Green spinach leather as a Fe source to increase nutritional intake

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Abstract. The basic health research data which has been released in 2013 shows that the anemia incidence number is still high, 21.7%. This is caused by the lack of micronutrition (fiber, folic acid, vitamin A or B12) as the result of the lack of green vegetable consumption. This research aims to reform the green spinach (Amaranthus spp.) into green spinach leather in a form of vegetable leather, to increase the perception of the vegetable reception and minimized the lost Fe content during processing to increase nutritional intake. This research uses experimental research design with the formulation of 85% green spinach leaf and 15% agar-agar as the binder. The Fe content measurement was conducted using Absorption Spectrometer (AAS). The measurement of the green spinach vegetable leather product sensory acceptance is conducted using rating hedonic test. The sensory test result from 53 panelists states that the vegetable leather has a significantly better perception compared with the original spinach for the flavor attribute, aroma, and texture. The Fe content test results in the Vegetable Leather product is 3.3 mg/100 g. This result still has enough Fe content as the daily intake.

Keywords: Anemia, vegetable leather, green spinach (Amaranthus spp.)

1. Introduction
Green vegetables contain vitamin, fiber, and bioactive compound categorized as an antioxidant which is good for human’s health. Consuming vegetables suiting its portion can prevent untransmuted disease [1]. It turns out that as a country which has many kinds and numbers of vegetables, Indonesia owns a very low daily vegetable intake, it is 107 gr/day [2]. That rate is far from the half of the vegetable and fruit standard intake which is recommended by The Health Ministry of Republic of Indonesia in The Regulation of the Minister of Health No. 41 the Year 2014 on the guidance for balanced nutrition, 400 gr/day [3].

Anemia is a nutritional problem which is often happened in some developing countries, including Indonesia. The nutritional problem that happened in anemia can occur in all age categories, including mothers-in-pregnancy. Based on the data from Basic Health Research on 2013, the anemia occurrence number in Indonesia is 21.7% where 28.1% happened in 12–59 months old age category, 26.4% (5–14 years old), 18.4% (15–24 years old), 16.9% (24–25 years old), 18.3% (35–44 years old), 20.1% (45–54 years old), 25.0% (55–64 years old), 34.2% (65–74 years old), and the anemia occurrence number...
for mothers-in-pregnancy is 37.1% [4]. This caused by the lack of micronutrients (fiber, folic acid, vitamin A or B12) as the effect of the lack of consuming green vegetables [5].

The low level of vegetable consumption is caused by the vegetable characteristic which is easy to be damaged after the harvesting time, the consumer perception towards the vegetable and its form [6–9]. Therefore, the fresh processing towards the vegetable is an effective way to maintain the content. One of them is the dried fresh vegetable in the form of vegetable leather [10,11].

In making vegetable leather, the drying process is needed to reduce the density so that the decay microorganism is not able to grow as well as inactivating the enzyme. Vegetable Leather is one of the vegetable-based food products which is hydrated, consumed as a snack or dessert in a strip form or a flexible sheet and chewy texture [10,12–13].

One of the green vegetables which are irresistible from heat and easily damaged in processing is green spinach (Amaranthus spp.). The green spinach (Amaranthus spp.) is one of the green vegetables which is high in the source of vitamin and fiber. The green spinach (Amaranthus spp.) also contains flavonoid which is functioned as an antioxidant [14]. The vitamin, mineral, and fiber which is contained in 100 gr green spinach (Amaranthus spp.) are vitamin C 28.1 mg, vitamin A 9377 IU, vitamin E 2.03 mg, folic acid 194 µg, calcium 99 mg, iron (Fe) 2.71 mg, and fiber 2.2 mg [15]. The green spinach (Amaranthus spp.) is often processed into various foods such as spinach, pecel, gado-gado, spinach cakes, and spinach chips. It is because the green spinach (Amaranthus spp.) can be found vastly in Asia, especially in Indonesia [16]. Therefore, this research aims to reform the green spinach (Amaranthus spp.) into green spinach leather in a form of vegetable leather, to increase the perception of the vegetable reception and minimized the lost Fe content during processing to increase nutritional intake.

