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## Research Article

# Effect of Different Cooking Methods on the Content of Vitamin C, Phenolics and Minerals in Several Green Leafy Vegetables

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### Abstract

**Background and Objective:** The consumption of green leafy vegetables are very important for human health. The nutrient quality such as vitamin C, phenolics and mineral (Fe, Zn, Mg) of green leafy vegetables may be decreased or increased by thermal-processing. This study evaluated the effect of different thermal cooking methods including boiling, steaming and stir-frying on the content of vitamin C, phenolics and mineral (Fe, Zn, Mg) in several green leafy vegetables. **Materials and Methods:** Observation in a laboratory experiment was done using iodine titration method, spectrophotometric Folin-Ciocalteu method and atomic absorption spectrophotometric method for determination of vitamin C, phenolics and minerals in control and treated samples, respectively. **Results:** Boiling process had maintained the vitamin C better than steaming and stir frying. The changes in the amount of phenolics were found to be significantly higher in stir-frying. Furthermore, the mineral contents was not affected in all cooking methods. **Conclusion:** In the present study, the boiling and stir-frying method of cooking has found to be the best for healthy eating of treated green leafy vegetables

**Key words:** Cooking methods, heat processing, healthy food, green leafy vegetables, boiling process, steaming, stir frying

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**Competing Interest:** The authors have declared that no competing interest exists.

**Data Availability:** All relevant data are within the paper and its supporting information files.

## INTRODUCTION

The study on exploration of healthy food diversity has been developing in Indonesia<sup>1</sup>. Vegetables are a healthy source of food where they can be consumed as raw or processed food<sup>2</sup>. Green leafy vegetable is a kind of vegetable that are popular due to their healthy effect. In addition to chlorophyll, green leafy vegetables contain a lot of vitamins and minerals as well as phenolics which can act as antioxidant. Therefore, their consumption could protect the human body from chronic diseases including cardiovascular disease, immune dysfunction and some cancers<sup>3</sup>.

Cooking is a general process of producing safe and edible food by applying heat. The cooking process makes the raw food more edible and easier to digest, however, it also can cause the changes in the nutrient quality of the raw food<sup>4</sup>. Heat treatments such as boiling, steaming and stir-frying are common cooking methods in Indonesia. These cooking methods may lead undesirable modification of the food such as the loss of nutrient due to lipid oxidation and changes in some component of protein fraction. To date, there is limited information that indicates the effect of cooking methods on the nutritional quality of green leafy vegetables. Therefore, the aim of this study was to investigate the changes of nutrient such as vitamin C, phenolics and minerals in green leafy vegetables after cooking by three heat treatments methods which are widely used in Indonesia.

## MATERIALS AND METHODS

**The preparation of sample materials:** The vegetables were obtained from some traditional market in Padang City West Sumatera Indonesia. The selected sample were named as: (1) Spinach (*Amaranthus* sp.), (2) Water spinach (*Ipomea aquatica*), (3) Cassava leaves (*Manihot utilissima*), (4) Katuk leaves (*Sauropus androgynous* L.) Merr), (5) Long bean leaves (*Vigna unguiculata* L.), (6) Pumpkin leaves (*Cucurbita moschata*), (7) Squash leaves [*Sechium edule*, (Jacq.) Swartz.], (8) Green mustard (*Brassica juncea* L.), (9) Singgalang Radish (*Brassica oleracea*), (10) Papaya leaves (*Carica papaya* L.).

The fresh vegetables were directly transferred to the laboratory within one hour after purchased. They were washed, cut and cooked by boiling, steaming and stir-frying.

**Cooking treatments:** The vegetables were cooked in the following methods:

- **Boiling:** About 300 g of green leafy vegetable were added to 800 mL of boiling water in a chamber. Time and temperature were set at 5-7 min and  $\pm 100^{\circ}\text{C}$ , respectively. During the process, the chamber was covered and the vegetable was stirred periodically
- **Steaming:** About 300 g of green leafy vegetables were steamed with 200 mL of boiling water. Time and temperature were set 5-7 min and  $\pm 95^{\circ}\text{C}$ , respectively
- **Stir-frying:** About 10 mL of cooking oil was heated in a frying pan. Then, 300 g of vegetables were added to the frying pan. Time and temperature were set at 5-7 min and  $\pm 105^{\circ}\text{C}$ , respectively

After each cooking treatments, cooked fish were hand de-boned and ground in a kitchen blender to ensure homogeneity and representative samples taken for analysis. Samples were packed in a polythene bags and kept under frozen conditions ( $-20^{\circ}\text{C}$ ). All tests were carried out on triplicate. Fresh cut samples were estimated as controls.

