



# Nutritional Composition, Minerals and Vitamins Analysis of Brussels Sprouts Genotypes: A Comparative Study across Diverse Growing Environments

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**Abstract:** This study examined the nutritional composition, mineral and vitamins analysis of Brussels sprouts genotypes cultivated under diverse environmental conditions. Four genotypes Hild's Ideal, Long Island Improved, Urja and Franklin F<sub>1</sub> were evaluated under open and protected environment. There were statistically significant variations in nutrient composition between cultivation environments. Brussels sprouts were characterized as a rich source of minerals including iron, magnesium, phosphorus, copper, potassium, zinc and manganese. The highest moisture (87.35%) and crude fat (1.53%) were recorded in Franklin F<sub>1</sub>, while the genotype Urja exhibited the highest crude fibre (3.59%) under polyhouse conditions. Long Island Improved genotype demonstrated the highest total carbohydrates (31.79%) and food energy (192.26Kcal/100g) under open field conditions. Brussels sprouts also found to be rich source of Vitamins C, E, K and A. This study highlights the critical influence of environment conditions on the nutritional and functional quality of Brussels sprouts and provides insights into optimizing cultivation strategies to enhance their health benefits.

**Keywords:** Brussels sprouts, Proximate composition, Minerals, Vitamins, Protected condition

*Brassica oleracea* var. *gemmifera*, commonly known as brussels sprouts, is a cold-season vegetable cultivated for its edible "buds or sprouts," which resemble miniature cabbages. This hardy and slow-growing plant belongs to the genus *Brassica* and the family Brassicaceae sharing a close phylogenetic relationship with other crops like cauliflower, broccoli, kale, and collards. These crops are widely recognised for their high nutritional value and versatility in culinary applications. In brussels sprouts the buds form in the leaf axils, the angles between the leaves and the stem, with the development initiating at the base of the stem and progressing upward. Each sprout/bud develops in the axil of a leaf, resulting in the characteristic arrangement of multiple small, round buds along the stem (Kumar et al., 2014). In recent year the cultivation of Brussels sprouts has gained popularity among Indian growers, especially in and around major metropolitan areas and hill stations, driven by growing demand from hotels and tourists. In India, Brussels sprouts are primarily grown in the Kodaikanal and Nilgiri hills of Tamil Nadu and in parts of Maharashtra. This crop is recognized for its distinctive botanical characteristics within the broader *Brassica oleracea* species (Tewari et al., 2020). Nutritionally, Brussels sprouts are very rich. The brussels sprouts rank among the top 20 most nutritious foods according to their aggregate nutrient density index score, based on vitamin, mineral, and phytonutrient content relative to caloric content, which might increase interest in them (Hwang 2017). Despite

the crop's ability to grow in a wide range of soil types, sandy loams and silt loam soils perform best. The pH of the soil is another important factor that determines the fate of a crop for a winter crop. Of these, sandy loam soil is known to be a better option for an early crop. Tewari et al. (2020) suggested in range of 5.8 and 7.2, while Kumar et al. (2014) propose a narrower range of 6.0 to 6.8. But in Himachal Pradesh Brussels sprouts is non traditional vegetable crop. No systematic research has been conducted on the evaluation of Brussels sprouts in Himachal Pradesh, despite the state having favourable agro-climatic conditions for their cultivation. The current studies aim to promote high-value Brussels sprouts by examining the proximate composition, minerals and vitamins analysis across a wide range of environmental conditions. Analyzing the proximate composition, minerals and vitamins content of Brussels sprouts will provide valuable insights into their nutritional profile.

## MATERIAL AND METHODS

**Plant materials:** The genotype of Brussels sprouts variety Hild's Ideal was procured from ICAR- Indian Agricultural Research Institute, Regional Station Katrain, Kullu (HP). Genotypes of Long Island Improved and Franklin F<sub>1</sub> were procured from open market of Distt. Kangra (HP), whereas the genotype of Urja variety were procured from KISANeSTORE 2, Vadodara, Gujarat state, India.

