ANTIMICROBIAL ACTIVITY OF EDIBLE FILM WITH CINNAMON ESSENTIAL OIL AS ANTIMICROBIAL PACKAGING

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ABSTRACT

The purpose of this study was to determine the best level of addition of cinnamon (Cinnamomum burmanii) essential oil in the manufacture of edible films so as to produce good antimicrobial activity against Staphylococcus aureus, Lactobacillus bulgaricus, Escherichia coli and Salmonella sp. The materials used were hydrolyzed casein, chitosan and gelatin with different proportions of cinnamon (Cinnamomum burmanii) essential oil added. This research method was a completely randomized design laboratory experiment with five treatments including without cinnamon essential oil (P0) and with cinnamon essential oil 0.5% (P1), 1% (P2), 1.5% (P3) and 2% (P4) with four replications. The variable measured was the antimicrobial activity of the edible film against Staphylococcus aureus, Lactobacillus bulgaricus, Escherichia coli and Salmonella sp. Data were analyzed using Analysis of Variance (ANOVA) and continued with Duncan's Multiple Range Test (DMRT) if there were significant differences or very significant differences. The results showed that there was a very significant difference (P<0.01) in antimicrobial activity against Staphylococcus aureus and Escherichia coli, but there was no significant difference (P>0.05) in Lactobacillus bulgaricus and Salmonella sp. The conclusion from this study is that the best results are edible films with the addition of 2% cinnamon essential oil.

Keywords: Antimicrobial activity; casein; chitosan; cinnamon essential oil; gelatin
INTRODUCTION

The food industry in Indonesia has increased the use of plastic packaging by 80%. The use of plastic packaging will increase from year to year so it is necessary to anticipate by developing packaging materials that are biodegradable. Preservation of food products using packaging technology is currently increasingly used because this technology is safe for human health. In general, food packaging materials are divided into two major groups, namely non biodegradable and biodegradable packaging materials. Non biodegradable packaging materials are packaging materials that cannot be decomposed by microbes in the soil so that they cannot be destroyed and can pollute the environment.

Non biodegradable packaging materials include plastic, paper and aluminum foil. Biodegradable packaging materials are packaging materials that are environmentally friendly and safe for human consumption. Biodegradable packaging can inhibit the transfer of water vapor, easily degraded by soil so as to reduce environmental problems (Indriyanto et al., 2014). Biodegradable packaging materials consist of non-edible and edible. Edible packaging is a food product packaging material that is safe for human consumption. The main ingredients used to make edible packaging consist of hydrocolloids, lipids, and composites.

Hydrocolloid components include proteins, starch, cellulose derivatives, alginates, pectin and other polysaccharides. Lipid components include waxes, acylglycerols and fatty acids. The composite component consists of a combination of hydrocolloid and lipid components (Santoso, 2020). Based on the manufacturing technology, edible packaging is grouped into three forms, namely edible film, edible coating, and encapsulation.

Edible film is a thin sheet-shaped edible packaging that can be eaten and used as a food product packaging. Both processed and fresh livestock food products cannot last long if not stored properly. Processed livestock products such as meat, eggs and milk are easily damaged by bacteria Salmonella sp. Escherichia coli, Lactobacillus bulgaricus and Staphylococcus aureus. One way that can be used in protecting fresh and processed food products is by using packaging methods. Edible film as packaging for food products such as sausages, meat, fresh fruits and vegetables can slow down the decline in quality, maintain product safety and extend shelf life.

Edible film has a function as a mass transfer barrier (air humidity, oxygen, carbon dioxide, lipids, light and solutes) which is used in reducing O2, increasing CO2, maintaining the quality and safety of food products (Manab et al., 2017). Edible film has a function as a mass transfer barrier (air humidity, oxygen, carbon dioxide, lipids, light and solutes) which is used in reducing O2, increasing CO2, maintaining the quality and safety of food products (Manab et al., 2017).

