Anti-bacterial Activity of Alginate Based Edible Coating Solution Added with Lemongrass Essential Oil Against Some Pathogenic Bacteria

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Abstract. Edible coating is a thin layer that can be made of several materials, one of which is polysaccharides, such as alginates, carrageenan, agar, chitin, chitosan, pectin, starch, cellulose derivatives, and gums. The application of food products with edible coatings has been widely carried out and has been proven to improve quality and extend the shelf life of the product. Antibacterial agent can be added to improve the performance of edible coating. This study was aimed to explore the potential of lemongrass essential oil as an antibacterial agent in alginate based antibacterial edible coating solutions, especially against pathogenic bacteria. Edible coating is made of alginate powder, modified cassava flour (Mocaf), beeswax, glycerol and antibacterial agent. The additional levels of lemongrass essential oil into edible coating formula were 0.25, 1.50 and 0.75%. The antibacterial activity of the edible coating solution produced was tested against Escherichia coli, Staphylococcus aureus, Salmonella, and Pseudomonas aeruginosa by employing a disk diffusion testing method. Antibacterial agents used in previous studies to develop alginate-based antibacterial edible coatings and potential applications of the developed alginate-based edible coatings incorporated with lemongrass essential oil were identified by browsing through the internet. The results showed that various antibacterial agents have been explored to improve the performance of alginate based edible coatings. An antibacterial activity study exhibited that the highest antibacterial activity was found in the edible coating with the addition of 0.50% lemongrass essential oil, except for S. aureus at the addition level of 0.75%. This study suggests that the addition of lemongrass essential oil for the manufacture of alginate based edible coating solution is 0.50%. The potential uses of edible coatings made from alginate with the addition of lemongrass essential oil are to coat various animal and plant based food products.

1. Introduction
Edible coating is often confused with edible film and is even considered as another name for one another. Edible coatings are different from edible films. Edible films, according to Ottoni [1], are structures that are prepared and then applied to food surfaces, between food components, or even sealed into edible pouches. Edible coatings, on the other hand, are applied directly to food surfaces by
dipping, spraying, or panning, the latter of which is accomplished by combining the food material and the coating solution in a spinning bowl and then drying it.

Edible coating is a thin layer that can be made of several materials, one of which is polysaccharides, such as alginates, carrageenan, agar, chitin, chitosan, pectin, starch, cellulose derivatives, and gums [2]. The application of food products with edible coatings has been widely carried out and has been proven to improve the quality and extend the shelf life of food products [3]. Alginate which is one of the ingredients for the manufacture of edible coatings can be obtained by extracting it from brown seaweed. Indonesia is rich in various types of seaweed, including brown seaweed (Phaeophyceae), such as Sargassum filipendula, Sargassum duplicatum, Hormophysa tricuutra, Turbinaria conoides and T. decurens [4]. Brown seaweed has not been farmed in Indonesia, therefore the need for the seaweed for alginate production or other purposes is obtained by harvesting it in the wild. Sargassum spp is a type of brown seaweed that is abundantly available in Indonesian waters, so the availability of alginate which is used for edible coating preparation can be guaranteed, especially if its culture has been developed in the future. The culture of Sargassum spp. has not yet developed, because its needs can still be met by harvesting from nature.

The performance of alginate-based edible coatings can be improved by adding antibacterial agents. One option that can be used as a source of antibacterial is essential oil. Various types of essential oils from spices are reported to have potential to be developed as a preservative because it has antimicrobial activity, including against pathogenic bacteria and food spoilage. One of the plants that can be extracted its essential oil is lemongrass which is widely used for cooking spices in Indonesia and other purposes [5]. Lemongrass is included in the five main plants among various plants in the tropics besides turmeric, curcuma, cutcherry, vetiver, galangal and others. Lemongrass is one of the commodities that have the potential to be developed for its use, both as a food ingredient and as an industrial raw material. As a food ingredient, lemongrass is widely used as a spice in some processed foods. Meanwhile, as a raw material for the lemongrass industry, it can be processed into citronella oil or into citral. Increasing the added value of the lemongrass plant can be performed by extracting or distilling into essential oils [6]. Lemongrass essential oil has antimicrobial activity on gram positive and gram negative bacteria [7].