**Experimental site:** Field experiment was laid out at the Agricultural Research Farm of the Krishi Vigyan Kendra, (CSKHPKV) Kangra, District. Kangra (HP), India, during *rabi* season of (2022-2023 & 2023-2024) from September to February. The geographically Agricultural Research Farm of the Krishi Vigyan Kendra is situated at 32.107753° latitude, 76.262736° longitude (Fig. 1).

**Sample preparation:** Samples were collected from experiment site at the Agricultural Research Farm of the Krishi Vigyan Kendra, Kangra Himachal Pradesh. Brussels sprouts were harvested at physiological or horticultural maturity. Immediately after harvesting, fresh sprouts were cut into small strips and shade dried using the filter papers. The dried samples were finely ground with a mortar and pestle. The dried powder of the brussels sprouts was stored at room temperature until its application for nutritional analysis.

**Proximate composition:** The proximate compositions of Brussels sprouts were determined in triplicate using standardized protocols of the Association of Official Analytical Chemists (AOAC 2005, AOAC 2000) methods with minor modifications, which are well-regarded for their accuracy and reliability. The moisture content of fresh Brussels sprouts was evaluated by oven drying method. The

ash content was determined by using combustion method with muffle furnace at 550°C, Soxhlet extraction method with n-hexane was used for crude fat. Crude fibre was estimated by muslin cloth method. Kjeldahl method was used for the determination of crude protein content. Total carbohydrates content was determined by Phenol sulphuric acid method (Dubois et al., 1956).

**Food energy:** The energy value of Brussels sprouts based on their protein, carbohydrate and fat content was determined according to the conversion factor using the following equation (Verma and Srivastat 2017):

$$\text{Energy (Kcal/100g)} = (\%CP \times 4) + (\%F \times 9) + (\%CHO \times 4)$$

Where CP = crude protein; F = fat; and CHO = carbohydrate

**Mineral analysis:** Atomic absorption spectrophotometer was used to estimate macro and micro minerals using the method by Renuka et al. (2016).

**Vitamin analysis:** The dry powder of various Brussels sprouts genotypes were analyzed for their vitamin content using by high performance liquid chromatography (HPLC).

**Statistical analysis:** The raw data was statistical analysis using IBM-SPSS.

## RESULTS AND DISCUSSION

**Proximate composition:** The nutritional compositions of the different genotypes of Brussels sprouts are statistically significant different (Table 1). The proximate composition including moisture content under open environment showed highest moisture content (85.86%) in genotype Long Island Improved which was statistically higher than other genotypes and lowest (84.89%) in Franklin F<sub>1</sub> genotype whereas under polyhouse highest moisture content (87.35%) was observed in genotype Franklin F<sub>1</sub> and lowest (85.95%) in Hild's Ideal genotype. The moisture is an essential variable in food processing as well as testing. The moisture content value of brussels sprouts is consistent lower (Mark et al., 2013) with moisture value of 88.4%, 88.2%, and 96% in green cabbage, broccoli, and lettuce. Hanif et al., (2006) also reported high moisture content. The presence of more than 15% moisture content in fruits and vegetables promote microbial activity throughout storage, however a rigid as well as compact head of brussels sprouts make it a more challenging for microorganisms to access, resulting in longer shelf life. Highest ash content (9.63%) was in genotype Urja and lowest (6.4%) in Hild's Ideal genotype under open environment whereas under protected environment highest ash content (10.20%) was Long Island Improved and lowest (8.95%) in Franklin F<sub>1</sub>. Doniec et al. (2022) reported less ash content in brussels sprouts raw material as well as after thermal treatments. Kmiecik et al. (2007) observed the ash

