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Variation in Proximate Composition and Nutrient Interrelationships in Commonly Consumed Vegetables

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Abstract

The rapid increase in global population, coupled with environmental challenges and declining agricultural resources, has intensified the demand for affordable and nutrient-rich food sources to ensure food and nutritional security. Vegetables are essential components of a healthy diet due to their rich content of vitamins, minerals, dietary fiber, and bioactive compounds, and play a key role in preventing micronutrient deficiencies and chronic diseases. The present study evaluated the proximate composition of six commonly consumed vegetables: spinach (Spinacia oleracea), carrot (Daucus carota), cauliflower (Brassica oleracea), onion (Allium cepa), capsicum (Capsicum annuum), and coriander (Coriandrum sativum). Standard AOAC methods were used to determine moisture, ash, crude fiber, protein, and nitrogen, along with derived parameters including dry matter, organic matter, carbohydrate content, moisture to dry matter ratio, and ash to organic matter ratio. Significant variation ($p \leq 0.05$) was observed among vegetables. Capsicum exhibited the highest protein (25.38%) and nitrogen (4.06%), while coriander showed the highest fiber (25.01%) and ash content (9.06%). Carrot had the highest moisture (20.00%) and moisture to dry matter ratio (0.25), whereas onion recorded the highest dry matter (90.00%) and carbohydrate content (66.57%). Spinach showed the highest organic matter (95.94%), while coriander and capsicum exhibited higher ash to organic matter ratios. Correlation analysis revealed a strong positive association between nitrogen and protein, while moisture was inversely related to dry matter and carbohydrates. These findings highlight the nutritional diversity of commonly consumed vegetables and emphasize the importance of dietary diversity for achieving balanced nutrition and improving public health.

1. Introduction

Food is one of the main needs of human survival and it is a key factor in human survival, productivity, and the overall quality of life. In addition to its fundamental biological role, food also determines cultural identity, social behavior, and economic development in societies (Jiemuratova, 2025). As the world population grows at a very high rate, urbanization is on the rise and there is a change in the dietary patterns of people. So, the demand for safe, nutritious and sustainable food sources have also risen greatly. Meanwhile, the global food system is experiencing severe problems due to the lack of agricultural lands, climate change, soil erosion, shortage of water, and a decrease in soil fertility (Hossain et al., 2020). All these are threatening food production and are contributing towards these increasing concerns of global food and nutritional security. Malnutrition remains a major concern in contemporary nutrition, as persistently high rates in both developing and developed nations underscore its global significance. Malnutrition involves not only undernutrition

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but also micronutrient deficiencies and, more recently, overnutrition is the cause of obesity and associated metabolic abnormalities (Kobylińska et al., 2022). The global health reports indicate that millions of people are affected by the lack of essential nutrients like iron, calcium, vitamin A, and zinc, which may result in severe health complications such as anemia, weakened immunity, stunted growth, and impaired cognitive development (World Health Organization, 2023). All these nutritional issues are especially acute within the population with low income where the number of different and balanced diets is limited.

Various factors such as socioeconomic status, cultural preferences, education level, geographic location, and food availability influence dietary habits (Bennett et al., 2022). In most developing areas, meals are highly reliant on the staple crops of rice, wheat, and maize which are good sources of calories, but often do not have the necessary micronutrients (Kiran et al., 2022). This nutritional imbalance is one of the factors contributing to the phenomenon of hidden hunger where people consume enough energy but are lacking in the necessary vitamins and minerals (Agu & Lu, 2025). Thus, there is a need to determine the availability of nutrient-rich foods at affordable prices and locally, to enhance dietary quality and the overall results of the population of a particular country. One of the most crucial elements of a healthy and balanced diet is vegetables. They are also naturally abundant in essential nutrients, including vitamins (A, C, and K), minerals (iron, calcium, potassium, and magnesium), dietary fiber, and a wide variety of phytochemicals such as flavonoids, carotenoids, and polyphenols (Awuchi et al., 2020). These bioactive compounds have been quite linked to antioxidant, anti-inflammatory and disease-preventive effects. Frequent intake of vegetables has been associated with a lower risk of non-communicable disease especially cardiovascular diseases, diabetes mellitus, obesity, and some types of cancer (Kibr, 2022).