The use of essential oils in edible coating solutions is expected to improve its performance. Therefore, this study was aimed to explore the potential of lemongrass essential oil as an antibacterial agent in alginate based edible coating solutions, especially against pathogenic bacteria.

2. Material and Method

2.1. Material

Alginate powder was obtained from the extraction of brown seaweed Sargassum sp purchased from a seaweed trader in Gunung Kidul, Yogyakarta. The modified cassava flour (Mocaf) of the “Ladang Lima” brand used was purchased from an online shop. Meanwhile, PT Geochem Globalindo (Jakarta, Indonesia) provided beeswax, glycerol and tween 80 as well as lemongrass essential oil. According to certificate of analysis provided by CV. Pavetta Wangi Atsiri, lemongrass essential oil was extracted from Cymbopogon flexuosus and characterized to have 70% citral content, 0.887 specific gravity, 1.485 refractive index, -2.10° optical rotation and reddish yellow colour [8].

2.2. Alginate extraction

After being washed and soaked in KOH solution, the freshly harvested Sargassum is dried in the sun. NaOH solution was then used to soak dried Sargassum for 2 hours and continued with neutralization by washing it with fresh water. Sargassum was boiled in Na₂CO₃ solution for 2 hours and then filtered to extract alginate. After blanching the filtrate with NaOCl, it was acidified with HCl to pH 2.5 to 3. The obtained alginic acid was rinsed with water before being mixed with NaOH to achieve pH of 9 to 10. To get alginate fibers, the sodium alginate was precipitated with isopropanol. The alginate fiber was sun-dried and ground to produce alginate flour [9].
2.3. **Preparation of edible coating solution**

Alginate-based edible coating was prepared by employing a method developed by Murdinah et al [10]. First, 100 ml of distilled water was heated to 70-80°C and then 1.5 g of alginate powder was added while stirring using a magnetic stirrer. The solution was added with 0.5 g Mocafo, 0.25 g beeswax, and 1 ml glycerol. Each ingredient is added one by one after the previous ingredients have dissolved. The homogeneous solution was removed from the hotplate and cooled to room temperature which was then added with lemongrass essential oil. The antibacterial of lemongrass essential oil was prepared by mixing each level of 2.5% (2.5 ml), 5% (5 ml), and 7.5% (7.5 ml) into 1.25 ml, 2.5 ml, and 3.75 ml of tween 80, respectively. The dissolved mixture is then put into a cold edible coating solution, then stirred until homogeneous. The solution is ready to be tested for antibacterial activity.

2.4. **Antibacterial test**

Antibacterial test was carried out by modified disc method [11] against *Escherichia coli*, *Staphylococcus aureus*, *Salmonella*, and *Pseudomonas aeruginosa*. The test bacterial suspension was made by inoculating the bacteria on an agar slant first, then one loop was taken and suspended in 5 ml of TSB (Tryptone Soya Broth) solution and incubated in a water bath shaker at 37°C for 24 hours. Approximately 100 μL of bacterial suspension was put into a sterile petri dish, then 5 mL of Nutrient Agar was poured. The disc paper that was previously dipped evenly into the edible coating solution, was removed and left for 10 minutes, then placed on the media after the agar hardened. The positive control and negative control used in the analysis were chloramphenicol and distilled water, respectively. A Scan® 1200 Colony Counter (Interscience, France) was used to measure the diameter of the formed inhibition zone.

2.5 **Identification of antibacterial potential and application opportunities of alginate-based antibacterial edible coatings**

Essential oils, plant extracts and chemical compounds that showed antibacterial activity and were considered potentially used in the development of alginate based edible coatings were identified from the results of previous studies published as scientific articles through online searching. While, food products that showed a potential to be improved their quality and shelf life by employing the developed alginate-based edible coatings incorporated with a selected antibacterial agent, i.e. lemongrass essential oil, were also identified from scientific publications by browsing through the internet.

