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# Understanding spices and herbs as source food of potassium (macromineral): How does the cooking method influence it?

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## Abstract

Population studies reported that most of the world's population consume an amount of potassium that falls below the recommended intake levels. The most prominent source of potassium are fruits, vegetables, and nuts. However, there is still limited study that shows spices and herbs (SH) contain high potassium. Potassium is a nutrient that is intimately linked to diet quality; however, the cooking process of SH frequently results in a reduction of its nutrient. This study is a literature review based on an electronic database concerning the nutritional content and the effect of cooking on the content of macromineral's in SH. The data presented in this study were derived from Indonesian and United States food composition databases. The study found that SH mostly contains potassium in the category of medium to very high, as well as low sodium. The highest potassium content is found in turmeric, which is 2,080 mg/100 g. SH have long been used for culinary and medicinal purposes that require cooking methods, although the cooking process (dry heat cooking and moist heat cooking) affects the micromineral content in SH, especially moist heat cooking (steaming, blanching, and boiling), which significantly reduces potassium content. A comprehensive review of the extant literature in the field has confirmed that SH contains high potassium content and cooking process can decrease its potassium content. It is necessary to conduct further experimental research to prove potassium content of SH and the effect of other cooking processes on macromineral content in SH.

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## 1. Introduction

Potassium is the central intracellular cation, along with magnesium, calcium, and sodium. Potassium is essential for maintaining normal bodily functions such as stabilizing body fluids, acid-base balance, and osmotic equilibrium. Moreover, it also has an essential role in regulating molecules actively transported across cell membranes in determining membrane potentials of smooth muscles and nerves and promoting cellular growth (1). Causes of abnormalities in the dietary intake of these nutrients may play a role in the pathogenesis of hypertension, both the cause and treatment of hypertension (2,3). Specifically, high sodium and low potassium intakes are associated with an increased risk of many health problems, cardiovascular disease, stroke, and all-cause mortality (4–6).

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Population studies and meta-analyses have reported that most of the world's population, especially children, adults, and the elderly consume less than the recommended intake of potassium; however, salt (sodium) consumption is well above the recommendation (7–10). The WHO reported that people ingest approximately 30-40 mmol of potassium per day, which is well below than 100 mmol of potassium adequacy (7). Increasing potassium intake and reducing salt intake have been identified as priority interventions to reduce noncommunicable diseases (7,11). Achieving the recommendations is an urgent public health challenge, as potassium is a nutrient closely associated with diet quality, and it can be a predictor of overall dietary quality. However, the cost of the diet may often inhibit its intake (11). Moreover, programs relating to increasing potassium intake in the community are still not progressive. Therefore, a targeted and effective strategy is required to provide affordable foods to achieve an adequate potassium intake (12).

It is recommended that potassium should be consumed through food because of the safety and no upper limit. The most common recommendation to consume a high potassium intake is generally through increased consumption of fruits and vegetables (13,14). In reality, most people still consume less fruits and vegetables than recommended (10,13). Therefore, presenting food sources of potassium that are affordable and commonly used is an important requirement. Several studies demonstrated spices and herbs (SH), which are rich in phytochemical components, contain high levels of micronutrients and play an essential role in the quality of diet. It is widely known that SH has long been used for culinary and medicinal purposes that require cooking methods. Furthermore, it is fast and often used SH in our menu diet while considering their role as culinary seasonings (15,16).

Spices and herbs are commonly found in markets, and Indonesia is recorded as the world's largest producer of SH, accounting for approximately 21.06% of the total world market (17). The benefit of SH has been reported to significantly improve health status. However, fewer studies have analyzed the macromineral content in spices and herbs, and moreover, the cooking process often may affect its nutrients. Therefore, it is important to carry out this research with the aim of identifying the macromineral (potassium and other cations, sodium, magnesium, calcium) content of spices and herbs categorized as culinary nature and analyzing the effect of cooking methods on the macromineral content in the spices and herbs.

