



## EVALUATION OF EGGSHELL AS ORGANIC FERTILIZER ON SWEET BASIL

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### ABSTRACT

#### Article History

Received: 10 December 2018

Revised: 15 February 2019

Accepted: 25 March 2019

Published: 3 May 2019

#### Keywords

Food waste

Eggshell fertilizer

Organic fertilizer

Eggshell tea

Sweet basil

Sustainable development goals.

Food waste, for example, eggshell has been piling up on earth through the years. On the other hand, home-gardening has been a trend that encouraged by the government. The focus in this study is to decrease and use the eggshell waste by utilizing it as fertilizer. Eggshell has potential to become fertilizer for plants due to its nutrient content. The eggshell fertilizer used in this study was in liquid/foliar and solid form. The comparison of eggshell fertilizer and commercial fertilizer effectiveness was conducted to see their compatibility in basil's growth. The chemical analysis was conducted on eggshell tea fertilizer to see the nutrient content. The result from this study shows that eggshell fertilizer in liquid/foliar form is compatible with commercial fertilizer. The compatibility might be achieved due to nutrients, such as nitrogen, potassium and chloride in eggshell tea fertilizer. However, the eggshell fertilizer in liquid form performed better than in its solid form. Further studies could be focusing on the effectiveness of crushed eggshell fertilizer in a more controlled environment. In conclusion, eggshell fertilizer can be used as an alternative for fertilizer in home-gardening due to its compatibility to commercial fertilizer. The result of this study might contribute to reducing food waste, specifically eggshell waste. The result of this study might lead to more utilization of eggshell waste, especially as fertilizer, thus decrease the cost of using commercial fertilizer.

**Contribution/Originality:** This study might contribute to supporting household practice in using eggshell as fertilizer as eggshell indeed has significant effect to plants growth.

### 1. INTRODUCTION

Food waste refers to discarding the use of food that is nutritious and safe for human consumption along the entire food supply chain (Food and Agriculture Organization, 2014). There are around 1.3 billion tons of food or roughly one-third of the food produced for human wasted every year (FAO, 2015). Due to the increasing amount of food waste, there are a few solutions suggested for this problem. One of them is a movement to increase awareness of food waste, for example, is the movement in Portugal to recover under graded fruits and vegetables to be sold in markets (UF, 2015). The other solution is by changing consumer's behavior to focus on eating certain food and avoiding others (Rowland, 2017; Pinto *et al.*, 2018). Other changes in consumer's behavior that could be possible are to increase awareness and knowledge regarding food waste. So, consumers themselves can be contributing to reducing the amount of food waste (Aschemann-Witzel *et al.*, 2015).

The food waste is divided into three main categories in term of edibility, namely edible; inedible; and questionably edible (Hoover, 2017). One of the concerns of food waste is on eggshell waste, which is one of the examples of inedible food waste. In egg production industry only, approximately 70 million tons of eggs produced in the year 2014 that led to 8 million of eggshell waste created (De Angelis *et al.*, 2017). The average consumption of egg for a person in 2011 is 8.9 kg and it's estimated to increase to 10.3 kg in 2030 (Global Poultry Trends, 2015). These increased amounts of an eggshell is a problem, especially in the environment (Shearman, 2016).

However, there is a trend developing in households which are called home gardening. Home gardening activities are encouraged by the government (Wyss, 2016). Home gardening is not different than ordinary plantation in term of fertilizer needs to boost plants growth (The Grow Network, 2017). Utilization of commercial fertilizer could be costly. Due to this, eggshell actually could be a cheaper alternative for fertilizer due to its nutrient content (Hamester *et al.*, 2012; Faridi and Arabhosseini, 2018).