The components of edible film consist of hydrocolloids, lipids and composites. Casein is a group of hydrocolloids containing glutamine amino acids that can be combined with other packaging materials. Chitosan is a chitin polymer derivative polysaccharide obtained from fishing industry waste which has elastic, strong, flexible and environmentally

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friendly properties (Apriliyani et al., 2019). Chitosan is used as an edible film material because it has antimicrobial agent properties against gram positive bacteria that can extend the shelf life of food. The use of biodegradable packaging made from natural materials such as carbohydrate compounds and their derivatives tends to be easily moistened so that it can become a medium for bacterial growth. Improving the quality of edible film as an antimicrobial packaging material is done by adding essential oils to improve the function of edible film in protecting food products from microbial contamination. Antimicrobials derived from natural ingredients such as essential oils have the potential to be developed as active packaging. Essential oils have strong antibacterial properties against foodborne pathogens (Winarti et al., 2012). Essential oils contain chemical compounds such as alcohols, aldehydes, phenols, and esters that are known to have antimicrobial abilities. Cinnamon (*Cinnamomum burmanii*) contains 70-88% cinnamaldehyde which functions as antibacterial and fungicidal (Wang et al., 2005). The addition of cinnamon (*Cinnamomum burmanii*) essential oil in edible films based on casein chitosan and gelatin is expected to be used as a packaging material for food products to extend the shelf life.

**MATERIALS AND METHODS**

The research was conducted in April at the Animal Product Technology Laboratory, Faculty of Animal Science, Universitas Brawijaya, sample preparation and microbiology room.

**Research Materials**

Materials used in the manufacture of edible films include hydrolyzed casein, chitosan, gelatin, cinnamon (*Cinnamomum burmanii*) essential oil, 80% tween, acetic acid, glycerol, distilled water. The materials used in the antimicrobial activity test included MRS Agar, Salmonella-Shigella Agar, MacConkey Agar, Nutrient Agar and *Lactobacillus bulgaricus, Salmonella sp., Escherichia coli, Staphylococcus aureus*.

**Research Equipment**

The tools used in making edible films include digital scales, magnetic stirrers, thermometers, beaker glass, measuring cups, laboratory spatulas and petri dishes. The tools used for testing antimicrobial activity include, test tube, autoclave, beaker glass, analytical balance, hot plate, Erlenmeyer, petri dish, measuring cup, micropipette, incubator, L rod, round loop and calipers.

**METHOD**

The method used was a laboratory experiment using a completely randomized design with 5 treatments and 4 replications. (P0) control treatment without the addition of cinnamon (*Cinnamomum burmanii*) essential oil, (P1) the addition of 0.5% cinnamon (*Cinnamomum burmanii*) essential oil, (P2) the addition of 1% cinnamon (*Cinnamomum burmanii*) essential oil, (P3) addition of 1.5% cinnamon (*Cinnamomum burmanii*) essential oil and (P4) addition of 2% cinnamon (*Cinnamomum burmanii*) essential oil. Research variables include antimicrobial activity against *Staphylococcus aureus, Lactobacillus bulgaricus, Escherichia coli* and *Salmonella sp.*

**Procedure For Making Edible Film**

Making edible films refers to Fabra, et al., 2011 with modifications. Dissolve casein hydrolyzate with distilled water using a magnetic stirrer for 30 minutes at 50°C then add glycerol and stir again for 30 minutes, dissolve chitosan with distilled water and acetic acid using a magnetic stirrer for 60 minutes at 50°C then add glycerol and stir again for 30 minutes, dissolved gelatin with distilled water using a magnetic stirrer for 10 minutes at 60-70°C and added glycerol. Homogenized for 2 hours at 40-50°C a solution of casein, chitosan, gelatin, cinnamon (*Cinnamomum


**RESULTS AND DISCUSSION**

Fresh and processed foodstuffs are susceptible to damage caused by internal and external factors. Microbes can grow and develop in food products that have high water activity, neutral pH, high humidity and high oxygen content. The nutritional content of food ingredients affects the shelf life of food products.

Edible film is a food product preservation using packaging technology that functions as an antimicrobial and antioxidant packaging material by adding good natural antimicrobial and antioxidant compounds. Essential oils have antibacterial properties against foodborne pathogens. Essential oils contain high concentrations of phenolic compounds such as carvacrol, eugenol and thymol which have antioxidant and antimicrobial properties (Maizura et al., 2007). The bacterial inhibition zone test on edible film can be seen from the formation of a clear zone.

