

Kale, a complementary, rich mineral food - a review

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Abstract

Vegetables are becoming increasingly valued as products for the domestic market and export because they have a great potential to improve nutrition and therefore consumers' health. Vegetables are an exceptional source of minerals, proteins, bioactive compounds, and vitamins, all of which are necessary for the proper functioning and development of the human body. Kale has become very well known for its rich nutrient content, for the benefits it brings to health, and last but not least for its excellent taste. This work aims to evaluate the nutritional profile of kale, as well as to highlight its health benefits. Kale is known as the vegetable with the highest vitamin K content, a vitamin essential for skin health, eyes, and mucous membranes, it is anti-cancer, and diabetes and has anti-inflammatory action. All varieties of Kale have a high content of calcium, iron, magnesium, sodium, potassium, manganese, and copper. They have more vitamin C than oranges, having the capacity to maintain a strong immune system. The high fiber content accelerates intestinal transit and supports the detoxification of the body. Due to the high content of antioxidants, and the presence of over 45 flavonoids; kale is a real anti-cancer food, it lowers cholesterol and improves blood circulation. Regarding the low-calorie trend in diets, it contains fewer calories being a perfect food for losing weight.

Key words: brassica family, minerals, functional food, brassica family, miraculous diet

1. Introduction

Kale (*Brassica oleracea* var. *acephala*) is a cruciferous vegetable with leaves that run the entire length of the stem and has recently enjoyed a surge in popularity. Considered a "superfood," kale is featured on many "healthiest vegetable lists" [14]. There are several varieties of kale, including green kale, marrow kale, scotch kale, dwarf kale, spiny kale, curly kale, tree kale, and bore kale. The leaves of these types of kale are eaten fresh and unprocessed, or in various forms in salads or cooked and used as a garnish [15]. This vegetable thrives well during the cool season, and evidence has shown that its use as a food crop dates back to 2000 BC in the eastern Mediterranean regions. Still, it has come to the attention of the scientific community only in recent years [6,11]. Due to their nutrient-rich composition, these brassica green vegetables

provide the nutrients consumers need and are marketed as health superfoods. Cabbage as well as kale, eaten raw in the form of salads, contains a wide variety of micronutrients, vitamins and minerals, antioxidants, carotenoids, glucosinolates, and polyphenols, which are beneficial for human health [1]. Kale is rich in vitamins (A, C, K, and folate) and important minerals (potassium, calcium, and magnesium) as well as dietary fiber [9]. This cruciferous vegetable ranks first in terms of vitamin K content, and is extremely rich in vitamin K1, providing approximately 817 micrograms (mcg) of vitamin K per 100 grams, which means many times more than the recommended daily dose (90-120 mcg for adults) [24]. Kale is a good source of prebiotic carbohydrates and phytochemicals such as folic acid, riboflavin, and carotenes that serve as antioxidants, having the ability to scavenge

free radicals and help reduce inflammation [5]. Due to its properties, kale has become widely known as a source of medicinal food for the treatment of various intestinal ailments, obesity, chronic diseases, malnutrition, cardiovascular diseases, and cancer; to reduce DNA damage and improve the activity of vitamin C, carotene and erythrocyte glutathione peroxidase, to increase the activity of cytochrome CYP1A2, which is important for human metabolism [4,7,10]. Although kale is very rich in nutrients, it is relatively low in calories, with a value ranging from 36-98 kcal/100 g [18]. This aspect has made kale one of the superfoods that should be integrated as a healthy alternative to foods that are popularly calorie-dense [3]. Cabbage (*Brassica napus* var. *pabularia*) is a member of the Brassicaceae family, a vegetable rich in nutrients, such as vitamins (especially vitamins K, A, and C) and minerals (calcium and iron), as well as antioxidants, generating numerous health benefits. The leaves of this cabbage have a low calorie content, which makes them a suitable choice for healthier diets. It can be consumed in various forms, raw in salads, cooked or added to various soups and smoothies. It is a very popular vegetable in vegetarian and vegan cuisine [17]. Adding Kale *napus* to the diet contributes significantly to supporting a very good general condition of the body. By consuming kale cabbage, several benefits are noted such as reducing the risk of cardiovascular disease, an important role in supporting the immune system, anti-inflam-

matory properties, it also helps prevent macular degeneration, significantly improving digestive health, having a low calorie content and rich in fiber helps maintain the feeling of satiety [13,19]. Brussels sprouts (*Brassica oleracea* var. *gemmifera*) are part of the vegetable category, they are a variety of cabbage that belongs to the Brassicaceae plant family. This vegetable is cultivated for its edible sprouts, the buds form on a 50 - 70 cm stem, distributed in an upward spiral. Brussels sprouts are rich in potassium, vitamins A, C, and K1, but also vitamin B6 and folic acid. It is also an excellent source of iron, magnesium, phosphorus and calcium. Plus, it's low in calories but high in solid protein and fiber. Due to the active ingredients in its composition, Brussels sprouts have amazing properties on the human body if consumed regularly. It can reduce the risk of cardiovascular diseases and has anticancer effects, neuroprotective effects, as well as anti-inflammatory properties [20].