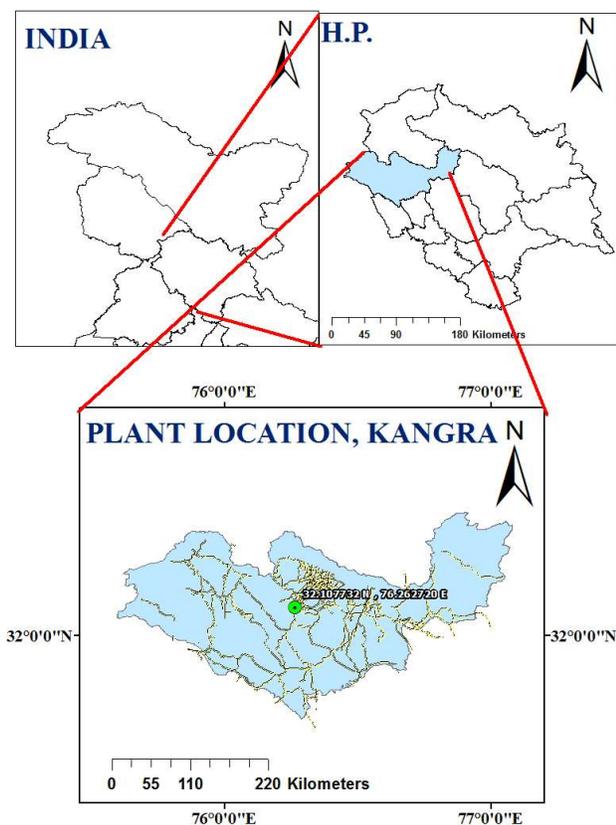


Fig. 1. Experiment site at KVK, Kangra (H.P.)

content 7.01g/100g in brussels sprouts and 8.60g/100g in broccoli. The highest crude fibre content was Urja under both environmental conditions which was followed by Long Island Improved under protected conditions and Franklin F<sub>1</sub> under open environment. The highest fat content (1.35%) was observed in genotype Urja under open field whereas under protected environment highest fat content (1.53%) was in Franklin F<sub>1</sub>. The crude fat content in both conditions were higher than reported in brussels sprouts (Anonymous 2011). Under open environment highest crude protein content (14.45%) was in Hild's Ideal which was statistically higher to other genotypes except Long Island Improved (14.25%) and lowest (12.25%) in Urja whereas under polyhouse highest crude protein content (17.25%) in Urja and lowest (13.35%) in s Long Island Improved. The highest carbohydrates content was observed in Long Island Improved genotype which was followed by Franklin F<sub>1</sub> genotype in both environmental conditions. Hanif et al. (2006) reported 4.8% carbohydrate content and Ogbede et al. (2015) 4.52% carbohydrate content in *Brassica oleraceae* var. *Capitata* L.

**Food energy:** Food energy content ranges from 156.08Kcal/100g to 192.26Kcal/100g and 167.06 to 188.45Kcal/100g under open field and polyhouse respectively. The total energy content ranges from 24 to 40KCal/100g in various *Brassica* vegetables (Anon 2011)

while 248.8 to 307.1KCal/100g in some leafy vegetables (Isong et al., 1999). The observed differences in proximate composition and food energy could be attributed to environmental factors, varietal difference, bioavailability, physical properties of the soil and other factors (Soetan et al., 2010).

**Mineral analysis:** The brussels sprouts are excellent source of all the necessary dietary minerals. There was significant variation of the mineral analysis of different genotypes of brussels sprouts grown under open as well as protected environment (Table 2). The minerals contents phosphorus (0.15 to 0.18%), Potassium (0.84 to 1.20%) and magnesium (0.16 to 0.21%) were observed under open environment and under polyhouse condition (phosphorus 0.14 to 0.19%, potassium (0.20 to 1.02%) and Magnesium (0.25 to 0.31%). Lewu & Kambizi (2015) reported phosphorus, potassium and magnesium content were 0.56, 3.20 and 0.26% respectively in *Brassica napus* and 0.56, 2.81 and 0.90% respectively in *Brassica oleracea*. Emebu and Anyika (2011) reported magnesium content (6.69mg/100g) in kale. Manganese content varies from 22.15 to 29.35 and 22.95 to 28.15mg/kg under open field and polyhouse respectively. The significantly higher manganese content (29.35mg/kg) was observed in Urja variety under open field which was followed by Long Island Improved (28.15mg/kg) under protected