The clear zone is the area of the microbial inhibition area where the area is not overgrown with bacteria (Yandriani and Jannah, 2022). Data analysis of variance on the antimicrobial activity of hydrolyzed casein edible film, chitosan and gelatin with the addition of cinnamon (*Cinnamomum burmannii*) essential oil with different levels in each treatment against *Staphylococcus aureus*, *Lactobacillus bulgaricus*, *Escherichia coli* and *Salmonella sp.* contained in Table 1.

**Table 1. Diameter of Inhibition Zone Edible Film**

<table>
<thead>
<tr>
<th>Treatment</th>
<th><em>Staphylococcus aureus</em> (mm)</th>
<th><em>Lactobacillus bulgaricus</em> (mm)</th>
<th><em>Escherichia coli</em> (mm)</th>
<th><em>Salmonella sp.</em> (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0</td>
<td>16.71 ± 1.19&lt;sup&gt;a&lt;/sup&gt;</td>
<td>17.66 ± 2.52</td>
<td>30.06 ± 1.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>25.84 ± 4.68</td>
</tr>
<tr>
<td>P1</td>
<td>22.05 ± 1.83&lt;sup&gt;b&lt;/sup&gt;</td>
<td>26.89 ± 2.77</td>
<td>32.44 ± 2.45&lt;sup&gt;a&lt;/sup&gt;</td>
<td>32.83 ± 1.16</td>
</tr>
<tr>
<td>P2</td>
<td>23.39 ± 1.19&lt;sup&gt;b&lt;/sup&gt;</td>
<td>27.01 ± 2.99</td>
<td>32.90 ± 1.89&lt;sup&gt;a&lt;/sup&gt;</td>
<td>31.48 ± 3.14</td>
</tr>
<tr>
<td>P3</td>
<td>24.49 ± 2.29&lt;sup&gt;b&lt;/sup&gt;</td>
<td>32.93 ± 6.38</td>
<td>34.05 ± 1.02&lt;sup&gt;b&lt;/sup&gt;</td>
<td>29.56 ± 4.32</td>
</tr>
<tr>
<td>P4</td>
<td>25.69 ± 1.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>33.64 ± 15.16</td>
<td>35.58 ± 0.69&lt;sup&gt;b&lt;/sup&gt;</td>
<td>28.45 ± 4.75</td>
</tr>
</tbody>
</table>

<sup>a,b,c</sup>: Different superscripts indicate the concentration of cinnamon (*Cinnamomum burmannii*) essential oil addition gives a very significant difference (P<0.01) against *Staphylococcus aureus* and *Escherichia coli*. 

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*burmanii*), essential oil according to the treatment and added 80% tween. 20 ml of edible film solution was poured into a petri dish and dried at room temperature.

**Antimicrobial Activity Test Procedure**

Antimicrobial activity test procedure refers to Apriliyani, et al (2020). Selective agar media were prepared for the growth of each bacteria, the media and the tools used were sterilized using an autoclave at 121°C with a pressure of 1.5 atm for 15 minutes, the media that had been sterilized was poured as much as 15 ml into a petri dish. Bacteria *Salmonella sp.*, *Lactobacillus bulgaricus*, *Staphylococcus aureus*, *Escherichia coli* were inoculated into a petri dish containing 0.1 ml of agar media containing 10^6 CFU/ml of bacteria using the spread plate method, round edible film sheets with a diameter of 10 mm placed on the surface of the agar media that has been inoculated with bacteria, then incubated at 37°C for 24 hours and the inhibition zone was measured using a caliper.

**Statistical Analysis**

The data obtained was tabulated using Microsoft Excel. Data were analyzed statistically by calculating using analysis of variance (ANOVA) according to the method used, namely Completely Randomized Design. If there are results showing significant differences or highly significant different effects between treatments, then proceed with Duncan's Multiple Range Test (UJBD).
Antimicrobial Activity of Edible Film Against Staphylococcus aureus

The results of the analysis of variance showed that the addition of cinnamon essential oil \((Cinnamomum burmannii)\) with different percentages in the manufacture of casein hydrolyzate, chitosan and gelatin edible films produced very significant differences \((P<0.01)\) in the diameter of the inhibition zone of \textit{Staphylococcus aureus} bacterial growth. The diameter of the inhibition zone of casein hydrolyzate, chitosan and gelatin edible films with or without the addition of cinnamon \((Cinnamomum burmannii)\) essential oil against \textit{Staphylococcus aureus} bacteria was 16.71 mm, 22.05 mm, 23.39 mm, 24.49 mm and 25.69 mm, respectively.