The sporadically-grown vegetables in most developing countries are known to provide the rural and urban populations with vital micronutrients at a low cost (Thakur et al., 2022) The availability, affordability, and nutritional value of vegetables such as spinach, carrot, cauliflower, onion, capsicum, and coriander make it widely consumed and grown in different regions (Adewoyin, 2023). Their nutrient content, however, can vary considerably with the environmental conditions, the soil quality, agricultural practices, seasonal variation, and post-harvest handling. Proximate analysis is commonly employed in the study of food science and nutrition by understanding the nutritional value of food materials. The quantitative determination of the major components of food, including moisture, ash, crude protein, crude fiber, fat, and carbohydrates, is known as proximate composition (Hait et al., 2023). The moisture content is one of them because moisture is a key indicator of freshness, stability and shelf life since high moisture content may encourage microbial growth and food spoilage. The amount of ash is the total mineral amount of food, which gives an approximation to the essential inorganic nutrient content in food, including calcium, potassium, magnesium, and phosphorus (Ismail, 2024).

Protein is an important macronutrient that is needed to grow and repair tissues, produce enzymes and control metabolism. Particularly, plant-based sources of protein are of greater significance in those regions where animal protein is less available, or it might not be economically affordable (Varela-Ortega et al., 2022). Crude fiber, conversely, is also very important in the digestive system enhancing bowel movement, regulating the level of blood glucose and reducing cholesterol absorption. Dietary fiber has a positive association with a decreased likelihood of gastrointestinal disorders and chronic metabolic diseases (Snauwaert et al., 2023). Although the nutritional significance of vegetables is recognized, the proximate composition of vegetables is still required to be more region-specific, since the nutrient content of vegetables is very diverse (depending upon environmental and agricultural factors). Consistent compositional information is needed to develop effective dietary guidelines, enhance nutritional awareness and facilitate food-based intervention to combat malnutrition. Thus, the present study was aimed at investigating the proximate composition of six commonly consumed vegetables, namely spinach (*Spinacia oleracea*), carrot (*Daucus carota*), cauliflower (*Brassica oleracea*), onion (*Allium cepa*), capsicum (*Capsicum annuum*), and coriander (*Coriandrum sativum*), collected in the local markets of Hyderabad and Jamshoro District. The research aims at ascertaining contents of moisture, ash, crude protein, and crude fiber using standard AOAC methods. The results will be used to give credible nutritional facts, which can be applied in dietary planning, population health nutrition policies, and the utilization of the functional food application based on the locally available vegetable resources.

2. Materials and Methods

2.1 Design of the Study and Collection of Samples

The current experimental research was aimed at establishing the proximate composition of the habitually consumed vegetables with the use of conventional methods of analysis. A total of six vegetables which have a significant dietary value and are available in the local markets were selected. In March 2021, fresh samples were taken in the retail vegetable markets in Hyderabad and Jamshoro District (Figure 1). Caution was exercised in choosing vegetables that were fresh, mature, and without any visible physical damage, microbial infections, or spoilages. Samples were taken in sterile polyethylene bags and taken to the laboratory under hygienic

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conditions to prevent contamination and degradation of nutrients.

over a period of about two weeks. This was done to minimize the moisture level and growth of microbes during storage.



Figure 1. Sample collection site showing the field/location where vegetable samples were collected for proximate analysis, ensuring representative sampling for nutritional assessment.

2.2 Sample Preparation

All vegetable samples on arrival at the laboratory were thoroughly washed with deionized water to eliminate dust, soil, and surface contaminants. Washing was repeated three times to ensure complete cleaning. The water was washed after which the surplus water was wiped away with clean absorbent paper. The purified samples were then left to naturally sun-drying in controlled environmental conditions

The samples were then dried thoroughly and manually chopped and ground further into fine powder by means of a clean mortar and pestle (Figure 2). The last step was homogenization, and this was done using an electric grinder (West Point Automatic Series Grinder, Model WF-929) to achieve uniform particle size. Powdered samples were stored in airtight glass containers, properly labeled and kept in a cool dry place until further analysis.



Figure 2. Sample preparation showing washing, sorting, and processing of collected vegetable samples prior to proximate analysis.

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2.3 Chemicals and Reagents

All chemicals and reagents used in this study were of analytical grade and obtained from the Institute of Chemistry, University of Sindh, Jamshoro. The reagents included:

- Sulphuric acid (H_2SO_4, 1.25% and concentrated)
- Sodium hydroxide (NaOH, 1.25% and 40%)
- Boric acid (H_3BO_3, 2%)
- Hydrochloric acid (HCl, 0.1N)
- Potassium sulphate (K_2SO_4)
- Copper sulphate ($CuSO_4$)
- Bromocresol green indicator

All solutions were prepared using distilled water to ensure accuracy and prevent contamination.