**Table 1.** Proximate composition and food energy of different genotypes of brussels sprouts grown under open and protected environment

Proximate composition (%)	Open environment				Protected environment			
	Hild's ideal	Long Island improved	Urja	Franklin F <sub>1</sub>	Hild's ideal	Long Island improved	Urja	Franklin F <sub>1</sub>
Moisture	84.92 <sup>a</sup>	85.86 <sup>b</sup>	85.02 <sup>a</sup>	84.89 <sup>a</sup>	85.95 <sup>a</sup>	86.27 <sup>b</sup>	86.35 <sup>b</sup>	87.35 <sup>c</sup>
Ash	6.41 <sup>a</sup>	8.93 <sup>c</sup>	9.63 <sup>d</sup>	7.76 <sup>b</sup>	9.70 <sup>b</sup>	10.20 <sup>c</sup>	9.78 <sup>b</sup>	8.95 <sup>a</sup>
Crude fibre	2.15 <sup>a</sup>	2.68 <sup>b</sup>	3.53 <sup>d</sup>	3.11 <sup>c</sup>	2.99 <sup>a</sup>	3.14 <sup>a</sup>	3.59 <sup>b</sup>	3.06 <sup>a</sup>
Crude fat	1.15 <sup>b</sup>	0.90 <sup>a</sup>	1.35 <sup>c</sup>	1.05 <sup>ab</sup>	1.13 <sup>a</sup>	1.26 <sup>a</sup>	1.21 <sup>a</sup>	1.53 <sup>b</sup>
Crude protein	14.45 <sup>b</sup>	14.25 <sup>b</sup>	12.25 <sup>a</sup>	12.35 <sup>a</sup>	14.35 <sup>b</sup>	13.35 <sup>a</sup>	17.25 <sup>c</sup>	14.53 <sup>b</sup>
Carbohydrates	23.08 <sup>a</sup>	31.79 <sup>d</sup>	23.73 <sup>b</sup>	29.10 <sup>c</sup>	24.86 <sup>a</sup>	30.03 <sup>d</sup>	27.13 <sup>b</sup>	28.58 <sup>c</sup>
Energy (KCal/100g)	160.49 <sup>b</sup>	192.26 <sup>d</sup>	156.08 <sup>a</sup>	175.58 <sup>c</sup>	167.06 <sup>a</sup>	184.00 <sup>b</sup>	188.45 <sup>d</sup>	186.26 <sup>c</sup>

Means with different letters within the same row shows significant difference (p<0.05)