**Total phenolics determination:** The amount of total phenolics in extracts was determined according to the Folin-Ciocalteu procedure. Samples (2 mL, triplicates) were introduced into test tubes; 1.0 mL of Folin-Ciocalteu's reagent and 0.8 mL of sodium carbonate (7.5%) were added. The tubes were mixed and allowed to stand for 30 min. Absorption at 765 nm was measured. The total phenolics content was expressed as gallic acid equivalents (GAE) in  $\text{mg g}^{-1}$  FW.

**Vitamin C determination:** Vitamin C test was done using iodine titration method; the level of Vitamin C was calculated by total number of Iodine ( $\text{mL} \times 0.01 \text{ N}$ )  $\times$  (0.88 mg ascorbic acid).

**Mineral analyses:** For mineral analyses, the sample were digested in  $\text{HNO}_3/\text{HClO}_4$ . The elements of iron (Fe), Magnesium (Mg) and zink (Zn) were measured by atomic absorption spectrophotometer (AAS) using a Varian Spectra atomic spectrophotometer model A-400 (Palo Alto, California, USA).

**Statistical analyses:** Statistical analyses was performed using the SPSS package version 11.5 (SPSS Inc., Chicago, IL, USA). Data were analysed using one-way analysis of variance (ANOVA), followed by Duncan's multiple range post-hoc test. Results are expressed as mean  $\pm$  SD of triplicate samples. Differences were considered significant as  $p < 0.05$ .

**RESULTS AND DISCUSSION**

**Total phenolics content:** Although, green leafy vegetables contain the high amount of chlorophyll, in this study, chlorophyll was not analyzed. Syukri *et al.*, 2018<sup>5</sup> assumed that chlorophyll is an indicator for the level of freshness or greenness of fresh vegetables therefore in cooked vegetables, the chlorophyll profile was not focused. Figure 1 indicates the effect of the cooking method on the level of phenolic content in all treated vegetables. Phenolics are a group of plant

secondary metabolites that are important for indicating the quality of plant based foods. They are responsible for the colour characteristics<sup>6,7</sup> and are also involved in flavor properties<sup>8</sup>. The cooking method affected the total phenolic content especially stir-frying induced the higher level of phenolic contents.

**Vitamin C:** Vitamin C is one of the most important nutrients in many horticultural crops including vegetables<sup>9</sup>. Figure 2 indicates the change of vitamin C in all treated samples.

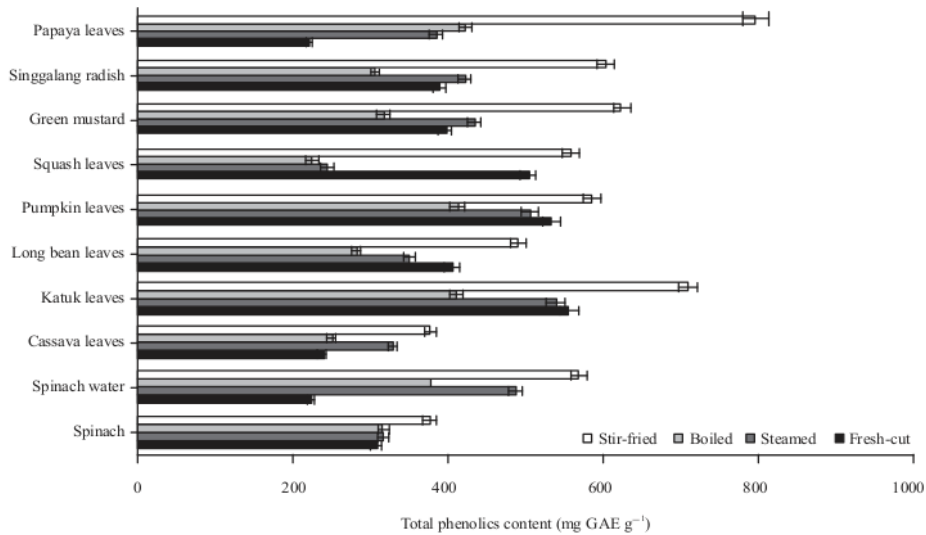


Fig. 1: The total phenolics content in several green leafy vegetables cooked by steaming, boiling and stir-frying