2.4 Determination of Proximate Composition

Proximate analysis was performed to determine moisture content, ash content, crude fiber, and crude protein using standard methods recommended by the Association of Official Analytical Chemists (AOAC, 1975).

2.4.1 Moisture Content

Moisture content was determined using the gravimetric oven-drying method. Approximately 5 g of each powdered sample was weighed accurately and placed in pre-weighed petri dishes. The samples were dried in a hot air oven at 105 °C for 3 hours until a constant weight was achieved. After drying, samples were cooled in a desiccator and reweighed. Moisture content was calculated using the following formula:

$$\text{Moisture (\%)} = \frac{\text{Initial weight – Final weight}}{\text{Initial weight}} \times 100$$

2.4.2 Ash Content

Ash content was determined by incineration in a muffle furnace. About 2–3 g of dried sample was placed in pre-weighed porcelain crucibles and heated at 550 °C for 6 hours until complete combustion of organic matter occurred, leaving only inorganic residue. The crucibles were cooled in a desiccator and weighed again. Ash content was calculated as:

$$\text{Ash (\%)} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

2.4.3 Crude Fiber Content

Crude fiber was determined using sequential acid and alkali digestion. The sample (2 g) was boiled in 1.25% sulphuric acid (30 min) and then filtered. This was then further boiled in 1.25% sodium hydroxide solution during the next 30 minutes. The residue was filtered, washed with distilled water, dried and weighed. This was incinerated in a muffle furnace, and crude fiber was determined as:

$$\text{Crude Fiber (\%)} = \frac{\text{Loss in weight after ignition}}{\text{Weight of sample}} \times 100$$

2.4.4 Crude Protein Content

Crude protein was estimated using the Kjeldahl method. Approximately 2 g of sample was digested with concentrated sulphuric acid in the presence of potassium sulphate and copper sulphate as catalysts until a clear solution was obtained. The digest was neutralized with sodium hydroxide and distilled to release ammonia, which was absorbed in boric acid solution. The liberated ammonia was then titrated with 0.1N hydrochloric acid. Nitrogen content was calculated and multiplied by a conversion factor of 6.25 to obtain crude protein content:

$$\text{Protein (\%)} = \text{Nitrogen (\%)} \times 6.25$$

2.4.5 Calculation of Derived Nutritional Parameters

In addition to experimentally determined proximate composition, several nutritional parameters were calculated using standard equations to provide a more comprehensive evaluation of vegetable quality.

Dry matter content was calculated by subtracting the moisture percentage from 100:

$$\text{Dry Matter (\%)} = 100 - \text{Moisture (\%)}$$

Organic matter content was estimated by subtracting ash content from 100:

$$\text{Organic Matter (\%)} = 100 - \text{Ash (\%)}$$

Total carbohydrate content was determined by difference, subtracting the sum of moisture, ash, crude protein, and crude fiber from 100:

$$\text{Carbohydrates (\%)} = 100 - (\text{Moisture} + \text{Ash} + \text{Protein} + \text{Fiber})$$

The moisture to dry matter ratio was computed to assess the relative water content of the samples:

$$\text{Moisture/Dry Matter Ratio} = \frac{\text{Moisture (\%)}}{\text{Dry Matter (\%)}}$$

The ash to organic matter ratio was calculated to evaluate the proportion of mineral content relative to organic constituents:

$$\text{Ash/Organic Matter Ratio} = \frac{\text{Ash (\%)}}{\text{Organic Matter (\%)}}$$

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A protein–nitrogen conversion consistency index was also assessed by dividing crude protein content by nitrogen content to verify the applicability of the standard conversion factor:

$$\text{Protein/Nitrogen Ratio} = \frac{\text{Protein (\%)}}{\text{Nitrogen (\%)}}$$

All calculated parameters were derived from mean values obtained from triplicate analyses.

2.5 Data Analysis

All the analyses were conducted in triplicate, and the results were presented as means standard error. One-way analysis of variance (ANOVA) was used to determine the statistical difference among vegetable samples in Statistix 8.1. Treatment means were compared with the help of the Honest Significant Difference (HSD) test (significant difference) at a 5% probability level. OriginPro software was used to perform a correlation analysis of measured and derived parameters, to assess the relationship between variables.

compositional ratios. In general, a considerable dispersion was found in all the measured parameters, which represented a significant difference in the biochemical and nutritional profiles of the chosen vegetable species.