2. Databases analysis

To compare and identify the most nutrient-dense vegetables among kale, collard greens, and Brussels sprouts, where analyzed various databases such as USDA, FoodB, FAO, and scientific papers. All materials used are listed in the text, tables, and references. Data analysis was performed using Excel version 3.22 with XLOOKUP and MVSP, as well as direct comparison and ranking of vegetables by nutrient content. All data are presented in Tables 1 and 2 and stacked bar graphs.

Table 1. Nutritional values of Kale

Nutritional compounds	Symbol	U.M	Kale (<i>Brassica</i> var. <i>acephala</i>) nutrient value/ 100 g fresh matter	Kale (<i>Brassica</i> <i>napus</i> var. <i>pabularia</i>) nutrient value/ 100 g fresh matter	Brussel sprouts (<i>Brassica oleracea</i> var. <i>gemmifera</i>) nutrient value/ 100 g fresh matter
Water	H2O	%	89.60 [21]	45.50 [22]	86.00 [23]
Energy	EN	kcal	35.00±43.00 [21] 66.00 [18] 58.46 [8]	49.00 [22]	43.00 [23]
Fibre	FI	g/100g	4.10 [21] 3.00 [8] 8.39 [16]	1.70 [22]	3.80 [23]
Protein	PR	g/100g	1.94 [12] 2.92 [21] 4.20 [18] 11.67 [8] 4.16 [16] 3.28 [12]	2.15 [22]	3.38 [23]

Table 1. Nutritional values of Kale (continued)

Nutritional compounds	Symbo l	U.M	Kale (<i>Brassica var. acephala</i>) nutrient value/ 100 g fresh matter	Kale (<i>Brassica napus var. pabularia</i>) nutrient value / 100 g fresh matter	Brussel sprouts (<i>Brassica oleracea var. gemmifera</i>) nutrient value/ 100 g fresh matter
Total lipid (fat)	FAT	g/100g	1.49 [21] 0.26 [8] 0.67 [16] 0.74 [12]	0.75 [22]	0.30 [23]
Total carbohydrates	CARB	g/100g	4.42 [21] 2.36 [8] 10.14 [16] 10.00 [12]	3.70 [22]	8.95 [23]
Ash	Ash	g/100g	1.54 [21] 1.33 [8] 2.11 [16]	0.31[22]	1.37 [23]
Calcium	Ca	mg/100g	254.00 [21] 106 [18] 384.08 [16]	94.50 [22]	42.00 [23]
Potassium	K	mg/100g	348.00 [21] 488.00 [18] 446.00 [8] 440.20 [16]	188.50 [22]	389.00 [23]
Sodium	Na	mg/100g	53.00 [21] 4.69 [8] 38.50 [16]	30.25 [22]	25.00 [23]
Phosphorus	P	mg/100g	55.00 [21]	7.50 [22]	69.00 [23]
Iron	Fe	mg/100g	1.60 [21] 1.10 [18] 12.19 [2] 8.94 [8]	1.77 [22]	1.40 [23]
Zinc	Zn	mg/100g	0.39 [21]	0.40 [22]	0.42 [23]
Copper	Cu	mg/100g	0.05 [21] 0.18 [2]	0.06 [22]	0.07 [23]
Magnesium	Mg	mg/100g	32.70 [21] 44.00 [18] 6.69 [8] 34.9 [16]	8.70 [22]	23.00 [23]
Manganese	Mn	mg/100g	0.92 [21] 0.80 [18] 0.86 [16]	0.23 [22]	0.33 [23]

Table 2. Comparison of the nutritional profiles of Kale (*Brassica var. acephala*) - (KA), Kale (*Brassica napus var. pabularia*) - (KN), and Brussels sprouts (*Brassica oleracea var. gemmifera*) - (BS).

Symbol	KA	KN	BS	Max	Min	Average
H2O	89.6	45.5	86	89.6	45.5	73.7
EN	50.61	49	43	50.61	43	47.54
FI	4.36	1.7	3.8	4.36	1.7	3.29
PR	5.25	2.15	3.38	5.25	2.15	3.59
FAT	0.79	0.75	0.3	0.79	0.3	0.61
CARB	6.73	3.7	8.95	8.95	3.7	6.46
Ash	1.66	0.31	1.37	1.66	0.31	1.11
Ca	0.25	0.1	0.04	0.25	0.04	0.13
K	0.43	0.19	0.39	0.43	0.19	0.34
Na	0.05	0.03	0.03	0.05	0.03	0.04
P	0.06	0.01	0.07	0.07	0.01	0.05
Fe	5.96	1.71	1.4	5.96	1.4	3.02
Zn	0.39	0.4	0.42	0.42	0.39	0.4
Cu	0.12	0.06	0.07	0.12	0.06	0.08
Mg	29.58	8.7	23	29.58	8.7	20.43
Mn	0.86	0.23	0.33	0.86	0.23	0.47