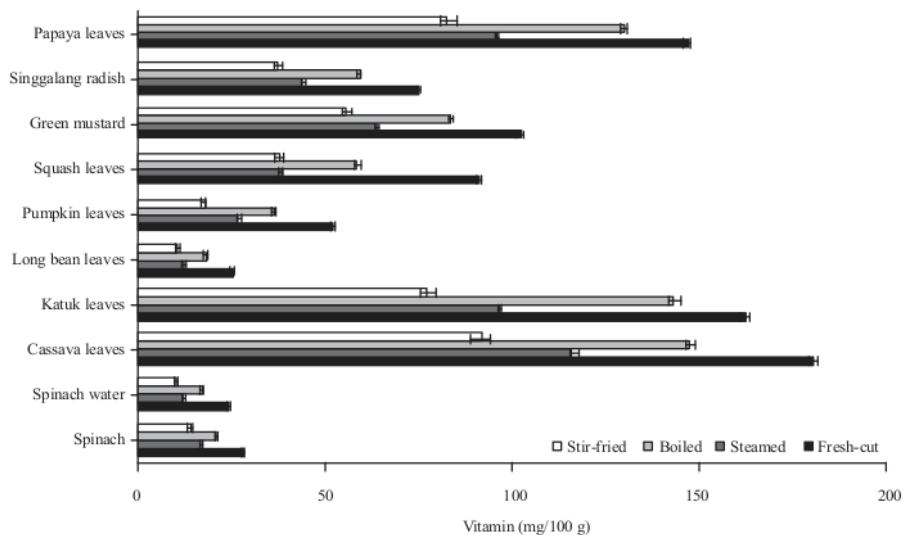


Fig. 2: The vitamin C content in several green leafy vegetables cooked by steaming, boiling and stir-frying

Similar pattern of vitamin C degradation was observed on all cooked vegetables. Boiling treatment could prevent the degradation of vitamin C in the higher amount compared to other treatments while stir-frying had induced the highest loss of vitamin C.

**Mineral analyses:** Figure 3 indicates the change of minerals (Fe, Zn, Mg) in all treated samples. Fe was present as the highest mineral in all samples compared to Zn and Mg. Our results indicated that cooking methods had little effect on

these elements. There were no significant influence of temperature on Fe, Zn and Mg profile in treated samples. Some research also indicated that cooking methods had similar results on some commodities<sup>10,11</sup>.

It suggested that the degree of degradation of bio-molecules in heat-processed samples is highly dependent on the processing time and size of vegetables. Many studies have reported that the cooking process can cause the changes on the physical characteristics and chemical composition of vegetables. Some reports showed that cooking might caused

