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# ENHANCEMENT OF IRON CONTENT IN SPINACH PLANTS STIMULATED BY MAGNETIC NANO PARTICLES

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**Abstract.** In our previous study, the iron content in spinach plants could be detected by magnetic susceptibility values. In the present work, magnetic nano particles were found from the iron sand. The magnetic nano particles are synthesis by using co-precipitation process and sol-gel technique. The stimulation of magnetic nano particles in the plant has been done by the provision of magnetic nano particles in growing media. After certain time, plant samples was characterized using susceptibility-meter MS2B and atomic absorption spectroscopy to measure the magnetic susceptibility and the amount of iron content that absorbed of the plant, respectively. The iron content in the spinach plants was increased when the magnetic nano particles was injected in the growing media.

## INTRODUCTION

The content of iron in green vegetables such as spinach is an interesting topic to be studied in physics. It is based on the fact that ferrous metal with nickel and cobalt metals have magnetic properties prominent than the other elements. In the iron atom there are has a number of valence electrons that generate a magnetic dipole moment which is an emergence agent in magnetic properties of ferrous metals. Due to this fact makes the presence of iron in green vegetables can be detected by magnetic susceptibility measurements.

Some researcher was suggested that the iron in vegetables can be detected from the magnetic susceptibility values. Aji *et al.* (2005) measured the magnetic susceptibility in several areas of potential contact with pollutants in Semarang [1]. The results showed that the spinach plants have a positive magnetic susceptibility, which means that there is the iron content in spinach samples. Kuncoro *et al*. (2009) was reported that spinach plants were grown and controlled by the magnetic field does not show the positive magnetic susceptibility [2]. In other words, all of the spinach plants samples was examined has iron content is very low or virtually non-existent. The data is confirmed from the results of atomic absorption spectroscopy, Fe element was not found in the spinach plants samples.

The contradictions result was reported by Subber *et al.* (2012) was investigated the effect of magnetic fields on *Zey mays* plant grown [3]. Long radicals and protein percentage are increased significantly formed with the long time of a magnetic field was applied. The similar result was reported by Jabail *et a.l* (2013) that use magnetic fields at the growing process of *Triticum aestivum* plants [4]. Application of the magnetic field on the *Triticum aestivum* plants also affect in the process germination and the significant effect on the protein radical formation.

Furthermore, some researchers used iron sand to increase the iron content in green vegetables such as Kusumastuti et al. (2012). Iron sand dissolved by HCl solution then injected in the planting medium [5]. Green vegetable samples shows that the iron content in the green vegetables was increased. Cifuentes *et al*. (2010) was

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studied absorption and translocation on the root of the plants by nano particles of iron sands [6]. Stimulation of magnetic nano particles were also performed on Tobacco BY-2 cells, which results that the magnetic nano particles stimulated affect in antioxidant elements contained in Tobacco BY-2 cells [7]. Other advantages of the application of magnetic nano particles was reported by Tang (2013) which that magnetic nano particles is considered a stabilizing factor at the environment condition through binding and precipitating ions are dangerous for environment life.

In this paper, studied the effect of magnetic nano particles to raise the iron content in spinach plants through stimulated magnetic nano particles on the growing media. The iron content was determined through the measurement of the amount of iron that is absorbed in the plant and magnetic susceptibility value. The measurement has been done using atomic absorption spectroscopy and susceptibility-meter.

## EXPERIMENTAL PROCEDURE

Spinach plants samples was grown in the green house with dimension 8 x 8 x 4 m. The roof of the green house was prepared by UV plastics and the green house walls made from black paranet. First, the spinach seeds are sown in the media that made of a mixture of soil and compost. Spinach is growing in about 3 days. Spinach plants aged 10 days and then transferred to the medium which is made of husk charcoal grille. After one or two days, the spinach plant has been growing steadily. Furthermore, the magnetic nano particles were resulted from the synthesis of iron sand (25 ml FeCl mixture with 2500 ml mineral water) was injected to the media growing. Injection of magnetic nano particles solution was performed regularly every 3 days and watering with clean water is done every 2 days. Spinach plant samples picking is done every week. Spinach plant sample was characterized by susceptibility-meter and atomic absorption spectroscopy to determine magnetic susceptibility and the amount of iron that is absorbed in the plant, respectively.