3.1 Moisture Content

The moisture content was found to be 10.00% to 20.00% among the chosen vegetables (Figure 4). Carrot had the highest moisture content (20.00%), then onion (18.00%), and cauliflower (14.00%). Coriander and capsicum had intermediate values of 12.40% and 11.25% respectively, and spinach contained the lowest moisture content (10.00%). The variations of moisture content were statistically significant ($p \leq 0.05$). The identified variation can be explained by the fact that tissue structure, water-holding capacity, and physiological characteristics may differ. Root vegetables like carrot normally have higher moisture retention levels because of the composition of storage tissues, leafy vegetables usually have a higher moisture loss rate during processing and drying.

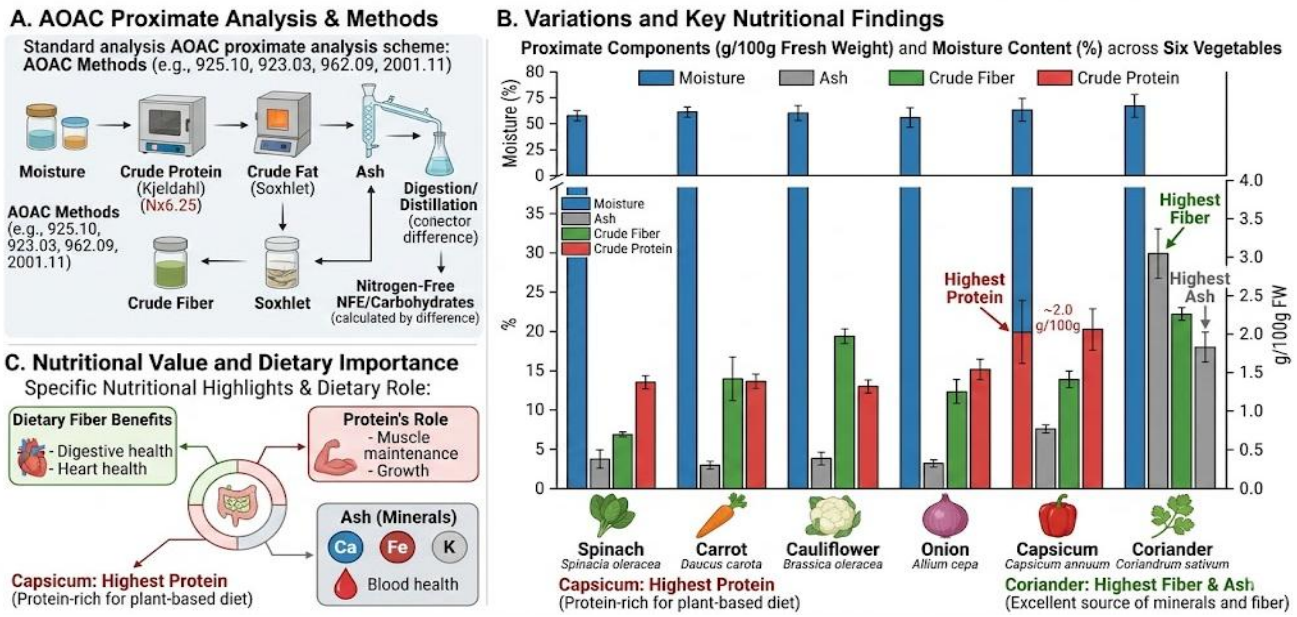


Figure 3. Proximate composition of six vegetables (spinach, carrot, cauliflower, onion, capsicum, coriander) showing AOAC analysis and variations in moisture, ash, fiber, and protein; capsicum had highest protein, while coriander had highest fiber and ash, highlighting nutritional value and dietary importance.

3. Results

Standard AOAC procedures were used to determine the proximate composition of six selected vegetables (spinach, carrot, cauliflower, onion, capsicum and coriander) (Figure 3). It was analyzed in terms of moisture, ash, crude fiber, protein, and nitrogen with the derived parameters of dry matter, organic matter, carbohydrate content and select

3.2 Ash Content

Figure 5 showed that the content of the ash was between 4.02% and 9.06% among the analyzed vegetables. Coriander had the highest ash content (9.06%), then capsicum (8.20%) and cauliflower (6.01%). Carrot and spinach had moderate values of 5.10% and 4.36% respectively and onion had the

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least ash content (4.02%). The variations were statistically significant ($p \leq 0.05$) which showed a clear variation in mineral composition. The higher values of coriander and capsicum in terms of ash content indicate that this nutrient tends to accumulate more in these foods, and the lower values of coriander and capsicum in the same aspect indicate that the inorganic component of these foods tends to be lower.