2.6. **Data Analysis**

The data obtained related to alginate-based antibacterial edible coatings were analysed descriptively to identify potential antibacterial materials which were abundantly available in Indonesia and considered for further study to develop alginate based antibacterial edible coatings against pathogenic bacteria. Meanwhile, the optimum effectiveness of antibacterial edible coatings developed using selected antibacterial agents, namely lemongrass essential oil against *E. coli*, *S. aureus*, *Salmonella*, and *P. aeruginosa* was determined by comparing quantitatively based on the diameter of the inhibition zone according to laboratory studies conducted in two replications. Utilization trends were employed to identify food products that were suitable for the application of alginate and lemongrass essential oil based antibacterial edible coating based on the results of studies that have been carried out by scientists around the world in the form of published scientific reports or articles. Therefore, a list of food products will be produced with potential to improve quality and shelf life by coating them using an alginate-based edible coating solution inserted with lemongrass essential oil.

3. **Results and Discussions**

3.1. **Development of Antibacterial Edible Coating**

Edible coating solutions have been widely used for various applications in foods and also have been intensively studied and scientifically reviewed by Dhall [12], Khan et al [13], Han [14], Raghav et al
Alginate was used as a component in the manufacture of edible coating in this study, while some researchers have used alginate as an ingredient in the production of edible coatings as well including Cahyana et al [23], Koushki et al [24], Chiabrando and Giacalone [25], Parreidt et al [26], Parreidt et al [27], Alexandre et al [28], Giyatmi et al [29], and Medina-Jaramillo et al [30].

Table 1. Antibacterial agents that have been used in the development of alginate based edible coating

| No. | Antibacterial Agents                          | References |
|-----|---------------------------------------------|------------|
| 1.  | Basil essential oil                        | [31]       |
| 2.  | Betel essential oil                        | [32]       |
| 3.  | Chitosan                                    | [23] [25] [33] |
| 4.  | Cinnamon essential oil                      | [34] [35] [36] |
| 5.  | Clove essential oils                        | [34]       |
| 6.  | Grapefruit essential oil / grapefruit seed extract | [37] [38] |
| 7.  | Lemon (Citrus lemon L.) essential oil        | [39]       |
| 8.  | Green grass jelly leaves essential oil       | [40]       |
| 9.  | Lactic acid bacteria                        | [41]       |
| 10. | Lemon (Citrus lemon L.) essential oil        | [39]       |
| 11. | Lemongrass essential oil                    | [34] [42] [43] [44] [45] |
| 12. | NanoZnO                                     | [46]       |
| 13. | Nutmeg essential oils                       | [36]       |
| 14. | Olive leaves extract                        | [47]       |
| 15. | Oregano essential oil                       | [42] [48] |
| 16. | Pomegranate peel extract                    | [49]       |
| 17. | Probiotic                                   | [16] [50] |
| 18. | Quercetin glycoside compound                | [51]       |
| 19. | Rosemary essential oil                      | [48]       |
| 20. | Shirazi thyme (Zataria multiflora Boiss) essential oil | [52] |
| 21. | Complex of trans-cinnamaldehyde in beta-cyclodextrin | [53] |
| 22. | Vanillin / vanilla essential oil             | [40]       |