## 2. Materials and Methods

### *2.1. The Identification of Spices and Herbs as Source Food of Potassium*

Dietitians with many years of experience in nutrition fieldwork identified and analyzed food compositions rich in potassium from spices and herbs of a culinary nature, such as galangal, ginger, and others. The food composition data for calculating these nutrients were based on the Indonesian food composition databases (*Tabel Komposisi Pangan Indonesia*/TKPI 2017) as the primary nutrient data sources (18). The researchers also identified macromineral content in spices and herbs from the U.S. Department of Agriculture (USDA) database (19). These two databases were used because they are nutritional databases for researchers and professionals who share what nutrients and compounds are found in food. For clarity, the researchers divided the food list based on each spice and herb. Then, the researchers sorted the food list based on the potassium content per 100 g and sorted them from highest to lowest. The researchers also classified and ranked them into four categories (1) very high (≥1000 mg/100 g), (2) high (500–999 mg/100 g), (3) medium (100–

499 mg/100 g), and (4) low (<100 mg/100 g). In addition to potassium, the researcher also noted 3 other macrominerals (sodium, calcium, and magnesium) content of spice and herb.

### *2.2. The Influence of Cooking Methods*

All figures and tables should be cited in the main text as Figure 1, Table 1, etc. Significantly, the influence of cooking methods on macromineral content is based on literature studies. Reference was made to correlated studies in multiple electronic databases (Pubmed and Google Scholar) using keywords and subject headings. The search strategies used the following keywords: potassium, herbs, spices, and cooking methods. Inclusion criteria were as follows: (1) Cooking methods that were searched were dry heat cooking and moist heat cooking. These two cooking methods were chosen because K, Na, Mg, and Ca are soluble in water, so these two methods are believed to have an impact on the K, Na, Mg, and Ca content in spices and herbs; (2) cooking effect on herbs and spices published during the period 2012–2022; (3) availability of full-text articles; (4) primary outcomes macromineral content (potassium (K) sodium (Na), magnesium (Mg), and calcium (Ca)); and (5) language of publication: English. Exclusion criteria were: (1) outcomes irrelevant to this study; (2) case reports, review articles, commentaries, and letters. Primary data from the articles were extracted into a spreadsheet using Microsoft Office 2010.

## 3. Results and Discussion

Spices and herbs are commonly found in markets, and Indonesia is recorded as the world's largest producer of SH, with a contribution of around 21.06% of the total world market (17). The benefit of SH has been reported to significantly improve health status. However, fewer studies have analyzed the macromineral content in spices and herbs, and moreover, the cooking process often may affect its nutrients. Therefore, this study aimed to identify the macromineral (potassium and other cations, sodium, magnesium, calcium) content of spices and herbs categorized as culinary nature and analyze the effect of cooking methods on the potassium content in the spices and herbs.

### *3.1. Potassium Concentration of Spices and Herbs*

Putri & Fibrianto stated that by dividing spices into 3 (1) spice seasonings (seasoning); (2) condiment (added seasoning); and (3) herbs (medicinal plants). Therefore, researchers discussed the potassium content of spices (seasoning) and herbs. Furthermore, spices and herbs contain nutrients that are good for health, such as macronutrients (ash, fat, protein, etc.) and micronutrients (minerals, e.g. Ca, K, Mg, Na, etc.). The concentrations of four minerals (Na, K, Mg, and Ca) determined in spices and herbs are shown in Table 1.

Spices are biological resources used for hundreds of years for cooking and medicine (20). Spices act as seasonings, flavor enhancers, and food preservatives in cookery. Moreover, spices come from plant parts, such as stems, leaves (orange leaves, bay leaves, celery, pandan leaves), bark (cinnamon), tubers (onions), rhizomes (ginger, turmeric, galangal), seeds (cumin, coriander, fennel seeds), flowers (cloves), and fruits/berries (chili, pepper) (21). In addition to their used in cooking, spices have health benefits and are therefore classified as functional food ingredients (22,23). The use of spices in foods can be divided into 3 (24), namely: (1) Spice seasoning (seasoning). Seasonings are a mixture of several spice components and spice extracts that aim to increase consumption choices by adding flavor. Various processed spices have their names as the identity of these spices (24).