3.3 Crude Fiber Content

The content of crude fiber exhibited significant difference among the vegetables, with the highest values of crude fiber reaching as high as 25.01% (Figure 6). The highest fiber content was observed in coriander (25.01%), followed by cauliflower (20.00%) and carrot (15.01%). Capsicum, spinach and onion reported relatively low fiber contents of

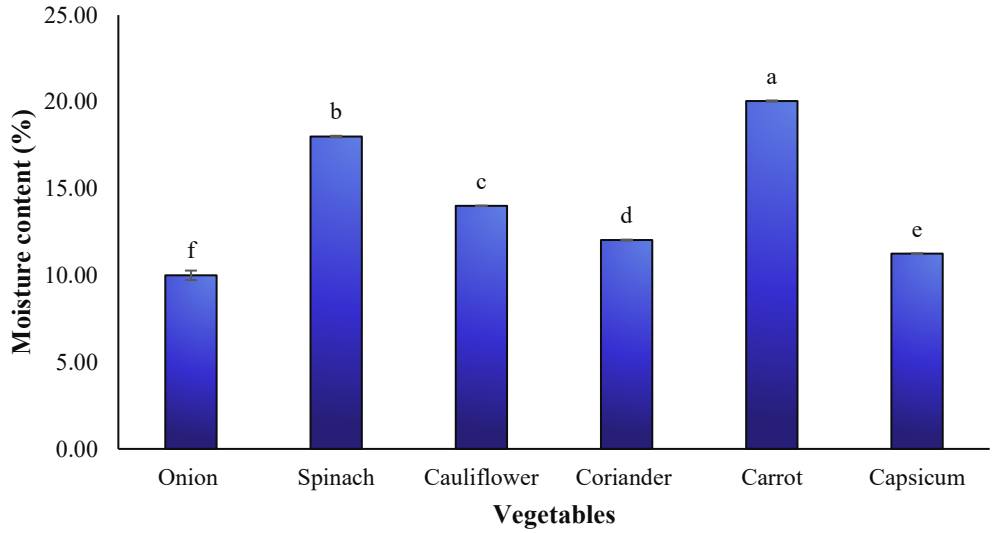


Figure 4. Comparative analysis of moisture content (%) among selected vegetables. Bars represent mean values and different lowercase letters indicate statistically significant differences among treatments according to Tukey's HSD test ($p \leq 0.05$).

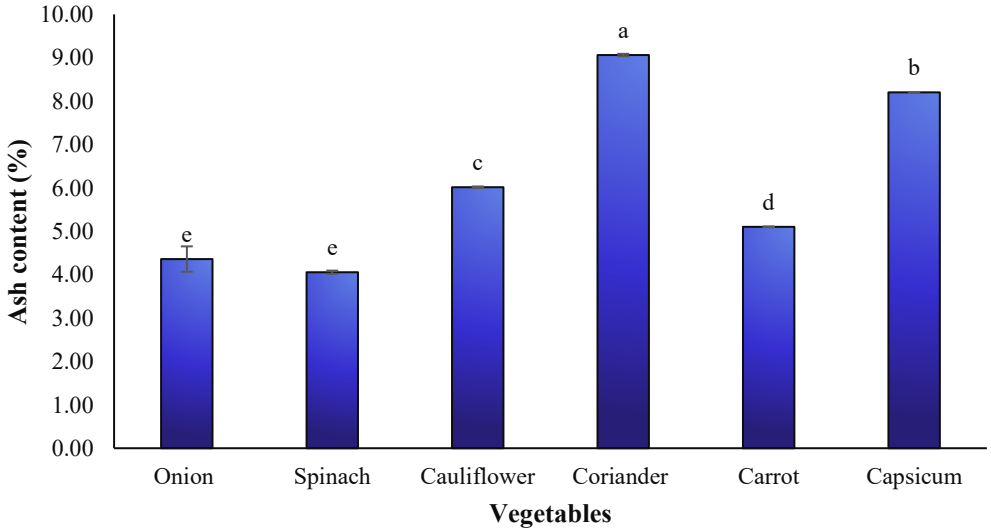


Figure 5. Comparative analysis of ash content (%) among selected vegetables. Bars represent mean values and different lowercase letters indicate statistically significant differences among treatments according to Tukey's HSD test ($p \leq 0.05$).

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6.01%, 5.01% and 5.00% respectively. The differences were statistically significant ($p \leq 0.05$). The high content of fiber in the coriander implies the coriander has a high potential of improving digestive health whereas the lower values of the leafy and bulb vegetables imply a less rigid tissue structure and generally lower structural carbohydrate accumulation.