2. Method
This research is a laboratory experiment. This research was conducted in the processing laboratory of Universitas Kristen Satya Wacana, Salatiga. The sample of the spinach used was the one that has young and soft foliage and the agar-agar obtained from Salatiga, Central Java. The research process covered the puree-making, formulation, the iron (Fe) analysis, and the sensory reception rate.

2.1. The making of spinach puree
As many as 500 gr of green spinach had been washed and blanched using iced water along 10–15 minutes. Then it was mashed up by using a blender until it became a puree. The next step was to take 100 g spinach puree and mix it with 15 agar-agar as the binder. Later it was mashed up using a blender until evenly mixed.

2.2. The drying process
The spinach puree would be spreader evenly on the baking sheet for at least 1mm thick and dry it at low temperature (165°F) along ± 75 minutes. The drying process was conducted until the level of the water content reached 13%. The drying process was conducted to form the structure and the color of the product.

2.3. The analysis of the total Fe content
The analysis of the total iron (Fe) content was determined using the Atomic Absorption Spectrometry method (AAS) in The Integrated Laboratory of The Faculty of Science and Mathematics, Universitas Kristen Satya Wacana, Salatiga.

2.4. The sensory reception test
The sensory reception test for the material of the real spinach and the green spinach leather used Hedonic rating test using the untrained 53 panelists with women in fertile age from some region of origins. The test attribute used was flavor, texture, and aroma. The rating scale used was from 1–5 from very dislike, dislike, neutral, like, very like. The test result was analyzed using SPSS 16.
3. Result and discussion
The obtained result of the drying process using microwave was the spinach sheet with bright green color which indicated the original color of the spinach (figure 1).

Figure 1. Green spinach Leather (*Amaranthus* spp.)

The obtained characteristic of the vegetable sheet was dry on the surface but it was still flexible and could be torn. The product has a green color, but there were some spots that showed a darker color. This may happen because of the different thickness levels of the vegetable sheet so that when it was dried, the evaporating process did not occur evenly on each side. The Fe content analysis in the green spinach leather (*Amaranthus* spp.) by using AAS method is shown in table 1.

| Spinach Leather (mg/100g) | Fresh Spinach (mg/100g) |
|---------------------------|-------------------------|
| Total Fe                  | 3.3 ± 0.13\(^{a}\)      | 3.9\(^{b}\)               |

Note: \(^{a}\) shows The result of the total Fe content on the vegetable leather; \(^{b}\) shows the total Fe content on the green spinach fresh [1].

Fe is a micronutrient component that has a role in forming the blood, it is the hemoglobin molecule (Hb). Fe is kept in the liver, spleen, and marrow. The reserved Fe in the body can be obtained from daily, food intake. Nevertheless, if the amount of the obtained Fe from the food intake does not fulfill the needs, the unbalanced Fe in the body will happen, which will lead to anemia. Based on the table of Recommended Dietary Allowances (RDA), the recommendation of iron (Fe) adequacy based on age groups for Indonesians in between is 7 mg (7–11 months old), 8 mg (1–3 years old), 9 mg (4–6 years old), 10 mg (7–9 years old), 13–26 mg (10–49 years old), and 12–13 mg (50–80+ years old).

In table 1, it is obtained that the analysis result of the Fe content in the green spinach leather (*Amaranthus* spp.) is 3.3 mg/100 g product. By adding agar-agar as the binder in the formulation of vegetable leather, it gives the protection towards the active component (Fe) when the drying process is conducted so that it can obtain an adequate content of Fe. This shows that the green spinach leather product (*Amaranthus* spp.) still has the Fe content which can help to fulfill the additional Fe intake by consuming the product as many as ± 200–300 g/days green spinach vegetable leather (*Amaranthus* spp.). The analysis of the green spinach leather (*Amaranthus* spp.) is conducted to reveal the water
content, fiber, carbohydrate, protein, and fat in the product. The Analysis result of each nutritional content is presented in table 2.