The development trend of edible coatings in recent years, including alginate based edible coatings, is antibacterial or antimicrobial edible coatings. Various types of antibacterial and antimicrobial agents that have been investigated for the manufacture of alginate based antibacterial edible coatings are shown in Table 1. Most of the antibacterial materials explored for use in edible coatings with alginate as a component in the manufacture are obtained by extracting them from plants and animals. Antibacterial extracted from animals, especially crab and shrimp shells, namely chitosan. While antibacterials extracted from plants are generally in the form of essential oils, such as oregano, vanilla, clove, lemongrass, cinnamon, rosemary, nutmeg, lemon, orange, grapefruit, green grass jelly leaves, and shirazi thyme essential oils. Among the antibacterial agents that have been studied, lemongrass essential oil is the most interesting to study its use in alginate-based edible coatings [34] [42] [43] [44] [45]. Those studies revealed that edible coating with lemongrass essential oil showed antibacterial activity and increased product quality and shelf life. Lemongrass plants are widely cultivated in Indonesia, because lemongrass is a type of spice that is commonly used in Indonesian cuisine. By considering those facts, the utilization of lemongrass essential oil as an antibacterial agent in alginate based edible coatings has good prospects in the future. Therefore, the use of lemongrass essential oil in this study to develop alginate based antibacterial edible coating is on the right track.

Lemongrass essential oil has main components consisting of 42.11% geranial (citral α), 34.78% neral (citral β), and 13.71% mirsen. The presence of geranial (citral α), neral (citral β) and mirsen, then
Lemongrass essential oil has potential as anti-amoebic, antibacterial, anti-diarrheal, and anti-fungal [54] [55]. Lemongrass oil was reported to contain iso-thujone, neral (Z citral), cis-geraniol, geranial (E citral), neryl acetate, trans farnesol, β-caryophyllene, and γ-cadinene. Citral as the main component of lemongrass essential oil contains 66.21%. Those compounds are suspected to play a role in the antibacterial activity of lemongrass essential oil [56].

3.2. Antibacterial activity of alginate based antibacterial edible coating solution

The alginate based antibacterial edible coating solution produced in this study and being ready to be applied to food products was tested for its antibacterial activity against *E. coli*, *S. aureus*, *Salmonella*, and *P. aeruginosa*.

3.2.1. *Escherichia coli*. Alginate based antibacterial edible coating solution using lemongrass essential oil showed antibacterial activity against *E. coli* (Figure 1) and its activity increased with increasing concentration of lemongrass essential oil from 2.5% to 7.5% with inhibition zone diameter from 6.00 mm to 8.70 mm (Table 2). The increase rate of antibacterial activity decreased significantly at the additional level of lemongrass essential oil from 5% to 7.5%. Thus, if the target is to suppress the growth of *E. coli*, the addition of lemongrass essential oil to the alginate based edible coating can be performed up to 5% to obtain optimal antibacterial activity.

![Figure 1](image-url)

*Figure 1 Inhibition zone of alginate based edible coating added with the lemongrass essential oil against Escherichia coli (Replications 1 and 2)*

On day 0, an alginate-based edible coating containing malic acid but no essential oil was effective against the population of *E. coli* O157:H7 in fresh cut apples, with a 1.23-log reduction in population. When essential oils that were cinnamon, clove, and lemongrass essential oils, or their active components were added into the edible coating, however, higher inhibition of this pathogen was achieved, resulting in an improved antimicrobial action. In general, the more powerful an essential oil is, the higher its concentration [34]. Similar occurrence was demonstrated by soy-protein edible coatings incorporated with up to 3% thyme or oregano essential oils which exhibited antibacterial activity against *E. coli* [57]. The addition of nanochitosan suspension to carrageenan-modified starch based edible coating also resulted in inhibitory activity against *E. coli* [58].

| Concentration of lemongrass essential oil in edible coating (%) | Average Value of Inhibition Zone (mm) |
|---------------------------------------------------------------|--------------------------------------|
| 2.5                                                          | 6.60±0.00                            |
| 5                                                            | 8.13±0.11                            |
3.2.2. *Staphylococcus aureus*. Antibacterial activity against *Staphylococcus aureus* was shown by alginate-based edible coating solution using lemongrass essential oil as an antibacterial agent as demonstrated in Figure 2. The antibacterial activity increased with the higher addition level of lemongrass essential oil into alginate based edible coating solution. The lowest and highest inhibition zone diameter values were 6.93 mm and 8.2 mm which were indicated by edible coating with the addition of 2.5% and 7.5% lemongrass essential oil, respectively (Table 3).