Based on Table 2, we can classify the studied vegetables by, energy, fiber, carbohydrates, and mineral content. The grade of the total mineral content of Ca, K, Na, P, Fe, Zn, Cu, Mg, and Mn was calculated for each vegetable and is mentioned in the following lines:

- Calories: KA > KN > BS

- Carbohydrates: BS > KA > KN
- Fiber: KA > BS > KN
- Total Minerals: KA > BS > KN

The stacked bar chart (Figure 1) compares the amounts of various nutrients across the studied vegetables (KA, KN, and BS).

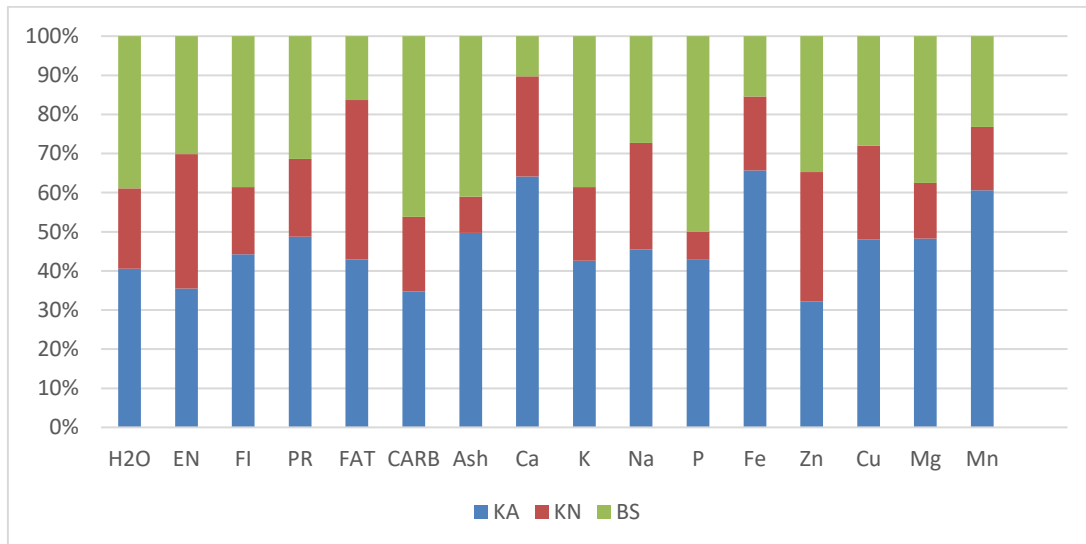


Figure 1. The stacked bar chart of studied vegetables

Legend: KA = Kale (*Brassica var. acephala*), KN = Kale (*Brassica napus var. pabularia*), BS = Brussels sprouts (*Brassica oleracea var. gemmifera*)

From Figure 1, it can be seen that kale (KA) has the best nutritional profile. It gleams in the content of fiber, protein, and essential minerals such as Fe, followed by Ca, Mg, and Mn. Brussels sprouts (BS) came next with significant benefits, especially regarding

carbohydrate and zinc content. On the other hand, it can be noted that KN, is not as nutritious as the other two, but also an intelligent and healthy choice, being excellent in diets that involve a lower carbohydrate intake. Based on the observed data, to produce

a nutritious food product, we can recommend the following quantities: kale (KA): 50 % because it takes full advantage of fiber, protein, and mineral content, kale napus (KN): 20% because it provides a variety of minerals and Brussels sprouts (BS): 30%, providing a large content of carbohydrates, fiber, and a unique texture.

Thus, these proportions can be adjusted according to each person's taste preferences or detailed dietary goals (for example, if we need more carbohydrates, we can increase the quantity of BS; if we need a bigger amount of fiber or minerals, we can increase the KA content). We can also improve the nutritional sense of balance of a meal by adding healthy fats (olive oil or avocado) and we can consider also, an intake of protein (such as nuts, seeds, or beans).

3. Conclusion

The study highlights that Kale is a mineral-rich food, providing an important quantity of Ca, Fe, Mg, and K, and also provides essential nutrients, showing a potential impact on human diet style. Thus, introducing Kale and Brussels sprouts into a varied diet, can improve health and help prevent various nutritional deficiencies. Due to its versatility, kale can be easily added to different food recipes, maximizing the nutritional benefits of the consumers.

Compliance with Ethics Requirements. Authors declare that they have no conflict of interest and that all procedures involving human / or animal subjects (if exist) respect the specific regulations and standards.

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