3.4 Crude Protein Content

The content of crude protein among the vegetables was significantly varied as it ranged between 7.87% and 25.38% (Figure 7). The protein content was the highest in capsicum (25.38%), followed by carrot (18.37%) and coriander

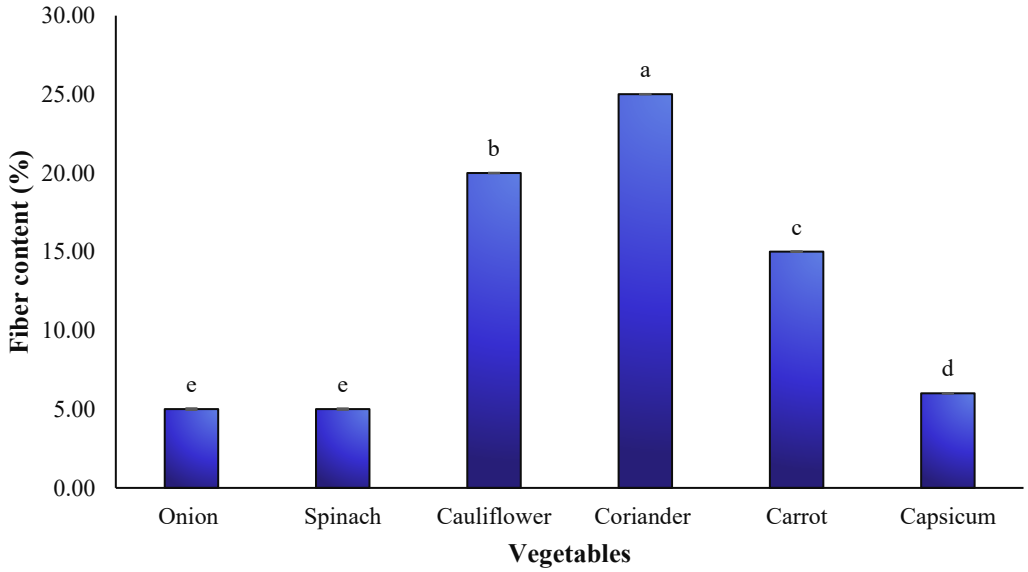


Figure 6. Comparative analysis of fiber content (%) among selected vegetables. Bars represent mean values and different lowercase letters indicate statistically significant differences among treatments according to Tukey's HSD test ($p \leq 0.05$).

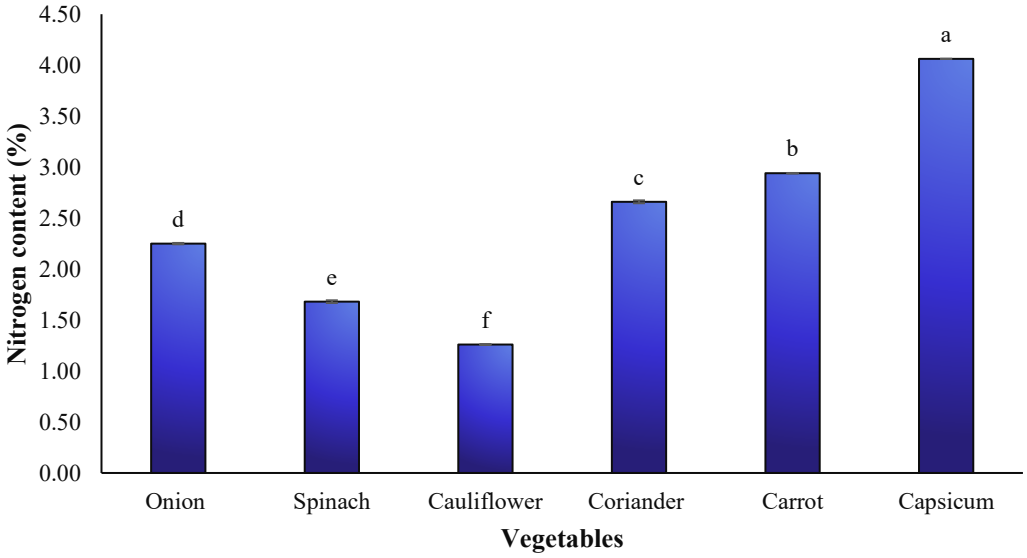


Figure 7. Comparative analysis of nitrogen content (%) among selected vegetables. Bars represent mean values and different lowercase letters indicate statistically significant differences among treatments according to Tukey's HSD test ($p \leq 0.05$).

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(16.62%). Protein composition in spinach was 14.06% with lower values of 10.50% and 7.87% in onion and cauliflower, respectively. The differences were found to be significant ($p \leq 0.05$). The relatively high protein contents in the capsicum indicate that they have the potential to serve as a valuable source of plant-based proteins, especially in vegetarian diets.