![Figure 2](image)

*Figure 2* Inhibition zone of alginate based edible coating added with the lemongrass essential oil against *Staphylococcus aureus* (Replications 1 and 2)

*S. aureus* was also inhibited by a grouper bone gelatine coating made with chitosan, clove, and pepper essential oil and utilized as an edible coating for vacuum-packed fish steak [59]. Antimicrobial activity of soybean protein coating with oregano and thyme essential oils was also demonstrated against *S. aureus*. When 3 % essential oils were applied to soybean edible coatings, they had a high antibacterial action against *S. aureus* [57]. On the other hand, a study on sago-alginate starch edible films incorporated with lemongrass oil (0.1 - 0.4 %, v/w) found no inhibition zone against *S. aureus*. This is most likely owing to the loss of some active chemicals that are more efficient at preventing the development of these bacteria during the film-forming process [59].

| Concentration of lemongrass essential oil in edible coating (%) | Average Value of Inhibition Zone (mm) |
|---------------------------------------------------------------|--------------------------------------|
| 2.5                                                           | 6.93±0.46                            |
| 5                                                            | 7.90±0.00                            |
| 7.5                                                          | 8.20±0.21                            |

3.2.3. *Salmonella*. The growth of *Salmonella* bacteria can be inhibited by alginate based antibacterial edible coating solution with the addition of lemongrass essential oil as antibacterial agent (Figure 3). The highest antibacterial activity was shown by edible coating solution added with 5% of lemongrass essential oil and the higher addition level of antibacterial agent resulted in the reduction of antibacterial activity (Table 4). Therefore, it is suggested that the addition of lemongrass essential oil into alginate based edible coating should be no more than 5% if the use of edible coating solution is targeted to limit the presence of *Salmonella* bacteria.
Figure 3. Inhibition zone of alginate based edible coating added with the lemongrass essential oil against *Salmonella* (Replications 1 and 2)

Table 4. Antibacterial activity of alginate based edible coating added with the lemongrass essential oil against *Salmonella*

| Concentration of lemongrass essential oil in edible coating (%) | Average Value of Inhibition Zone (mm) |
|---------------------------------------------------------------|--------------------------------------|
| 2.5                                                           | 7.08±0.39                            |
| 5                                                             | 9.05±1.77                            |
| 7.5                                                           | 8.65±0.71                            |

Edible coating with chitosan from rice husk dissolved in liquid smoke with a concentration of 1.5% chitosan and 5% liquid smoke can inhibit the growth of *Salmonella* and keep meatballs up to 54 hours [61]. Thyme oil mixed at 0.5 (v/v) with pre-gelatinized pea starch coating solution applied to chicken breast after being inoculated with *Salmonella* bacteria and packaged in plastic bags and stored for 12 days at 4°C can reduce *Salmonella* viability by 2 logs. CFU/g. Reducing the effect of cross-contamination and increasing the shelf life and product safety of chicken carcasses can be performed by applying an antimicrobial coating [62]. Edible coating with apple pectin and coconut oil enriched with ethanolic extract of *Malva sylvestris* L. flower (mallow) showed antibacterial activity against *Salmonella enterica* NCTC 6017, where the use of mallow extract, in the amount of 0.15 ml, was characterized by the strongest antibacterial activity with an inhibition zone of 36 mm against *S. enterica* [63].

3.2.4. *Pseudomonas aeruginosa*. Edible coating solution made of alginate with incorporation of lemongrass essential oil demonstrated antibacterial effect on *Pseudomonas aeruginosa* (Figure 4). The addition of lemongrass essential oil into edible coatings manufactured from alginate at 2.5%, 5.0%, and 7.5% showed that the diameter of the inhibition zone against *P. aeruginosa* was 7.08 mm, 9.05 mm and 8.65 mm, respectively (Table 5). Antibacterial activities of the edible coating achieved the optimal performance with the added level of lemongrass essential oil at 5%. Thus, the addition of lemongrass essential oil in an alginate based edible coating solution aimed at suppressing the growth of *P. aeruginosa* should not exceed 5%.