(2) Condiment (added seasoning).

Table 1. Minerals Content of Spices and Herbs

| Spices and Herbs | Reference | Shape | Minerals Concentration (mg/100g) | | | |
|---|---|---|---|---|---|---|
| | | | K | Na | Mg | Ca |
| Spices | | | | | | |
| Turmeric | USDA** | ground | 2,080 | 27 | 208 | 168 |
| Cayenne pepper | USDA** | - | 2,010 | 30 | 152 | 148 |
| Corpiande, seed | TKPI* | dried | 1,787 | 91 | - | 630 |
| Shallot | USDA** | freeze-dried | 1,650 | 59 | 104 | 183 |
| Pepper | USDA** | black | 1,330 | 20 | 171 | 443 |
| Ginger | USDA** | powder | 1,320 | 27 | 214 | 114 |
| Cloves | USDA** | powder | 1,020 | 277 | 259 | 632 |
| Cloves | TKPI* | dried | 961 | 282 | - | 740 |
| Cayenne pepper | TKPI* | raw | 706 | 34 | - | 45 |
| Garlic | TKPI* | raw | 666 | 46 | - | 42 |
| Chinesedey | TKPI* | raw | 480 | 33 | - | 50 |
| Ginger | TKPI* | raw | 442 | 12 | - | 21 |
| Candlenut | TKPI* | - | 431 | 25 | - | 80 |
| Ginger | USDA** | raw | 415 | 13 | 43 | 16 |
| Turmeric | TKPI* | raw | 407 | 6 | - | 24 |
| Peppers, hot chili, green | USDA** | raw | 340 | 7 | 25 | 18 |
| Shallot | USDA** | raw | 334 | 12 | 21 | 37 |
| Peppers, hot chili, red | USDA** | raw | 322 | 9 | 23 | 14 |
| Chilies red | TKPI* | raw | 272 | 23 | - | 29 |
| Chilies red | TKPI* | dried | 181 | 25 | - | 160 |
| Shallot | TKPI* | raw | 179 | 7 | - | 36 |
| Chilies green | TKPI* | raw | 151 | 7 | - | 14 |
| Galangal | TKPI* | raw | 137 | 24 | - | 50 |
| Peppers, chili, green | USDA* | canned | 113 | 397 | 4 | 36 |
| Pepper | TKPI* | dried | 100 | 4 | - | 460 |
| Pepper | TKPI* | seed dried | 79 | 2 | - | 120 |
| Peppers | USDA** | white | 73 | 5 | 90 | 265 |
| Herbs | | | | | | |
| Spearmint | USDA** | dried | 1,920 | 344 | 602 | 1,490 |
| Oregano | TKPI* | dried | 1,260 | 25 | 270 | 1,600 |
| Parsley | TKPI* | raw | 1,126 | 18 | - | 193 |
| Cajuput | TKPI* | leaf, powder | 619 | 180 | - | 86 |
| Peppermint | USDA** | raw | 569 | 31 | 80 | 243 |
| Spearmint | USDA** | raw | 458 | 30 | 63 | 199 |
| Basil | TKPI* | leaf, raw | 457 | 10 | | 35 |

*TKPI : *Tabel Komposisi Pangan Indonesia* (the Indonesian food composition databases)
**USDA : U.S. Department of Agriculture
Table 1 shows the macromineral concentration of natural spices and herbs. Its sorted the potassium content from the highest to lowest.