Utilization of eggshell waste is not just household practice. The utilization is actually supported by scientific studies. Eggshell can be used as a biomaterial for medical and dental therapy (Ducheyne *et al.*, 1986; Gergely *et al.*, 2010; Faridi and Arabhosseini, 2018). Eggshell can be used as biodiesel as well (Gole and Gogate, 2012). The last but not the least, eggshell can be used as fertilizer (Hamester *et al.*, 2012; Faridi and Arabhosseini, 2018). The potentials of eggshell utilization are because of components contained. The eggshell contains both organic and inorganic material. The main component that forms the hard structure of eggshell is calcium carbonate (Hincke *et al.*, 2012). Eggshell also contains uronic acid, sialic acid, even amino acids (Nakano *et al.*, 2003; Hincke *et al.*, 2012). As for nutrients, eggshell contains macronutrients and micronutrients that are essential for plants growth. There is potassium, nitrogen, calcium, magnesium and phosphorus as macronutrients (Cusack *et al.*, 2003; Rovenský *et al.*, 2003; Brun *et al.*, 2013; Makkar *et al.*, 2015). Eggshell also contains chloride and zinc as micronutrients (Barker and Pilbeam, 2007).

Based on fertilizer form, there are two types of fertilizer. First one is granular/pellet fertilizer which is in dry and solid form. Granular fertilizer can be created by blending some individual granular fertilizer in a certain ratio to achieve the desired purpose (Hopper, 2015). The second fertilizer is liquid/foiar fertilizer which is in liquid form and applied by spraying the fertilizer on leaves. The liquid fertilizer is usually provided in liquid concentrated form or water-soluble pellet (Martinez-Alcantara *et al.*, 2016). Based on these basic forms, there are two types of eggshell fertilizer as well. The granular fertilizer is represented by crushed eggshell fertilizer and the liquid fertilizer is represented by eggshell tea fertilizer.

Crushed eggshell fertilizer is simply made by crushing eggshell and put them on the soil. The eggshell under soil would be degraded in the purpose of releasing nutrients for plants. Crushed eggshell can be also put in composting bin to form compost. By using crushed eggshell fertilizer, the calcium content in soil can be increased alongside other nutrients contained in eggshell (Taylor and Locascio, 2004; Silveira *et al.*, 2016; Faridi and Arabhosseini, 2018). The advantage of using crushed eggshell is less energy needed for preparation, but the disadvantage relies on the time needed for eggshell degradation before it can provide nutrients for plants (Mitchell, 2005; Rai *et al.*, 2014).

Eggshell tea fertilizer is one of the homemade fertilizer. The fertilizer can be made by boiling crushed eggshell with water (Garden Care Zone, 2017). The boiling process helps to break down the eggshell and release nutrients to the water. These nutrients in liquid form can be sprayed on leaves. This way, the nutrients can be absorbed directly by plants through leaves. The advantage of using eggshell tea fertilizer relies on its application. The spraying process makes it easier for plants to absorb the nutrients (Ji *et al.*, 2017). The disadvantage relies on the tendency of liquid fertilizer to coagulate in an extended period of time (Hopper, 2015).

## 2. MATERIALS AND METHODS

In this study, sweet basil was used as treatment plants. Prior to treatments, the seeds were germinated before moved to treatment pots. On the other hand, the eggshell was collected for crushed eggshell treatment and eggshell tea making from the cafeteria of UCSI University. The eggshell collected was washed and dried to prevent spoilage. When cleaning eggshell, the membranes were left with the shell.

This study utilized two forms of eggshell fertilizer. The eggshell fertilizer in solid form was represented by crushed eggshell. The crushed eggshell fertilizer was prepared by crushing eggshell to smaller pieces. On the other hand, the liquid form was represented by eggshell tea. The eggshell tea fertilizer was made from boiling dried crushed eggshell with water in ratio 1:2 respectively. The eggshell fertilizer was compared to commercial fertilizer as well. The commercial fertilizer used in this study was calcium nitrate ( $\text{Ca}(\text{NO}_3)_2$ ). The calcium nitrate pellet was diluted in water with a ratio 1.35 gr in 1 L water.