**Table 2.** Mineral analysis of brussels sprouts grown under open and protected environment

Genotypes	Open environment							Protected environment						
	Macro elements (%)			Micro elements (mg/ kg)				Macro elements (%)			Microelements (mg/ kg)			
	P	K	Mg	Mn	Fe	Cu	Zn	P	K	Mg	Mn	Fe	Cu	Zn
Hild's Ideal	0.18 <sup>b</sup>	1.17 <sup>c</sup>	0.19 <sup>b</sup>	22.15 <sup>a</sup>	106.15 <sup>a</sup>	16.10 <sup>d</sup>	40.90 <sup>e</sup>	0.14 <sup>a</sup>	1.02 <sup>d</sup>	0.30 <sup>bc</sup>	23.65 <sup>c</sup>	149.25 <sup>a</sup>	10.45 <sup>a</sup>	40.00 <sup>e</sup>
Long Island Improved	0.16 <sup>b</sup>	0.84 <sup>a</sup>	0.16 <sup>a</sup>	25.45 <sup>c</sup>	452.55 <sup>d</sup>	13.65 <sup>b</sup>	33.15 <sup>a</sup>	0.19 <sup>c</sup>	0.81 <sup>c</sup>	0.29 <sup>b</sup>	28.15 <sup>d</sup>	315.55 <sup>c</sup>	13.20 <sup>b</sup>	35.65 <sup>b</sup>
Urja	0.14 <sup>a</sup>	1.03 <sup>b</sup>	0.17 <sup>a</sup>	29.35 <sup>d</sup>	128.30 <sup>b</sup>	14.85 <sup>c</sup>	35.40 <sup>b</sup>	0.15 <sup>ab</sup>	0.20 <sup>a</sup>	0.25 <sup>a</sup>	23.05 <sup>b</sup>	243.25 <sup>b</sup>	14.85 <sup>c</sup>	34.95 <sup>a</sup>
Franklin F <sub>1</sub>	0.15 <sup>a</sup>	1.20 <sup>c</sup>	0.21 <sup>c</sup>	23.10 <sup>b</sup>	318.25 <sup>c</sup>	13.25 <sup>a</sup>	43.20 <sup>d</sup>	0.16 <sup>b</sup>	0.71 <sup>b</sup>	0.31 <sup>c</sup>	22.95 <sup>a</sup>	323.50 <sup>d</sup>	18.00 <sup>d</sup>	41.05 <sup>d</sup>

Means with different letters within the same row shows significant difference (p<0.05)

conditions. Lewu and Kambizi (2015) reported manganese contents of 15.00mg/kg in *Brassica napus* and 13.67mg/kg in *Brassica oleracea*. Iron is an essential microelement necessary for haemoglobin formation, normal functioning of the central nervous system, and the oxidation of carbohydrates, proteins, and fats (Adeyeye and Otokiti 1999). Iron content varies from 106.15 to 452.55mg/kg under open field and 149.25 to 323.50mg/kg under polyhouse. The iron content was highest in Long Island Improved genotype under open field which was followed by Franklin F<sub>1</sub> genotype under protected conditions. Baloch et al. (2015) observed iron content 2.83mg/100g in fresh, 27.22mg/100g in dehydrated and 26.22 mg/100g in open sun drying cauliflower. Copper is a vital micronutrient required as a component of various redox enzyme and lignin biosynthetic enzymes. The copper content ranges from (13.25 to 16.10mg/kg) under open field and (10.45 to 18.00mg/kg) under polyhouse. The copper content was highest in (18.00 mg/kg) in Franklin F<sub>1</sub> under protected condition which was followed by Hild's Ideal (16.10mg/kg) under open field. Copper content was 4 and 3mg/kg in *Brassica napus* and *Brassica oleracea* (Lewu and Kambizi 2015). The zinc content ranged from (33.15 to 43.20 mg/kg under open field conditions and under polyhouse conditions(34.95 to 41.05 mg/kg). The Zinc content was highest in Franklin F<sub>1</sub> genotype under open field which was followed by Franklin F<sub>1</sub> under protected conditions. Lewu and Kambizi (2015) observed the zinc content (52.33 mg/kg) in *Brassica napus* was higher than in *Brassica oleracea*(25.33 mg/kg). Baloch et al. (2015) reported zinc content of 1.86 mg/100g in fresh, 17.88 mg/100g in Dehydrated and 17.23mg/100g in open sun drying cauliflower.

**Vitamins analysis:** The vitamin A content in four genotypes ranged from 0.55mg/kg to 1.99mg/kg in open field while under polyhouse conditions it ranges from 0.83 to 20.9mg/kg (Table 3). Brussels sprouts are ranked as an excellent source of vitamin A due to their high concentration of on account beta carotene content. Within the body beta carotene serves as a precursors, being converted into active vitamin A. The highest vitamin A content (2.09mg/kg) was found in genotype