The lowest average value of edible film inhibition zone was found in the treatment without the addition of cinnamon essential oil \((Cinnamomum burmannii)\). Chitosan has bactericidal properties against gram positive bacteria such as \textit{Listeria monocytogenes}, \textit{Bacillus megaterium}, \textit{Bacillus cereus}, \textit{Staphylococcus aureus}, \textit{Lactobacillus plantarum}, \textit{Lactobacillus brevis} and \textit{Lactobacillus bulgaricus}, compared to gram negative bacteria such as \textit{Eschericia coli}, \textit{Pseudomonas fluorescens} and \textit{Salmonella typhimurium} with the required chitosan concentration of 0.1\% (No et al., 2000). Chitosan has antibacterial and antiviral properties because it contains lysozyme and aminopolysacharide groups that can inhibit the growth of bacteria or microorganisms (Romero et al., 2020). The positively charged amino group of the \(\text{NH}^3+\) group in chitosan interacts with the negative charge on the surface of gram positive bacterial cells which causes disruption of peptidoglycan formation so that the cells do not have a sturdy envelope, are easily lysed and ultimately cause bacterial cell death (Kusmawati et al., 2017).

The average analysis results of edible films based on casein hydrolysate, chitosan and gelatin with the addition of cinnamon essential oil \((Cinnamomum burmannii)\) ranged from 22.05 mm (edible film with the addition of 0.5\% cinnamon essential oil \((Cinnamomum burmannii)\)), 23.39 mm (edible film with the addition of 1\% cinnamon essential oil \((Cinnamomum burmannii)\)), 24.49 mm (edible film with the addition of 1.5\% cinnamon essential oil \((Cinnamomum burmannii)\)) and 25.69 mm (edible film with the addition of 2\% cinnamon essential oil \((Cinnamomum burmannii)\)).

The difference in the diameter of the edible film inhibition zone on \textit{Staphylococcus aureus} bacteria can be seen in Figure 1.

![Figure 1. Inhibition zone on Staphylococcus aureus bacteria](image)

Figure 1 shows that the higher the percentage of cinnamon essential oil \((Cinnamomum burmannii)\), the higher the content of antimicrobial substances so that more bacterial growth is inhibited (Amaliya and Putri, 2014). In the treatment with the
addition of 2% cinnamon essential oil (Cinnamomum burmannii) showed enlargement of the inhibition zone on the edible film.

The addition of cinnamon essential oil (Cinnamomum burmannii) in high concentrations can disrupt the membrane structure and swelling of bacterial cells so that the membrane undergoes lysis caused by damage to the permeability and membrane integrity of cinnamon essential oil (Sharma et al., 2013). Essential oil from ethanol extraction of cinnamon has the ability to inhibit the growth of bacteria E.coli, S. aureus, and Candida albicans with greater inhibition than ampicillin, streptomycin, amphoterin, and chloramphenicol (Fadhlina et al., 2014). Cinnamon essential oil (Cinnamomum burmannii) is a natural antimicrobial compound added to edible film.

The mechanism of action of active compounds of essential oils as antimicrobials is to inhibit microbial growth by interfering with the process of cell wall formation, so that the cell wall is not formed or remains formed but is not perfect (Putri et al., 2023). The addition of chitosan and cinnamon essential oil (Cinnamomum burmannii) to edible films based on casein hydrolysate, chitosan and gelatin can kill bacteria. Gram positive bacteria have a thick cell wall structure of peptidoglycan, which functions as a strong structure in bacteria so that it is more difficult to damage. Staphylococcus aureus bacteria are gram positive bacteria that have 30-40 layers of peptidoglycan, on a positive charge chitosan can be bound and cause bacterial cell wall breakdown (Damayanti et al., 2016).