3.5 Nitrogen Content

The level of nitrogen was also quite different in vegetables and ranged between 1.26% and 4.06%. Capsicum had the highest nitrogen level (4.06%), then carrot (2.94%) and coriander (2.66%). Onion had a moderate value (2.25%), whereas spinach (1.68%), and cauliflower (1.26%) had lower nitrogen levels (Figure 8). The variation in the distribution of proteins in terms of nitrogen was statistically significant ($p \leq 0.05$) and showed that there was a difference in the distribution of proteins in terms of nitrogen. The increased nitrogen level in capsicum and carrot indicates the increased protein deposits whereas the lower values of cauliflower and spinach suggest the relatively lesser nitrogenous compounds.

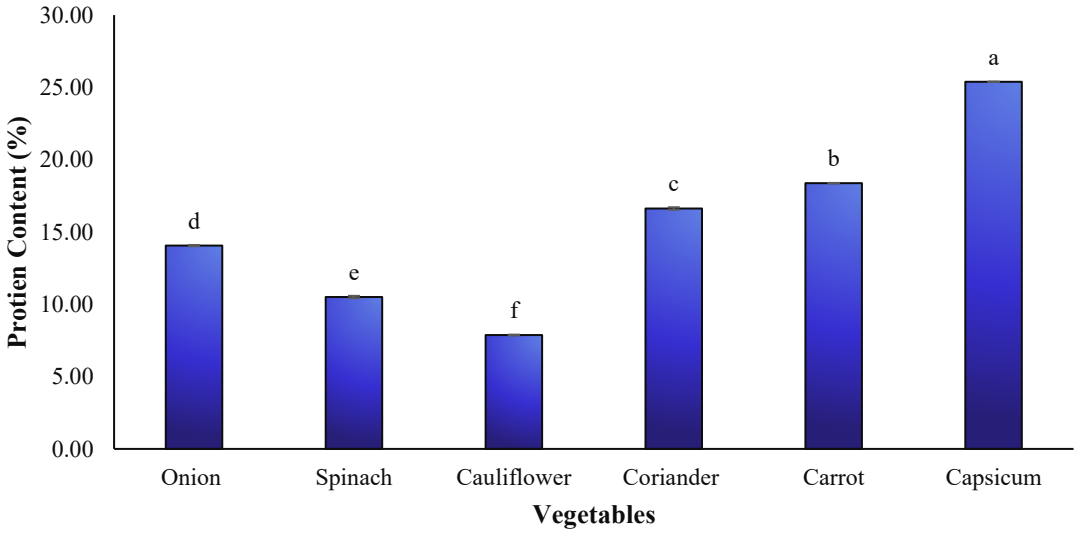


Figure 8. Comparative analysis of protein content (%) among selected vegetables. Bars represent mean values and different lowercase letters indicate statistically significant differences among treatments according to Tukey's HSD test ($p \leq 0.05$).

3.6 Dry Matter Content

Dry matter content ranged from 79.95% to 90.00%. Onion had the highest value (90.00%), then capsicum (88.75%), and coriander (87.96%) (Figure 9). Cauliflower had moderate value (85.99%), with spinach (82.00%), and carrot (79.95%) having lower dry matter contents. The statistical significance of the differences was low ($p \leq 0.05$). High dry matter in onion and capsicum means that the proportion of solid constituents is high, whereas low values in carrot and spinach means that the proportion of solid constituents is low.

3.7 Organic Matter Content

Organic matter content ranged from 90.94% to 95.94% (Figure 10). The highest value (95.94%), was recorded in spinach, followed closely by onion (95.64%), and carrot (94.90%). Cauliflower had 93.98, capsicum (91.80) and coriander (90.94) had the least. The statistical significance of the differences was statistically significant ($p \leq 0.05$). The higher values of spinach and onion in the higher organic matter suggest that more biochemical constituents are accumulated whereas the lower values of the capsicum and coriander in the higher organic matter indicate a relatively high amount of biochemical constituents.

3.8 Carbohydrate Content

Carbohydrate content ranged from 37.26% to 66.57% (Figure 11). The highest value was observed in onion (66.57%), then spinach (62.43%). Cauliflower (52.10%) and capsicum (49.15) had intermediate levels, with carrot (41.46%) and coriander (37.26) having the lowest values. The statistical significance of the differences was statistically significant ($p \leq 0.05$). The higher amounts of soluble carbohydrate collection in onion and spinach, and the lower quantity in carrot and coriander, indicates the presence of higher and lesser amounts of soluble carbohydrate collection respectively.