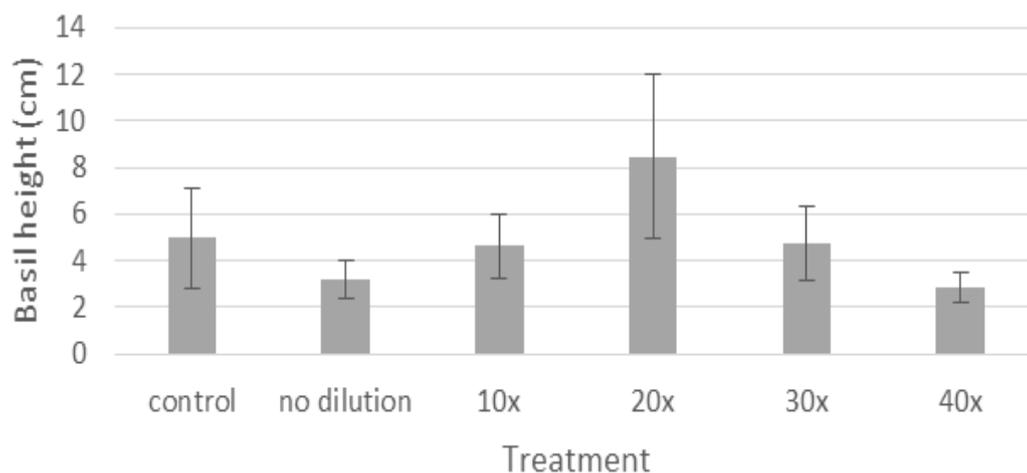
The treatments were divided into two based on the growing medium. The first treatment was conducted on soil growing medium. The soil used was gardening soil. There were comparisons between crushed eggshell fertilizer group, calcium nitrate group and eggshell tea fertilizer. The eggshell tea fertilizer had five different concentrations, namely no diluted; 10x dilution; 20x dilution; 30x dilution; and 40x dilution. The crushed eggshell was buried in the soil before basil planting. The second treatment was conducted on the water growing medium and based on the comparison between the calcium nitrate group and the most effective concentration of eggshell tea fertilizer, which was 20x dilution. The most effective concentration of eggshell tea fertilizer was obtained from the result of treatment on soil growing medium. After five weeks of observation on basil heights in each treatment, the statistical analysis was conducted using SPSS.

Other than the treatment of fertilizers on basil, the chemical analysis was conducted on eggshell tea fertilizer as well. Different methods were applied to the different nutrient in eggshell. AOAC was applied to nitrogen detection, while analysis for nutrition labelling was applied to phosphorus detection. Ion chromatography was applied to detect chloride and ICP-OES was applied to Sulphur detection. The last but not the least, AOAC and APHA method were applied to detect the presence of calcium, potassium and magnesium.

## 3. RESULTS

### 3.1. Treatment in Soil

There are mainly three comparisons of basil growth could be observed through treatment in soil growing medium. The first comparison is between eggshell tea fertilizer concentrations group. The eggshell tea fertilizer had five different concentrations as shown in Figure 1.



**Figure-1.** Graph of average height of basil with treatment of eggshell fertilizer in different concentration.  
Source: Wijaya (2018).

Based on statistical analysis, the eggshell tea fertilizer with a concentration of 20x dilution is significantly more effective than other concentrations ( $P < 0.001$ ) based on average basil growth.

As shown in Figure 1, the error bars of the control group and eggshell tea fertilizer with 20x diluted concentration are overlapped. The overlapping was due to the utilization of gardening soil as a growing medium. The gardening soil has contained nutrients originally. Due to this, the basil of the control group could still grow well. The eggshell tea fertilizer acts as a booster for basil growth. For more concentrated and less concentrated eggshell tea fertilizer, the basil growth was not as good as a group of eggshell tea fertilizer with 20x diluted concentration. This result was because of over-fertilized and under-fertilized condition. These conditions can cause inhibition in plants growth (Albornoz and Lieth, 2015; University of Massachusetts, 2017).

The second comparison is between eggshell tea fertilizer with 20x diluted concentration group and crushed eggshell fertilizer group as shown in Figure 2. The eggshell tea fertilizer is statistically more effective than crushed eggshell fertilizer ( $P < 0.001$ ).