Antimicrobial Activity of Edible Film Against Lactobacillus bulgaricus

The results of the analysis of variance showed that casein hydrolysate, chitosan and gelatin edible films with the addition of cinnamon essential oil (Cinnamomum burmannii) with different percentages produced differences that were not significant (P>0.05) to the diameter of the inhibition zone of Lactobacillus bulgaricus bacterial growth. Lactobacillus bulgaricus bacteria produce exopolysaccharides (EPS). Exopolysaccharide (EPS) is produced by several strains of lactic acid bacteria species, including homopolysaccharide type produced by Leuconostoc mesenteroides and heteropolysaccharide type produced by Streptococcus thermophilus OR 901 and Lactobacillus bulgaricus CNRZ 1187 (Al Awwaly and Abdul, 2007). Exopolysaccharides from microbes act as protectors of microbial cells in their environment against adverse conditions such as desiccation, phagocytosis, phage attack, osmotic pressure, antibiotics or toxin compounds (Patel and Prajapati, 2013).

The average diameter of the inhibition zone of edible film with the addition of cinnamon essential oil (Cinnamomum burmannii) against Lactobacillus bulgaricus bacteria in Table 1 shows that cinnamon essential oil (Cinnamomum burmannii) and chitosan are able to inhibit the growth of Lactobacillus bulgaricus bacteria. The highest inhibition zone diameter was in the treatment of adding 2% cinnamon essential oil (Cinnamomum burmannii) which amounted to 33.64 mm while the narrowest inhibition zone diameter was in the edible film treatment with the addition of 0.5% cinnamon essential oil (Cinnamomum burmannii) which was 26.89 mm.

The diameter of the edible film inhibition zone on the growth of Lactobacillus bulgaricus can be seen more clearly in Figure 2. These results show that it is not much different from the diameter of the inhibition zone of the antimicrobial activity of Staphylococcus aureus bacteria, which is thought to be both gram positive bacteria.

There are five criteria for the strength of the antibacterial effect based on the diameter of the inhibition zone, namely: no inhibition zone, ≤ 5 mm inhibition zone diameter is categorized as weak, 5-10 mm inhibition zone diameter is categorized as moderate, 10-20 mm inhibition zone diameter is categorized as strong and ≥ 20
mm inhibition zone diameter is categorized as very strong (Malinggas et al., 2015). Based on these categories, the diameter of the growth inhibition zone of *Lactobacillus bulgaricus* formed around the edible film can be categorized as very strong.

![Figure 2. Inhibition zone on *Lactobacillus bulgaricus* bacteria](image)

**Antimicrobial Activity of Edible Film Against *Escherichia coli***

The results of the inhibition zone analysis of casein hydrolyzate, chitosan and gelatin edible films with or without the addition of cinnamon essential oil (*Cinnamomum burmannii*) showed very significant differences (P<0.01) in the average inhibition zone on *Escherichia coli* bacteria.

The increasing percentage of cinnamon essential oil affects the inhibition zone produced, besides that the addition of antimicrobial ingredients against *E. coli* bacteria such as chitosan can also increase the inhibition zone. Chitosan provides the greatest inhibition against gram negative bacteria, namely *Escherichia coli* compared to gram positive bacteria (*Staphylococcus aureus*). *Escherichia coli* bacteria have a negative charge due to the presence of lipopolysaccharides and peptidoglycan containing COO groups so that they are more negatively charged than *Staphylococcus aureus* bacteria (Nurainy et al., 2008). The average inhibition zone of casein hydrolysate, chitosan and gelatin edible film with or without the addition of cinnamon essential oil (*Cinnamomum burmannii*) on *Escherichia coli* bacteria was 30.06 mm, 32.44 mm, 32.90 mm, 34.05 mm and 35.58 mm, respectively. Table 1 shows that the diameter of the edible film inhibition zone against *Escherichia coli* bacteria is relatively higher with an average value between 30.06 mm to 35.58 mm compared to the diameter of the edible film inhibition zone against *Staphylococcus aureus*, *Lactobacillus bulgaricus* and *Salmonella sp.*