In addition to lemongrass essential oil, basil essential oil also showed antibacterial activity against *P. aeruginosa*. Basil essential oil as much as 0.5, 1.0 and 1.5% added to the edible coating composite Sodium alginate, CaCl₂ and glycerol can inhibit the growth of *P. aeruginosa* as indicated by the formation of an inhibition zone with a diameter of 5.667–18.350 mm in the antibacterial activity test [31]. Chitosan 1 (w/v) solution enriched with garlic extract 2 (v/v) could inhibit *P. aureginosa*. The chitosan coating solution showed antibacterial activity against *P. aureginosa*. However, the addition of antimicrobial garlic extract to the chitosan solution exhibited an increase in the diameter of inhibition
zone on *P. aeruginosa* compared to using only one type of antimicrobial agent in the chitosan solution [64].

![Figure 4](image)

**Figure 4.** Inhibition zone of alginate based edible coating added with the lemongrass essential oil against *Pseudomonas aeruginosa* (Replications 1 and 2)

| Concentration of lemongrass essential oil in edible coating (%) | Average Value of Inhibition Zone (mm) |
|---------------------------------------------------------------|--------------------------------------|
| 2.5                                                           | 7.08±0.39                            |
| 5                                                             | 9.05±1.77                            |
| 7.5                                                           | 8.65±0.71                            |

### 3.3. Potential Applications of Alginate Based Antibacterial Edible Coating Solution

The explanation above informs that the edible coating solution made from alginate and incorporated with lemongrass essential oil showed antimicrobial activity against *E. coli*, *S. aureus*, *Salmonella* and *P. aeruginosa*, particularly according to the diameter of inhibition zone. By considering the diameter of the inhibition zone obtained which reflects the antibacterial activity level of the edible coating solution added with lemongrass essential oil to those bacteria, it is known that the optimal addition level of the oil is 5%. Thus, it can be recommended that the use of lemongrass essential oil in alginate-based edible coatings should not exceed 5%.

Like the alginate based antibacterial edible coatings that have been previously developed using antibacterial agents such as lemongrass essential oil or other antibacterial agents, the edible coating solution produced in this study, which in its application can also improve quality and extend the shelf life of coated food products. The potential application of edible coating solution developed in this study can be identified by examining the results of research on the use of antibacterial edible coatings in various food products, particularly alginate-based edible coatings as shown in Table 6.

![Table 6](image)