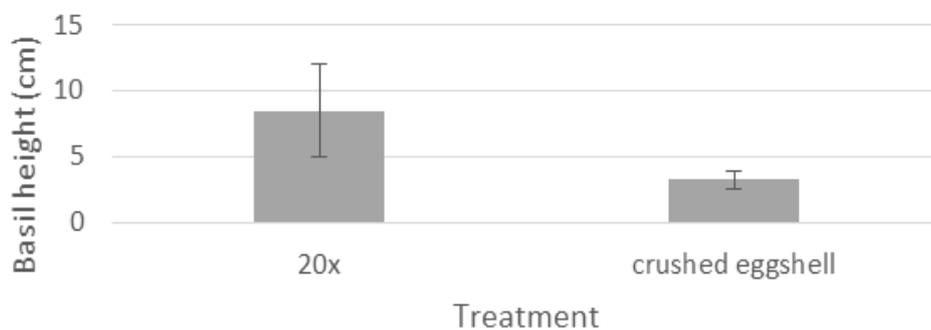


Figure-2. Graph of an average height of basil with the treatment of eggshell tea fertilizer and crushed eggshell fertilizer. Source: Wijaya (2018).

The factor affecting the better performance of eggshell tea fertilizer is the form of fertilizer. Eggshell tea fertilizer has a liquid/foliar form which means the basil can absorb nutrients easily without waiting for the fertilizer to be degraded. The application of liquid/foliar fertilizer is also on leaves which fasten up the absorption of nutrient (Martinez-Alcantara *et al.*, 2016).

The third comparison is between eggshell tea fertilizer with 20x diluted concentration and calcium nitrate fertilizer. Based on statistical analysis, the eggshell tea fertilizer group has significant result against commercial fertilizer ( $P < 0.001$ ). However, as shown in Figure 3, the error bars between two groups are overlapping which could be interpreted that eggshell tea fertilizer with 20x diluted concentration is compatible to commercial fertilizer.

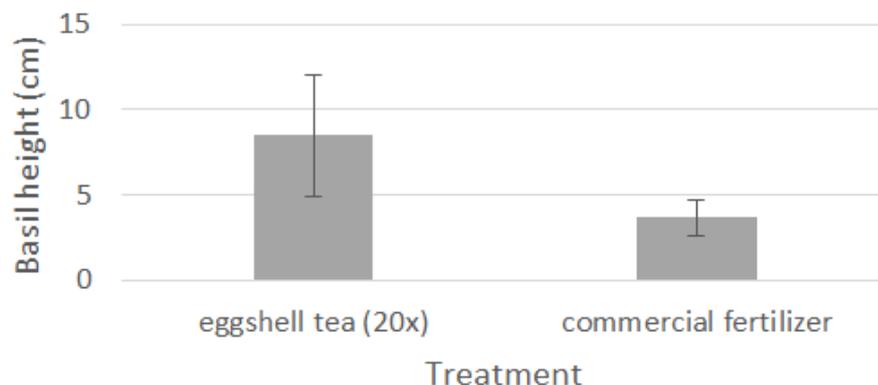
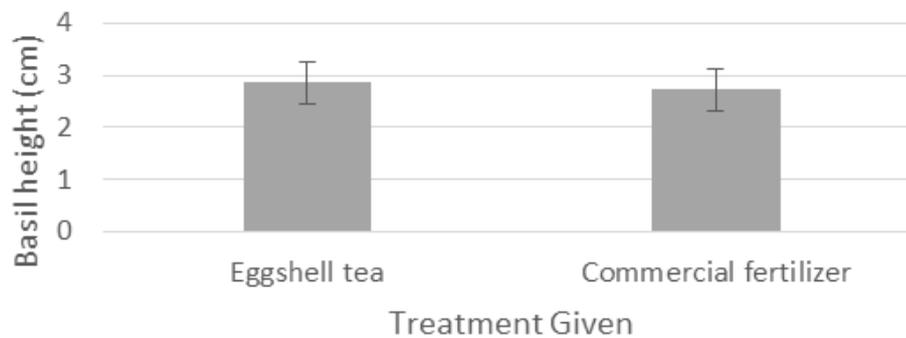


Figure-3. Graph of the average height of basil with the treatment of eggshell tea fertilizer and commercial fertilizer. Source: Wijaya (2018).

The average height of basil in eggshell tea fertilizer with 20x diluted concentration is relatively low in comparison to other research. In a research conducted by [Frąszczak et al. \(2014\)](#) the height of sweet basil under fluorescence light is 16.4 cm and sweet basil under LED lights is 14.9 cm, respectively. These results are relatively higher than the result of this study, which is  $8.43 \pm 2.44$  cm. The factor affecting the result relies on the type of light the basils received. In the other research, the light source came from fluorescence and LED lights ([Frąszczak et al., 2014](#)) meanwhile in this study the source of light was from sunlight.