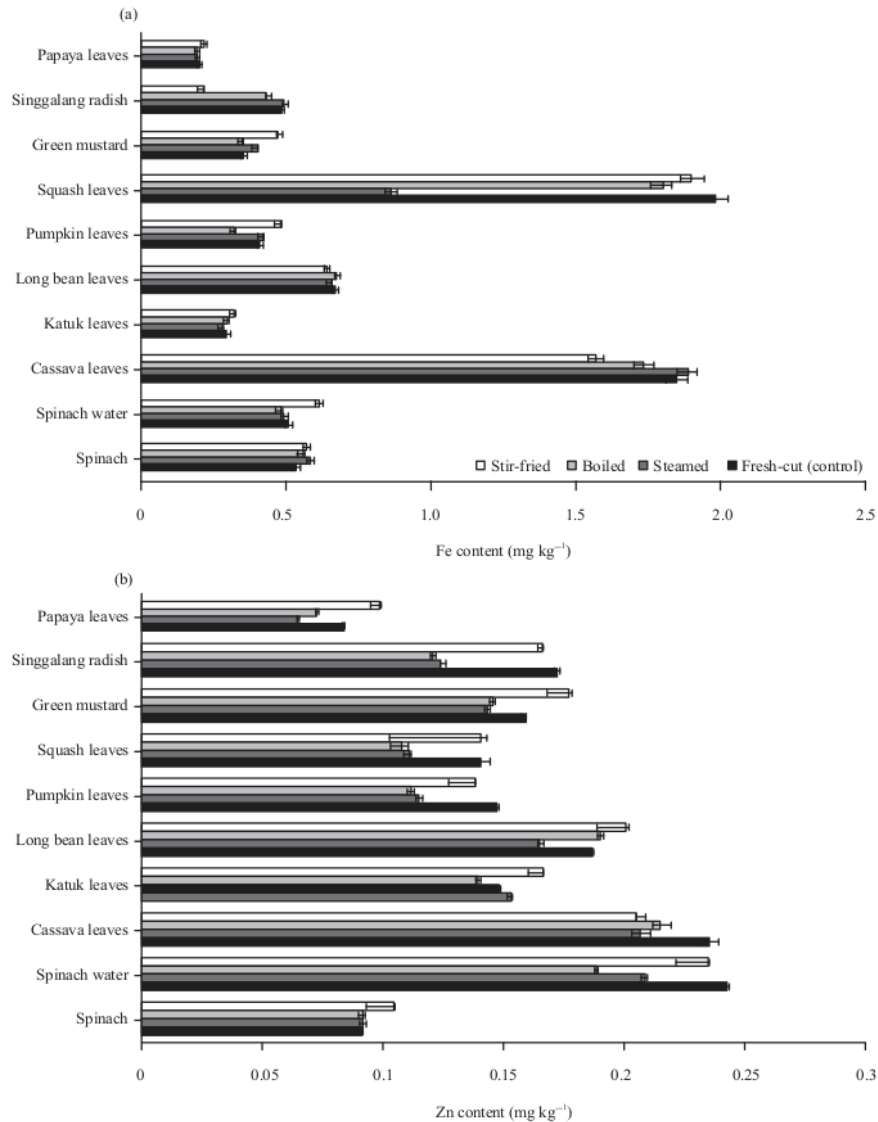


Fig. 3(a-c): Continue

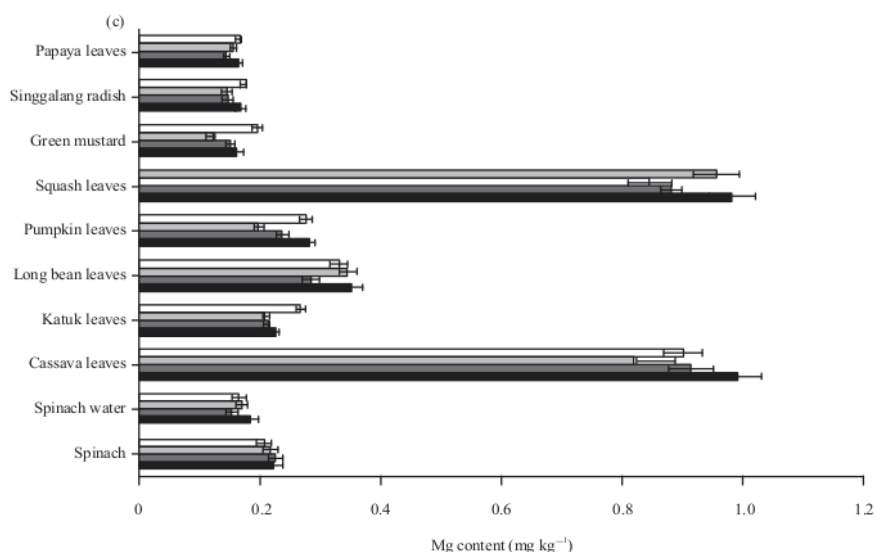


Fig. 3(a-c): The minerals content (Fe, Zn and Mg) in several green leafy vegetables cooked by steaming, boiling and stir-frying

a negative result for the quality of vegetables, however, some other studies addressed different results<sup>12-14</sup>. In this study, we have treated samples with several heat treatments (cooking methods) in a relatively short processing time (about 5 min). We suggest that the short duration of heat treatment has a good effect on the changes of nutrient compounds in the processed vegetables. Although, our results indicated that the boiling and stir-frying method of cooking has found to be the best for the nutrient quality of the treated green leafy vegetables, for general, the cooking methods have no extremely significant effect on general properties of treated vegetables. The optimal processing time of each treatment (cooking method) must be considered in further research.

### CONCLUSION

In Conclusion, the current study shows that nutrition and health-promoting compounds in several green leafy vegetables are significantly influenced by cooking methods. The boiling and stir-frying method of cooking has found to be the best for the nutrient quality of the treated green leafy vegetables.

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