## RESULTS AND DISCUSSION

### Fe Contain in Human Body

In Indonesia, the nutrient problem can be shown because on the over nutrition or malnutrition. Malnutrition problem was included Protein-Energy Malnutrition (PEM), iodine deficiency disorder, lack of vitamin A, and nutritional anemia iron (Jellife, 1989). Main Factor of causes the nutritional anemia is unbalanced of the nutrient input and nutrient ourput. Its means that the amount of the iron consumed (nutrient input) was smaller than the amount of the iron was used and released (nutrient output). The linkage of iron deficiency influenced by the type of the iron source absorbed by the body depends on daily meal menu. Generally, the food absorbed originates from animal, usually called as "*haem iron*", such as chicken meat, liver, bone marrow and anchovy which are high in uptake that is 20%-30%. The foods from plants or vegetable were called "*non-haem iron*", such as spinach, water spinach, lettuce, and nuts which the uptake is only 1%-5%. The rate of iron absorption is usually known as bio-availability [8].

**TABLE 1.** Distribution of the Fe contain in human body.

| Parts | The amount of the Fe contain (mg) | Percentage (%) |
|---|---|---|
| Haemoglobin | 2.500 | 67,19 |
| Reserves (ferritin and hemosiderin) | 1.000 | 26,87 |
| Myoglobin | 130 | 3,5 |
| Pool labile | 80 | 2,15 |
| Enzyme | 8 | 0,21 |
| The transports | 3 | 0,08 |
| Total | 3.721 | 100,00 |

**TABLE 2.** The human Fe need per day according the age

| Age interval | Fe need per day (mg) | Age interval | Fe need per day (mg) |
|---|---|---|---|
| 0 – 6 month | 3 | **Female** | |
| 7 – 12 months | 5 | 10 -12 years | 19 |
| 1 – 3 years | 8 | 13 – 15 years | 25 |
| 4 – 6 years | 9 | 16 – 19 years | 26 |
| 7 – 9 years | 10 | 20 – 45 years | 14 |
| **Male** | | 46 – 59 years | 14 |
| 10 -12 years | 14 | >60 years | +20 |
| 13 – 15 years | 17 | **Hamil/manyusui** | |
| 16 – 25 years | 13 | 0 – 6 month | +2 |
| 26 – 45 years | 13 | 7 – 12 month | +2 |
| 46 – 59 years | 13 | | |
| >60 years | 14 | | |

The presence of iron contain in human body is relatively small, approximately 3-5 g in adult. The distribution of iron in the body is almost 70% on haemoglobin. The 25% of the iron is iron reserves in the form of ferritin dan hemosiderin and the rest is contained in any oxidative enzymes, such as catalase, mitochondria, cytochromes and flavoproteins (Gustia, 2013). Distribution of the iron contain in the human body can be shown on Table 1.

The human Fe contain need per day also not in the higher contain of Fe. Only on the small amount of the Fe was needed on the human body. However, the Fe contain should be exist on our body to make the balancing of the nutrient was needed in the body. The human Fe need per day due to an age of the human can be shown in Table 2.

## Magnetism on the Vegetable

Symptoms of magnetism in plant are quite new field of the study. However, the last decade's research on this symptom was studied widely. Subber *et al*. (2012) was studied the effect of magnetic fields on growth of zey mays plant [3]. The results shows that the applications of magnetic fields influence on the biochemistry process are occur in plants. Florez *et al.* (2012) was studied also the effect of magnetic fields on germination process of herbal plants salvia officinalis and Calendula officinalis [9]. Further, the specific observation has been done by Uelas *et al.* (2004), which is the observation on the effect of magnetic field at the plant roots of Triticum aestivum [10]. They are reported that the magnetic field can be caused the plants root shows the symptoms magnetism is diamagnetic.