Additional spices are usually added to the finished food to strengthen the flavor until the desired flavor is achieved. each cook uses different amounts according to his or her preferences c. Additionally, a condiment is a seasoning that contains spices or spice extracts in a single form (shallot salt, garlic salt) or in a mixture (mustard, chili sauce) (25). (3) Herbs. Herbs or medicinal plants are also derived from spices that aim to treat or alleviate the symptoms of a disease (24).

Spices and herbs contain minerals that are good for health. As shown in table 1, spices contain a variety of minerals, including calcium, magnesium, sodium, and potassium. These four minerals are related to the body's fluid and electrolyte balance, which affects kidney function and hypertension (26,27). Overall, each age group has different needs for K, Na, Ca, and Ma. Here are the requirements for each age group (28,29).

Table 2. Adequate Intake of K, Na, Ca, and Mg

| Life-Stage Group Infans | K (mg/day)* | Na (mg/day)* | Ca (mg/day)* | Mg (mg/day)** |
|---|---|---|---|---|
| 0 – 6 months | 400 | 110 | 210 | 30 |
| 7 – 12 months | 860 | 370 | 270 | 75 |
| Children | | | | |
| 1 – 3 years | 2,000 | 800 | 500 | 80 |
| 4 – 8 years | 2,300 | 1,000 | 800 | 130 |
| Males | | | | |
| 9 – 13 years | 2,500 | 1,200 | 1,300 | 240 |
| 14 – 18 years | 3,000 | 1,500 | 1,300 | 410 |
| 19 – 30 years | 3,400 | 1,500 | 1,000 | 400 |
| 31 – 50 years | 3,400 | 1,500 | 1,000 | 420 |
| 51 – 70 years | 3,400 | 1,500 | 1,200 | 420 |
| > 70 years | 3,400 | 1,500 | 1,200 | 420 |
| Females | | | | |
| 9 – 13 years | 2,300 | 1,200 | 1,300 | 240 |
| 14 – 18 years | 2,300 | 1,500 | 1,300 | 360 |
| 19 – 30 years | 2,600 | 1,500 | 1,000 | 310 |
| 31 – 50 years | 2,600 | 1,500 | 1,000 | 320 |
| 51 – 70 years | 2,600 | 1,500 | 1,200 | 320 |
| > 70 years | 2,600 | 1,500 | 1,200 | 320 |
| Pregnancy | | | | |
| 14 – 18 years | 2,600 | 1,500 | 1,300 | 400 |
| 19 – 30 years | 2,900 | 1,500 | 1,000 | 350 |
| 31 – 50 years | 2,900 | 1,500 | 1,000 | 360 |
| Lactation | | | | |
| 14 – 18 years | 2,500 | 1,500 | 1,300 | 360 |
| 19 – 30 years | 2,800 | 1,500 | 1,000 | 310 |
| 31 – 50 years | 2,800 | 1,500 | 1,000 | 320 |

* AI : Adequate Intake
** RDA : Recommended Dietary Allowance

From table 2, it is known that the needs for K, Na, Ca and Mg are very different at different age group. Therefore, special attention is needed to meet macromineral intake, especially potassium, the consumption of which is largely deficient worldwide (11). Consumption of SH can help provide the body with the minerals it needs.

In addition to being an alternative to fulfilling potassium intake, SH consumption also has various benefits. A study showed that ginger extract has a positive effect on kidney