**Table 2.** The Macronutrient of the Green Spinach Leather and Fresh Green Spinach (*Amaranthus* spp.).

| Nutritional Content | Green Spinach Leather % (g/100 g) | Fresh Green Spinach (g/100g) |
|---------------------|-----------------------------------|------------------------------|
| Water Content       | 10.94                             | 0.7                          |
| Fiber               | 73.68                             | 0.7                          |
| Carbohydrate        | 17.56                             | 2.9                          |
| Protein             | 3.19                              | 3.5                          |
| Fat                 | 0.02                              | 0.5                          |

3.1. *Water content*

The result of the water content in the green spinach leather (*Amaranthus* spp.)

Table 2 shows the water content value, 10.94%. This result is compatible with the standard of Indonesian National Standard in dried products, less than 13%.

3.2. *Fiber*

The content of the fiber in the green spinach leather (*Amaranthus* spp.) in table 2 shows the fiber content as many as 73.68% g/100 g. As many as 15% agar-agar concentration was added into the vegetable leather product as some of the fiber content. Agar-agar is a seaweed polysaccharide component that is still included in dissolved food fiber so that it can increase the content of the food fiber.

3.3. *Carbohydrate*

The content of the carbohydrate in the green spinach leather (*Amaranthus* spp.) in table 2 shows that the carbohydrate content is as much as 17.56% g/100 g. The green spinach and the agar-agar have a low carbohydrate content so that the vegetable leather has a low carbohydrate content.

3.4. *Protein*

The protein content in green spinach leather (*Amaranthus* spp.) is as many as 3.19% g/100 g. The drying process conducted causes denaturized protein, broken protein aggregation structure, and decreased rehydration enzyme structure. Besides that, it is able to affect the changing of all secondary protein structure. It causes a broken protein.

3.5. *Fat*

The fat content in the green spinach leather (*Amaranthus* spp.) is as much as 0.02% g/100g. The conducted drying process makes the fat broken because of the heat so that the fat components are broken up into volatile products such as aldehyde, ketone, alcohol, acids, and hydrocarbon which affects the flavor forming very much.

3.6. *The hedonic test*

Besides having a useful intake content, the green spinach leather, as a product, needs to be tested for the flavor reception so that it can be obtained a product characteristic portrayal in it using. The flavor testing covers four main attributes, flavor, aroma, texture, and overall attributes. The real spinach is used as the comparing. The flavor testing is aimed at seeing how far the flavor reception before and after processing innovation is. The result of the flavor reception can be seen in figure 2.
In the testing scale from 1 to 5, from very dislike to very like, in general, the panelists’ concentration in figure 3 is on rating 2–3 in majority, which is from dislike rating to like rating with a close enough difference between control (green spinach) and the product (green spinach leather). The difference between the product and the control were tested with the statistic method, presented in table 3.

**Table 3.** The statistic test result of paired t-test between control and product.

| Sensorics | Paired Correlation Test Value | Independent Test Sample |
|-----------|-------------------------------|-------------------------|
|           | Correlation Value | Significance Value | *p* Value (Sig. 2-tailed) |
| Flavor    | 0.918             | 0.000                | 0.010                   |
| Aroma     | 0.938             | 0.000                | 0.002                   |
| Texture   | 0.898             | 0.000                | 0.000                   |

Information:
a. The correlation test value is stronger if it reaches 1.
b. The significance value in the correlation <0.05, the correlation value is significant.
c. The *p* value <0.05 shows there is a significance before and after treatment.
Based on the statistic test in table 3, the correlation value between control (spinach) and product (green spinach leather) for all test attributes shows a very strong and positive correlation, with the correlation value >0.5. Based on the p obtained from the statistic test, the form changing from green spinach into green spinach leather shows that there is a significant difference in the flavor, aroma, and texture attribute, with the p test value showing <0.005 (trustworthy rate 95%). Therefore, based on the statistic test, the significant changes from green spinach to green spinach leather happens to have an increased perception which is better for flavor, aroma, and texture attribute.

4. Conclusion
Based on the analysis result of the green spinach leather, the product still has enough Fe content as an additional Fe intake of 3.5 mg/100gr.

Based on the sensory result of the acceptance test for green spinach leather product has a better significant perception compared to original spinach. Therefore, the innovation for the spinach into vegetable leather can increase the receiver’s perception.

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