**Table 6.** Potential application of alginate based antibacterial edible coating solution incorporated with lemongrass essential oil with reference to alginate based edible coatings
| Food Products               | Edible Coating Components                                      | Antibacterial Agent                                                                 | References |
|----------------------------|------------------------------------------------------------------|--------------------------------------------------------------------------------------|------------|
| Tilapia fillet             | Na-alginate, CaCl₂, glycerol                                    | Basil essential oil, lemongrass oil, Pomegranate peel extract                        | [31] [44] |
| Mackerel fillets           | Na-alginate, CaCl₂                                              | Grapefruit seed extract                                                              | [49]       |
| Shrimp (layer by layer)    | Na-alginate, chitosan, CaCl₂, Tween 80                          | Oregano and rosemary essential oils                                                 | [38]       |
| Fresh cheese               | Na-alginate, CaCl₂                                              |                                                                                      | [48]       |
| Grape                      | Na-alginate, glycerol                                           | Grapefruit essential oil                                                             | [37]       |
| Guavas                     | Na-alginate, chitosan, glycerol, acetic acid, NaOH              | NanoZnO                                                                              | [46]       |
| Sweet Cherries             | Na-alginate, CaCl₂, glycerol, chitosan, acetic acid             | Olive leaves extract                                                                 | [47]       |
| Water apples               | Alginate, green grass jelly, glycerol, CaCl₂                    | Vanilla essential oil                                                                | [40]       |
| Fresh-cut Fuji apples      | Na-alginate, apple puree, glycerol                              | Lemongrass, oregano oil and vanillin essential oils                                  | [42]       |
| Fresh-cut Fuji apples      | Na-alginate, glycerol, malic acid, N-acetyl-L-cysteine, glutathione, calcium lactate | Cinnamon, clove, and lemongrass essential oils                                       | [34]       |
| Fresh cut melons, Fresh-cut pineapple | Na-alginate, CaCl₂, glycerol, sunflower oil, CaCl₂, citric acid, ascorbic acid Na-alginate, CaCl₂, pectin | Chitosan, Lemongrass, Complex of trans-cinnamaldehyde in beta-cyclodextrin | [33] [43] [53] |
| Fresh-cut apple            | Alginate, glycerol, calcium ascorbate (antibrowning)           | Cinnamon and rosemary essential oils                                                | [35]       |
| Fresh-cut nectarines       | Na-alginate, chitosan, acetic acid, glycerol, Tween 20          | Chitosan                                                                             | [25]       |
| Fresh-cut Jintao kiwifruit | Na-alginate, glycerol, CaCl₂                                    | Lemon, orange, and grapefruit essential oils                                       | [39]       |
| “Hayward” fresh-cut kiwifruit | Sodium alginate, CaCl₂, Tween-80 Na-alginate, CaCl₂, glycerol, ascorbic acid, citric acid | Lemongrass, eugenol and citral, Cinnamon and nutmeg essential oils               | [45] [36] |

Plant-based food products that have been explored to be coated with alginate based antibacterial edible coatings are generally fruits, which include grapes, guavas, sweet cherries, apples, melons, pineapples, nectarines and kiwifruits. The fruit is coated in whole, fresh cut and processed. Small fruits such as grapes and sweet cherries are coated with an edible coating as whole fruits, while relatively large ones such as apples, melons, nectarines, pineapples and kiwifruits are coated as freshcuts. Both animal and plant-based food products are generally coated with an alginate-based antibacterial edible coating in combination with storage at low temperatures. Based on the results of...
studies that have been carried out, the use of alginate based antibacterial edible coatings has been able to improve the quality and extend the shelf life of food products. This fact strengthens the prediction that the alginate based edible coatings incorporated with lemongrass essential oil are very promising in the future.

In general, the prospects for applying edible films to food products globally are very promising, since plastic material usage has risen from 5 million metric tons in the 1950s to approximately 230 million metric tons now. Traditional food packaging materials have various drawbacks in terms of environmental degradation and non-renewable resource manufacturing needs. The need for alternate packaging materials and packaging forms has risen considerably. Edible coating has the advantage of being an environmentally friendly technology that is used to regulate moisture transfer, gas exchange, and oxidation processes in various products. One of the most notable benefits of using edible films and coatings is that a variety of active compounds may be included into the polymer matrix and consumed with food, increasing food safety as well as nutritional and sensory characteristics, such as adding antibacterial agents. Between 2021 and 2026, the global edible films and coatings market is anticipated to increase at a 7.64% CAGR (compound annual growth rate) [65].

4. Conclusions

Previous studies have proven that alginate-based and non-alginate-based edible coatings can improve quality and extend shelf life of food products. The performance of edible coatings can be improved by adding an antibacterial agent.

The use of lemongrass essential oil as an antibacterial agent in alginate based edible coatings showed antibacterial activity against E. coli, S. aureus, Salmonella and P. aeruginosa. Based on the diameter of the inhibition zone indicating antibacterial activities against those pathogenic bacteria, it is recommended to incorporate lemongrass essential oil into an alginate based edible coating solution of no more than 5%.

Results of previous studies on the application of alginate based antibacterial edible coatings suggested that edible coatings in this study which were incorporated with lemongrass essential oil can be used to coat food products both animal and plant based in order to improve quality and extend the shelf life of the product.

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