Urja of Brussels sprouts. Anon (2011) reported 35.8µg/100g in Brussels sprouts, 85.9µg/100g in broccoli and 765.8µg/100g in kale. The vitamin C content is ranged from 335.43 to 518.17mg/kg in open field and 378.31 to 582.20mg/kg under polyhouse conditions. The Long Island Improved genotype was reported the highest vitamin C content, measuring 582.20mg/kg. Vitamin C content 90mg/100g in brussels sprouts, 120mg/100g in broccoli, 110mg/100g in kale and 61.5mg/100g in cauliflower were reported in earlier study (Anonymous 2011). Emebu and Anyika (2011) observed that kale contains 23.43mg/100g of vitamin C while Hall (1998) recorded a higher value of 41mg/100g for kale.

Vitamin E content varied from 0.58mg/kg to 80.15mg/kg under open field while under polyhouse conditions it ranges from 1.18 to 1.45mg/kg. In comparison the highest vitamin E content (80.15mg/kg) was observed in Hilds Ideal variety of Brussels sprouts. Emebu and Anyika (2011) reported a vitamin E content of 4.06mg/100g in kale. Vitamin E plays critical biochemical and physiological roles in the body when incorporated into the diet. As a fat-soluble nutrient it is particularly essential in protecting cell membrane from oxidative damage. Acting as an antioxidant vitamin E protects other nutrients and cellular components from oxidative stress induced by reactive agents (Wardlaw and Insel 1995). Brussels sprouts are an excellent source of vitamins K, a nutrient reported to play a crucial role in blood coagulation, bone health and the prevention of cardiovascular diseases (Beulens et al., 2013). Vitamin K content is varied from 0.16 to 0.72mg/kg in open field conditions and 0.10 to 0.25mg/kg under polyhouse conditions. The highest vitamin K content (0.25mg/kg) was observed in Hild's Ideal variety. Vegetables contribute these minerals and vitamins to enhance their availability in daily life. The percentage differences in proximate composition minerals and vitamins content among different genotypes of Brussels sprouts are likely due to variations in factors such as environmental conditions, soil properties, and mineral content in soils etc. Brussels sprouts contribute essential minerals to the diet, and their availability can be influenced by these various factors. These factors

**Table 3.** Comparison of vitamins in different genotypes of brussels sprouts grown under open and protected environment

Parameters (mg/kg)	Open environment				Protected environment			
	Hild's Ideal	Long Island Improved	Urja	Franklin F <sub>1</sub>	Hild's Ideal	Long Island Improved	Urja	Franklin F <sub>1</sub>
Vitamin A	ND	ND	0.55	1.99	0.83	ND	2.09	1.27
Vitamin C	424.84	ND	518.17	335.43	378.31	582.20	529.63	391.19
Vitamin E	80.15	ND	4.1	0.58	ND	ND	1.45	1.18
Vitamin K	0.72	0.17	0.16	0.16	0.25	0.19	ND	0.10

ND – Not determine

collectively contribute to the variability in the nutritional content of brussels sprouts, making them a diverse and valuable component of a healthy diet.

### CONCLUSION

The determination of proximate composition, mineral and vitamin content of brussels sprouts grown under both environmental conditions will go a long way in providing substantive information on the crop. The highest moisture content in Franklin F<sub>1</sub>, ash content in Long Island Improved, crude fibre content in Urja variety and crude fat content in Franklin F<sub>1</sub> under protected conditions. Brussels sprouts are an excellent source of protein having significant content of crude protein in both conditions. Highest total carbohydrates content and total energy content was in Long Island Improved under open field conditions. The Brussels sprouts were discovered to be an excellent source of all required dietary minerals. They provide a variety of important nutrients, including Potassium, Phosphorus, Magnesium, among macro elements and Iron, Manganese, copper and Zinc among microelements. Brussels sprouts despite being a lesser-known vegetable have huge nutritional potential and can be used as a viable substitute for mostly used vegetables. Brussels sprouts are a nutritionally dense vegetable which offers numerous health advantages due to their rich profile of essential nutrients and vitamins. Regular consumption can help to improve digestive health, immune function, bone health, and effective management of blood pressure and blood sugar levels. The presence of antioxidants and phytochemicals further enhances their role in reducing inflammation, protecting against numerous chronic diseases, such as cardiovascular disease as well as certain cancers. Incorporating Brussels sprouts into the diet can be beneficial for individuals of all ages. They can be cooked in a variety of ways, including roasting and steaming, to preserve their nutritional value while improving their flavour. For the best health benefits, consume them as part of a well-balanced diet rich in fruits and vegetables.