**TABLE 3.** The survey result on magnetic susceptibility value of the green vegetable in the different places.

| No. | Vegetables | Places | Magnetic Susceptibility (x $10^{-8}$ $m^3$/kg) |
|---|---|---|---|
| 1. | Kacang panjang | Gunungpati | -4.1 |
| 2 | Kangkung | Meteseh | 1.6 |
| | | Gunungpati | 3.3 |
| | | Semarang | 10.9 |
| | | Klego | 2.1 |
| 3 | Bayam | Meteseh | 5.1 |
| | | Gunungpati | 6.2 |
| | | Semarang | 19.8 |
| | | Wonogiri | 5.5 |
| 4 | Daun Singkong | Gunungpati | 31.0 |
| 5 | Selada | Sumowono | 7.0 |
| 6 | Daun Pepaya | Gunungpati | 10.7 |
| 7 | Daun Ubi | Gunungpati | 17.5 |

In the preliminary study, we has been done on the measurement of magnetic susceptibility in green vegetable in several different places. Based on these measurements, it was found that the magnetic susceptibility values of the green vegetable have negative and positive value as shown in Table 3. The negative and positive values of magnetic susceptibility mean the green vegetable has kind of magnetic susceptibility negative and positive according to diamagnetic and paramagnetic.

## AAS and Susceptibility Meter measurement

The study began with sowing seeds of spinach plants in polybag which the planting medium is a mixture of soil and compost. Seeds germinate grown in about 3 days. After ten days, spinach plants were transferred to growth media made from charcoal husk fuel. Furthermore, spinach plants samples was injected by magnetic nano particles solution (FeCl solution) at growing medium. The picking process of spinach plant samples has been done every week.

The absorption measurement of Fe content was characterized by atomic absorption spectroscopy (AAS). This method used to measure the Fe content was absorbed by spinach plants sample was injected by magnetic nano particles at planting medium. The amount of magnetic nano particles was absorbed by spinach plant products as shown in Table 4.

**TABLE 4.** Fe content of the spinach plants product.

| Sample No. | Mass (mg) | Fe Content (mg/100 gr) |
|---|---|---|
| S0 | 1,006 | 8,448 |
| S1 | 1,010 | 9,897 |
| S2 | 1,021 | 5,142 |
| S3 | 1,102 | 5,671 |

Stimulation of the magnetic nano particles through the growing media makes that the iron content in spinach plants product was increased. It is known that the iron content, Fe in spinach plant at the market around of 3,3 mg/100gr. In this study was obtained the spinach plants products has Fe content around of 9,897 mg/100gr. Its can be conclude that the stimulation of magnetic nano particles at spinach plants through the planting medium can be increased the Fe content 3 times higher than the spinach plants in the market. According to Table 4, shows that also the Fe content at S2 sample was decreased compare to Fe content at S1 sample. This happens because nearly 2 weeks the spinach plant samples are not given the injection of magnetic nano particles. After the stimulation was given again, the Fe content in spinach plant products increased as shown in the S3 sample.

Furthermore, the magnetic susceptibility was measured using susceptibility meter. The magnetic susceptibility value of the spinach plant was stimulated by magnetic nano particles as shown in Table 5.

**TABLE 5.** The magnetic susceptibility value of the spinach plant.

| Sample No | Magnetic Susceptibility ($\times 10^{-8}$ $m^3/kg$) |
|---|---|
| S0 | 104.1 |
| S1 | 278.9 |
| S2 | 97.9 |
| S3 | 0 |

From Table 5, its shows that magnetic susceptibility value increases with the stimulation of magnetic nano particle were injected. This result similar to the AAS result, which the Fe content increases with the stimulation of magnetic nano particles was injected on the growing media. However, the magnetic susceptibility was decreased when the stimulation of the magnetic nano particle not given to the spinach plant periodically. The magnetic susceptibility value decreases caused the nutrient on the growing media was absorbed in the spinach plant which is used to the spinach plants grown. The interesting results of the magnetic susceptibility value at sample no S3. Its can be seen the magnetic susceptibility value are 0 (zero) when the magnetic nano particle was injected again.

## CONCLUSION

Preliminary research on magnetic nano particles stimulation at spinach plants to improve the iron content in spinach plants has been done. Spinach plants products which are stimulated with magnetic nano particles on planting medium have high iron content than similar products on the market. Iron content on the spinach plants products was stimulated with magnetic nano particles and spinach plants in the market are 9.897 mg/100 gr and 3.3 mg/100 gr, respectively. Periodicities on the stimulasion of magnetic nano particles also influence the content of iron in the spinach plants products.

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