function. Based on a study that was conducted on rats by giving ginger extract orally up to 200 mg/kg body weight for six weeks. The results revealed that ginger extract helps maintain the balance of electrolytes in serum and prevents the retention of some electrolytes during urination (27). For this reason, the human body needs electrolytes, especially sodium and potassium, to maintain fluid and blood volume (30). Furthermore, sodium and potassium sodium and potassium play an essential role in muscle contraction and in the conduction of impulses in the nervous system (31–33). Within the cell, potassium acts as a catalyst in many biological reactions. Also, potassium aids in cell growth. The amount of potassium in muscle is related to glycogen stores and muscle mass (34). Table 1 shows that spices and herbs contain minerals (potassium, sodium, magnesium, and calcium). However, there are no complete details of the ingredient preparation process in the database used before the ingredients are checked for nutritional content. From the table, it is known that almost all SH have a medium to very high potassium content [very high (≥1000 mg/100 g); high (500–999 mg/100 g); medium (100–499 mg/100 g); (<100 mg/100 g)] and almost all spices have a low sodium content. Therefore, adding SH as a seasoning in cooking can help increase daily potassium consumption. For example, the daily potassium requirement for adults is 2600 mg/day for women and 34 mg/day for men. Consuming up to 5 grams of turmeric per day as a spice seasoning can meet up to 8% of the daily requirement. In making spice seasoning, a combination of various SH is used so that the weight of SH used as a seasoning is also higher, which causes the potassium content in the SH that we consume per day to also increase. The addition of SH as a seasoning can also reduce the addition of salt by up to 50% with an acceptable taste (35,36). In addition to being used as a seasoning, SH can also be consumed in the form of healthy drinks. However, SH cannot be used as the only alternative to meet the daily potassium requirement because the use of SH as a spice is not too high. Therefore, the consumption of vegetables and fruits is still necessary to fulfill the potassium intake.

### *3.2. Factors that Affect the Mineral Content of Spices and Herbs*

Cooking methods can change the chemical structure of food, making it easier to digest. Food processing also reduces the anti-nutrient content of food. However, it also reduces the levels of the nutritional content of food. Studies showed that food processing could reduce antioxidants and other components such as macronutrients and micronutrients of food (37,38).

As seen in Table 3, it is found that the processing process can have an impact on the content of Na, Ca, and Mg, especially K. The drying process increased the mineral content of spices and herbs. This is due to the effect of concentration, as drying is a process of dehydration (39,40). However, different drying methods also make a difference in the mineral content of spices and herbs. The study in Table 3 also found that some drying processes decrease the calcium concentration of spices and herbs. Barciela-Alonso and Barmejo-Barrera (2015) found that minerals can be lost during the cooking process due to heating.

In contrast to the study by Karimian-Khoroshahi et al., baking significantly increased the concentration of minerals (Na, K, Ca, and Mg). Microwave cooking significantly increased K and Mg concentration and did not affect Na and Ca; apparently, more research is needed on this. Although there were significantly different outcomes regarding minerals' resistance to heating, minerals are substances that are susceptible to heating using water (41). As seen in Table 3, the mineral content of ginger is decreased when it is boiled before being susceptible to water heating and being dried (37). Steam blanching also decreases the amount of K, Na,

and Ca in herbal tea (42). This result is due to the possibility of minerals leaching into the water while heating (41,42).

In processing food using spices, Table 3 lists the following typical cooking methods: boiling, steaming, microwave, and oven. The K, Na, Ca, and Mg content of the spices used can be affected by these four methods. Therefore, in order to preserve the mineral content of SH, especially SH that is processed using the moist heat cooking method, which may reduce the mineral content, it is preferable to cook foods just enough, not overcooked.

Table 3. Processing Effect of Spices and Herbs on Minerals Content of Spices and Herbs.