### REFERENCES

- Adeyeye EI and Otokiti MKO 1999. Proximate composition and some nutritionally valuable minerals of two varieties of *Capsicum annum* (Bell and Cherry peppers). *Discovery Innov.* **11**:75-81.
- Agoreyo O, Obansa ES and Obanor EO 2012. Comparative nutritional and phytochemical analyses of two varieties of *solanum melongena*. *Science World Journal* **7**(1): 5-8.
- Anon A 2011. *National Institute for Health and Welfare, Nutrition Unit. Fineli. Finnish food composition database, Helsinki.* <http://www.fineli.fi>.
- AOAC 2000 *Official Methods of Analysis of Association of Official Analytical Chemists*, 17th ed.; AOAC: Maryland, USA. **1**(2): 452-456.
- AOAC 2005. *Official Methods of Analysis Association of Official Analytical chemists* 17th Ed. 5b NO.33.2.10. AOAC. International Gathersburg Maryland, USA.
- Arlai A 2009. Effects of moisture heating and vacuum fry on organic and conventional okra quality. *Asian Journal of Food and Agro-Industry* **2**: S318-S324.
- Babarinde GO and Fabunmi OA 2009. Effects of packaging materials and storage temperature on quality of fresh okra (*Abelmoschus esculentus*) fruit. *Agricultura Tropica et Subtropica* **42**: 151-156.
- Baloch AB, Xia X and Sheikh A 2015. Proximate and mineral compositions of dried cauliflower (*Brassica oleracea* L.) grown in Sindh, Pakistan. *Journal of Food and Nutrition Research* **3**(3): 213-219.
- Beulens JW, Booth SL, van den Heuvel EG, Stoecklin E, Baka A and Vermeer C 2013. The role of menaquinones (vitamin K2) in human health. *British Journal of Nutrition* **110**(8): 1357-1368.
- Doniec J, Florkiewicz A, Dulinski R and Filipiak-Florkiewicz A 2022. Impact of hydrothermal treatments on nutritional value and mineral bioaccessibility of brussels sprouts (*Brassica oleracea* var. *gemmifera*). *Molecules* **27**: 1861.
- Dubois M, Gilles KA, Hamilton JK, Rebers PT and Smith F 1956. Colorimetric method for determination of sugars and related substances. *Analytical Chemistry* **28**(3): 350-356.
- Emebu PK and Anyika JU 2011. Proximate and mineral composition of kale (*Brassica oleracea*) grown in Delta State, Nigeria. *Pakistan Journal of Nutrition* **10**(2): 190-194.
- Haijun C, Bozhong G and Changying L 2007. Study on content determination of vitamin A and E in white yak' s milk by HPLC. *Journal of Gansu Agricultural University* **42**(2): 108-111.
- Hall R 1998. Kale, *Brassica oleraceae* (*Acephala* group). USDA Database for standard Reference, Release 12
- Hanif R, Iqbal Z, Iqbal M, Hanif S and Rasheed M 2006. Use of vegetables as nutritional food: role in human health. *Journal of Agricultural and Biological Science* **1**(1): 18-22.
- Hwang ES 2017. Influence of cooking methods on bioactive compound content and antioxidant activity of brussels sprouts. *Preventive Nutrition and Food Science* **22**(4): 353-358.
- IOM 2002. *Dietary reference Intakes for energy, carbohydrate, Fibre, Fat, Fatty Acids, Cholesterol, protein and amino acids*. Food and Nutrition Board, Institute of Medicine. National Academy Press, Washington DC. Chapter 6 and 7.
- Isong EU, Adewusi SAR, Nkanga EU, Umoh EE and Offiong EE, 1999. Nutritional and phytochemical studies of three varieties of *Gnetum africanum* ('afang'). *Food chemistry* **64**(4): 489-493.
- Kmiecik W, Lisiewska Z and Korus A 2007. Retention of mineral constituents in frozen brassicas depending on the method of preliminary processing of the raw material and preparation of frozen products for consumption. *European Food Research and Technology* **224**: 573-579.
- Kumar A, Choudhary AK and Rahi S 2014. *Scientific cultivation of Brussels sprouts (Brassica oleracea L. var. gemmifera)*. Advances in Vegetable Agronomy. Indian Agricultural Research Institute, New Delhi, India. pp. 92-95.
- Lewu MN and Kambizi L 2015. Nutritional assessment of selected leafy vegetables. *International Conference on Biotechnology and Food Technology* (ICBFT'15). 14-15, Harare (Zimbabwe).
- Lisiewska Z, Gębczyński P, Bernaś E and Kmiecik W 2009. Retention of mineral constituents in frozen leafy vegetables prepared for consumption. *Journal of Food Composition and Analysis* **22**(3): 218-223.
- Mark R, Church S, Pinchen H and Finglas P 2013. Nutrient analysis of fruit and vegetables. *Analytical Report* 24-49.
- Mc Donald P, Edward RA, Greenhalti FD and Morgan CA 1995. *Animal nutrition*. Prentices Hall, London. 101-122.
- Mertz W 1981. The essential trace elements. *Science* **213**(4514): 1332-1338