### 3.2. Treatment in Water

The comparison in treatment on the water growing medium is between eggshell tea fertilizer with 20x diluted concentration and calcium nitrate fertilizer as shown in [Figure 4](#). Based on statistical analysis, there is no significant difference between average basils height in eggshell tea fertilizer group and commercial fertilizer ( $P > 0.05$ ). It means that the growth of basils in eggshell tea fertilizer group is similar to basils in calcium nitrate fertilizer group.



**Figure-4.** Graph of average height of basil with treatment of eggshell tea fertilizer and calcium nitrate fertilizer on water growing medium.  
Source: Wijaya (2018).

This result shows support to interpretation of comparison between eggshell tea fertilizer group and commercial fertilizer group in soil growing medium. Same as result average height of basils in treatment on soil growing medium, the average height of basil in treatment on water medium is relatively low compared to other research. The average height of basil in eggshell tea fertilizer is  $2.5 \pm 0.41$  in week 3 observation. This result is lower compared to 13.5 cm of basil in research conducted by [Walters \(2015\)](#). The factor affecting this result is different system of plantation. In research conducted by [Walters \(2015\)](#) the NFT and DFT hydroponic system were utilized, meanwhile only the incubator and water as growing medium was utilized in this study.

### 3.3. Nutrient Content in Eggshell.

Based on chemical analysis, it shows that eggshell tea fertilizer contains essential nutrient for plants. The eggshell tea fertilizer contains nitrogen, phosphorus, potassium, magnesium, calcium, Sulphur, zinc and chloride as shown on [Table 1](#).

**Table-1.** Table of chemical components contained in eggshell tea fertilizer.

Eggshell tea fertilizer nutrient	Amount of nutrient content
Nitrogen	0.04%
Phosphorus	4.5 ppm
Potassium	116.8 ppm
Calcium	73.8 ppm
Chloride	64.8 ppm
Sulphur	10 ppm
Magnesium	23.5 ppm

Source: Wijaya (2018).

The presence of macronutrient and micronutrient in eggshell are confirmed by other research. Eggshell contains high amount of calcium and small amount of phosphorus, magnesium and nitrogen, respectively (Nakano *et al.*, 2001; Makkar *et al.*, 2015). For the amount of components contained in eggshell, they are relatively low in general compared to other research. The calcium content in this study is 0.0738 mg/g which is relatively compared to 385-393 mg/g calcium in eggshell tested in (Schaafsma, 2000) research. The phosphorus is 0.0045 mg/g and magnesium is only 0.0235 mg/g compared to 0.2-1.9 mg/g and 3.5-3.6 mg/g respectively (Schaafsma, 2000). The amount of nitrogen is 0.04% which is relatively low compared to 15-94% (Baker and Balch, 1962). The amount of Sulphur is also relatively low with only 0.01 mg/g compared to 37.8% mg/g Sulphur.

The source of eggs and chicken feeds are factors affecting the differences in the amount of component in eggshell. The treatment of eggshell also contributed to the result. In this study, the eggshell has been turned to eggshell tea fertilizer which has a liquid form. Boiling process was also conducted. Contact with water and boiling process might be affecting the lower result of chemical components in eggshell.

#### 4. CONCLUSION

Based on the results, the eggshell indeed contains macronutrients and micronutrients that are essential for plants growth. It can be concluded also that eggshell tea fertilizer in 20x diluted concentration performed better significantly than crushed eggshell in a short period of time. Eggshell tea fertilizer in 20x diluted concentration is compatible with commercial fertilizer in term of effectiveness as well.

**Funding:** This research was supported by the Centre of Excellent for Research Value Innovation and Entrepreneurship (CERVIE) (Proj-IN-FAS\_026) and Faculty of Applied Sciences of UCSI University.  
**Competing Interests:** The authors declare that they have no competing interests.  
**Contributors/Acknowledgement:** Both authors contributed equally to the conception and design of the study.

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