The diameter of the edible film inhibition zone on the growth of *Escherichia coli* can be seen more clearly in Figure 3. This is thought to be because *Escherichia coli* is a gram negative bacterium that has a thinner wall so it is more susceptible to damage than gram positive bacteria, the function of the cell wall is to maintain the integrity of the cell so that it is not easily damaged (Goy et al., 2016). The average inhibition zone of casein hydrolysate, chitosan and gelatin edible film with the addition of cinnamon essential oil (*Cinnamomum burmannii*) produces a very strong inhibition zone with an average value of 32.44 mm, 32.90 mm, 34.05 mm and 35.58 mm. The highest treatment was in the treatment of adding cinnamon essential oil (*Cinnamomum burmannii*) as much as 2%. Cinnamon essential oil contains sinamaldehyde (trans-sinamaldehyde or 3-phenyl-2 propenal) as much as 75%. Sinamaldehyde is a compound that has aldehyde and alkene functional groups conjugated by a benzene ring (Sangal,
The content of sinamaldehyde in cinnamon essential oil (Cinnamomum burmannii) will damage the bacterial cell membrane and its structure which causes ion leakage (Herman et al., 2016). Phenol compounds contained in cinnamon essential oil (Cinnamomum burmannii) function as antibacterials that can kill inorganisms by denaturing cell proteins. The protein structure in bacteria will be damaged due to the presence of phenol and protein. The presence of phenol and protein will form hydrogen bonds that affect the performance of the permeability of the cytoplasmic membrane and cell wall so that there is an imbalance between ions in the cell and between molecules which can cause cells to lysis (Khasanah et al., 2021). Cinnamon essential oil (Cinnamomum burmannii) showed strong antibacterial effects against S. aureus, B. subtilis, E. coli and S. cerevisiae.

**Antimicrobial Activity of Edible Film Against Salmonella sp.**

The results of the analysis of variance showed that the addition of cinnamon essential oil (Cinnamomum burmannii) with different levels in the manufacture of casein, chitosan and gelatin edible films in each treatment resulted in differences that were not significant (P>0.05) to the diameter of the inhibition zone of Salmonella sp. The average results showed that casein hydrolyzate, chitosan and gelatin edible films without the addition of cinnamon essential oil (Cinnamomum burmannii) produced a very strong inhibition zone against Salmonella sp. bacteria with an area of 25.84 mm. The amount of antimicrobial activity was calculated by measuring the clear zone along with the diameter of the well.
The average diameter of the edible film inhibition zone against *Salmonella sp.* bacteria in Table 1 shows that the addition of cinnamon essential oil (*Cinnamomum burmannii*) and chitosan is able to inhibit the growth of *Salmonella sp.* bacteria with the initial diameter used for testing is 10 mm, while in Table 1 it can be seen that the diameter of the edible film inhibition zone on *Salmonella sp.* bacteria is more than 10 mm. The diameter of the edible film inhibition zone on the growth of *Salmonella sp.* can be seen more clearly in Figure 4. Edible film has antimicrobial activity on *Salmonella sp.* bacteria which is characterized by the formation of inhibition zones in all treatments.

The addition of chitosan and cinnamon essential oil (*Cinnamomum burmannii*) with percentages of 0.5%, 1%, 1.5% and 2% successfully inhibited the growth of *Salmonella sp.* bacteria by 25.84 mm, 32.83 mm, 31.48 mm, 29.56 mm and 28.45 mm, respectively. The antimicrobial mechanism of cinnamon essential oil (*Cinnamomum burmannii*) in the cinnamaldehyde component is the presence of morphological abnormalities, including shrunken hyphal aggregates, collapsed hyphal structures and swollen mycelial walls (Lu et al., 2013). The addition of a higher percentage of cinnamon (*Cinnamomum burmannii*) essential oil resulted in a decrease in the diameter of the inhibition zone. Cinnamon essential oil (*Cinnamomum burmannii*) has antibacterial activity against Bacillus cereus, *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Klesiella sp.* (Ramadhani, 2017).

**CONCLUSION**

Based on the research results, it can be concluded that the addition of 2% cinnamon (*Cinnamomum burmannii*) essential oil had an effect on inhibiting *Escherichia coli* and *Staphylococcus aureus* with inhibition zones of 35.58 mm and 25.69 mm on edible films made from hydrolyzed casein, chitosan and gelatin.

**REFERENCES**


Chemical Engineering and Biological Sciences, 1(1), 26–29.