- Ogbede SC, Saidu AN, Kabiru AY and Busari MB 2015. Nutrient and anti-nutrient compositions of *Brassica oleraceae* var. capitata L. *IOSR Journal of Pharmacy* **5**(3): 19-25.
- Onyeike EN, Olungwe T and Uwakwe AA 1995. Effects of heat treatments and defatting on the proximate composition of some Nigerian local soup thickeners, *Food Chemistry* **53**: 173-175.
- Pattison DJ, Silman AJ, Goodson NJ, Lunt M, Bunn D, Luben R and Symmons DPM 2004. Vitamin C and the risk of developing inflammatory polyarthritis: prospective nested case-control study. *Annals of the Rheumatic Diseases* **63**(7): 843-847.
- Renuka N, Mathure SV, Zanan RL, Thengane RJ and Nadaf AB 2016. Determination of some minerals and  $\beta$ -carotene contents in aromatic indica rice (*Oryza sativa* L.) germplas. *Food Chemistry* **191**: 2-6.
- Rodriguez Jimenez RA, Fernandez-Bolanos, Guillen JR and Heredia A 2006. Dietary fibre from vegetable products as source of functional ingredients. *Trends in Food Science and Technology* **17**: 3-15.
- Soetan KO, Olaiya CO and Oyewole OE 2010. The importance of mineral elements for humans, domestic animals and plants: A review. *African Journal of Food Science* **4**(5): 200-222.
- Tewari V, Bhatt L and Joshi U 2020. Brussels sprouts: origin and production technology. *Times of Agriculture A Resonance in Agriculture* 101-107.
- Verma DK and Srivastav PP 2017. Proximate Composition, Mineral Content and Fatty Acids Analyses of Aromatic and Non-aromatic Indian Rice. *Rice Science* **24**(1): 21-31.
- Wardlaw GM and Insel PM 1995. *Perspectives in Nutrition*, 3<sup>rd</sup> Edn., WCB/Mc Graw-Hill, New York, pp: 217-225.
- World Health Organisation 2007. *Food and Agriculture Organisation of the United Nations University*. Protein and amino acid requirements in human nutrition: Report of a joint FAO/WHO/UNO expert consultation. Geneva: WHO

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