| Processing Methods | Spices and Herbs | Time | Temperature | Result | Reference |
|---|---|---|---|---|---|
| Drying | | | | | |
| Shade drying | Ginger | - | Room temperature | Ca > Ca microwave dried | (43) |
| | Turmeric | - | - | K ↑, Na ↑, Mg ↑, and Ca ↓ | (37) |
| Oven drying | Ginger | 6–8 h | 50±5$^0$C | Ca < Ca sun-dried | (43) |
| | Stinging nettle leaves | 15 h | 70$^0$C | K (fresh) = K (dried)<br>Na (fresh) = Na (dried)<br>Mg ↑<br>Ca ↓ | (44) |
| Microwave drying | Ginger | 3-4 min | - | Ca > Ca sun dried | (43) |
| Solar drying | Ginger | - | - | Ca > Ca oven dried | (43) |
| | Red Pepper | 8 h | 69 – 77.5$^0$C | Ca ↓<br>Ca > Ca sun dried | (45) |
| Sun drying | Turmeric | - | - | K ↑, Na ↑, Mg ↑, and Ca ↑ | (37) |
| | Red Pepper | 15 h | - | Ca ↓<br>Ca < Ca solar dried | (45) |
| Freeze drying | Stinging nettle leaves | 5 days | -40$^0$C | K (fresh) = K (dried)<br>Na (fresh) = Na (dried)<br>Mg (fresh) = Mg (dried)<br>Ca ↓ | (44) |
| Moist heat cooking | | | | | |
| Steam blanching | Dried Herbal Tea developed rom Moringa oleifera Leaves | 3 min | - | K ↓<br>Na ↓<br>Mg ↑ slightly<br>Ca ↓ | (42) |
| Balancing with plain water | Pepper | 4 min | 98$^0$C | Ca ↓ | (45) |
| Blancing with NaCl | Pepper | 4 min | 98$^0$C | Ca ↓ | (45) |
| Boiling | Turmeric | - | - | K ↓, Na ↓, Mg ↓, and Ca ↓ | (37) |

*In addition to cooking methods, food production also influences the nutritional concentration of spices and herbs, as do differences in cultural practices such as irrigation frequency, fertilizer type, rate and time of application as well as fertility status of the soil* (37).

Table 3 still has limitations, however, as not many differences in SH have been examined across a range of cooking methods. The macromineral content of each SH is known to be

affected differently by each cooking method. Except from that, data limitations prevented an analysis of the effects of temperature and cooking time. Therefore, more studies on other cooking techniques, as well as the temperature and cooking time of SH, are required.

Besides cooking methods, food production also influences the nutritional concentration of spices and herbs, such as differences in cultural practices such as irrigation frequency, fertilizer type, rate and time of the study disclosed that the same species of stinging nettle application as well as the fertility status of the soil (37). One grown under various agroecological settings had varying nutritional contents (44). Also, a study reported that medicinal plants vary enormously in mineral concentration due to different absorption of mineral elements from the soil (37).

## 4. Conclusions

The study's findings underscore the prevalence of high potassium and low sodium content among SHs, with turmeric exhibiting the highest SH potassium content (2080 mg/100 g), followed by cayenne pepper (2,010 mg/100 g). Consequently, the use of SH as a cooking spice may contribute to the fulfillment of daily potassium intake. The addition of SH as a seasoning has been shown to reduce salt usage by up to 50%. However, it is important to note that SH is the only ingredient used to meet daily potassium intake, owing to its limited use as a culinary spice. To ensure adequate intake, it remains essential to consume vegetables and fruits or to consume SH in the form of herbal drinks. In addition to the potassium content present in fresh SH, it is also necessary to consider the impact of cooking methods, particularly moist heat cooking, which can reduce the potassium content in food. Therefore, further research is required to explore alternative cooking processes that have not been addressed in this study.

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## Author Contributions

All authors contributed to write and review of articles. FF was involved in the conception and design, data analysis, and draft manuscript. AFP's contributions included the identification and analysis of a food composition database, the compilation of data, and the drafting of the manuscript. AWF's contribution included assistance with drafting of the manuscript, as well as its review. The validation and supervision was conducted by HAM. Finally, all authors read and approved the final manuscript.

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## Institutional Review Board Statement

The present study was conducted in accordance with the Declaration of Helsinki and all procedures were approved by the Ethical Committee of the Faculty of Public Health, Universitas Airlangga, with the number 78/EA/KEPK/2022. The authors extend their guidance to all investigators who collected and analyzed these data.

## Data Availability Statement

Available data are presented in the manuscript.

## Conflicts of Interest

The authors confirm that there are no conflicts of interest. Moreover, the funders had no role in the design study, interpretation of data, and publication of the results.

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