic substances are decomposed, yielding secondary metabolites known as bioactive compounds or phytochemicals. The extraction of enzymes, organic acids, and phenolic compounds through the fermentation process is preferred over conventional methods that require costly solvents, involve the possible degradation of heat-labile compounds, and hard to obtain high purity extracts. Thus, fermented fruit peels, known as eco-enzyme, could be an alternative endodontic irrigant [15].

For instance, an eco-enzyme extracted from fermented unripe papaya (*Carica papaya*) peels is rich in papain, exhibiting significant antibacterial efficacy against *Enterococcus faecalis*. A study by Duarte and co-workers reported that 0.8% of papain is equally effective as 1.0% NaOCl in inhibiting *Enterococcus faecalis* growth. It has less harmful effects on vital tissues than NaOCl, as its proteolytic activities selectively target unhealthy tissues where α1-antitrypsin plasmatic antiprotease is absent. Besides, phytochemicals found in the papaya peel eco-enzyme demonstrate a potential anti-inflammatory effect, which minimizes the chronic inflammatory process and tissue destruction, particularly in apical periodontitis [29]. Similarly, eco-enzyme derived from pineapple *(Ananas comosus*) and orange (*Citrus aurantium* L.) peels have been shown to have antimicrobial and anti-inflammatory properties. The synergistic effect of the two eco-enzymes increases the potency of their antimicrobial activity against a wide range of bacteria. The high content of polyphenolic compounds and flavonoids in pineapple and orange peel extracts are found to be responsible for their excellent antimicrobial and antioxidant activities. Bromelain from pineapple extracts effectively kills *Enterococcus faecalis* by disrupting the peptidoglycan and polysaccharide components of bacterial cell membranes [1].

Dhiman and Head [12] also reported that eco-enzyme could be used as a natural detergent, eco-enzyme can effectively break down grease and artificial chemical contaminants. Pouring diluted eco-enzyme into the rivers or drainage can purify the wastewater [16], [17], [20]. The ordinary detergent's surfactant will emulsify grease and drain away with water, making the wastewater polluted. However, the eco-enzyme detergent will effectively catalyst and break down grease into small molecules and intensify the cleaning process [1]. In terms of eco-enzyme as pesticides and natural fertilizers, studies such as Dhiman [12], Hasanah [15], Hemalatha and Visantini [16], Jannah *et al.* [18] have shown that growing plants without using chemical fertilizers can protect the environment and keep us healthy. Eco-enzyme is very useful for agriculture, where eco-enzyme can build fertile soil due to many nutrients found in the waste used to make it. Eco-enzyme also acts as a natural fertilizer. It can make a barren land fertile, repelling pests without using pesticides; spraying the mixture of eco-enzyme with water on the lawn will reduce insects. It is a natural herbicide, helping plants grow well, and eco enzymes can enhance photosynthesis. As a result, plants will get more nutrients, and their roots can absorb more air. In addition, the emitted ozone from eco-enzyme facilitates the growth of plants. Using eco-enzyme to clean areas for keeping livestock can make them healthier [14]. It maintains the cleanliness where eco-enzyme acts as a natural air freshener and by praying it on the floor of the shed for keeping animals can keep flies foul odor away. As a result, domestic animals will have a cleaner place to live. Eco-enzyme can also Improve animal health whereby. Adding eco-enzymes to food and water for feeding domestic animals can boost their immune system and improve the quality of poultry or meat because the waste used for making eco enzymes is rich in nutrients [7].

Furthermore, the eco-enzyme itself could be used as an aerial disinfectant in the form of fine mist via aerial fogging to target airborne pathogens, including the COVID-19 virus strain [36]. In addition, eco-enzyme is also beneficial to the earth's atmosphere because fermentation of eco-enzyme could produce gas such as ozone. To create an eco-enzyme suitable for aerial disinfection purposes, the eco-enzyme must be highly diluted with a water ratio of 1:1,000 ml [35]. The eco-enzyme is also infused with aromatherapy essential oil for fragrance since not all fermented eco-enzymes smell pleasant. The addition of essential oil enhances the freshness and significantly decreases the acidic smell of the eco-enzyme from producing acetic acid and alcohol [10].

According to recent studies, eco-enzyme can act as a disinfectant against pathogenic microbes due to the contained biocidal enzymes with an acid such as trypsin, lipase, amylase, and acetic acid [25]. Acetic acid is biocidal since its mechanism triggers biocidal effects against the virus envelope by inactivation and disaggregation of haemagglutinin glycoprotein structure. Furthermore, acetic acid itself could generate low pH-dependent conformational change toward COVID-19 glycoproteins destroying the viral envelope that protects the viral DNA of COVID-19. Thus, it inhibits viral transmission of COVID-19 and other airborne diseases. Acetic acid as inhalation medication against airborne pathogenic is a common folk remedy in Italy by diluting vinegar into boiling water and inhaling it [37]. The result of eco-enzyme with a ratio of molasses, organic waste, and water being 1:3:10 before adding essential oil and high-water dilution on pathogenic microbe analyses by the Health Laboratory of Semarang shows that eco-enzyme as the aseptic aerosol spray is effective due to its biocidal effect could reduce the total viable count of the pathogen from 61% to 38% just in an hour [10]. Mubarok *et al.* [23] also reported that a high concentration of orange peel in total organic waste for the production of eco-enzyme would contribute to the increase of specific biocidal flavonoid formation called hesperidin that could act as antibacterial, antifungal, antiviral, cell aggregation inhibition, and even UV protecting activity.

3.4. Article limitation

This review has several limitations in terms of article inclusion. To ensure the validity of the studies, we only included articles within ten years of publication from five databases. Furthermore, we could only interpret the obtained data qualitatively since we did not perform the analysis. Instead, we compiled results from previous studies to know the potential and application of eco-enzyme to act as a disinfectant.

4. CONCLUSION

This systematic literature review study shows that eco-enzyme is feasible, economical, and a perfect bio-waste utilization for nonchemical-based sanitation products for specific strains of microorganisms. Not only microorganisms but eco-enzyme is also effective against pest removal in the agricultural field. Hence, the transformation of eco-enzyme from organic waste is expected to reduce the amount of accumulated waste significantly. For future research, the authors suggested observing more the capabilities of eco-enzyme in various fields, especially for medicinal purposes.

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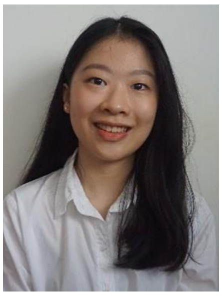

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