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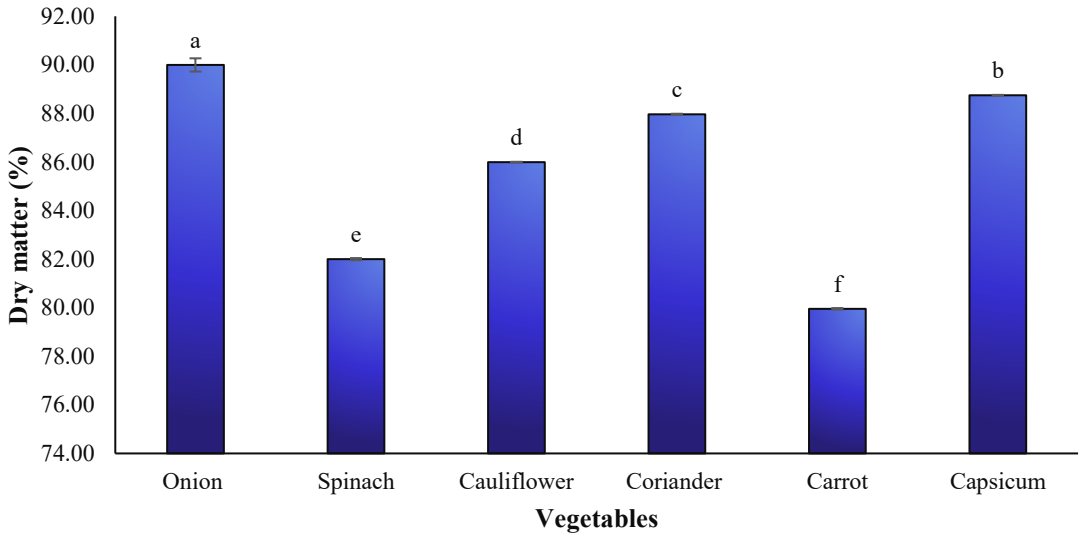


Figure 9. Comparative analysis of dry content (%) among selected vegetables. Bars represent mean values and different lowercase letters indicate statistically significant differences among treatments according to Tukey's HSD test ($p \leq 0.05$).

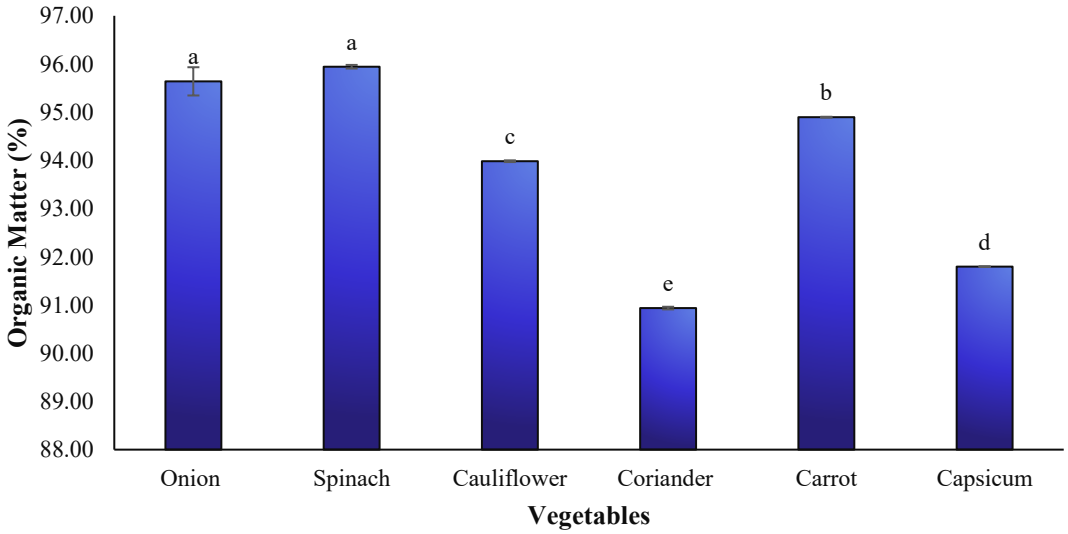


Figure 10. Comparative analysis of dry content (%) among selected vegetables. Bars represent mean values and different lowercase letters indicate statistically significant differences among treatments according to Tukey's HSD test ($p \leq 0.05$).

3.9 Moisture to Dry Matter Ratio

The ratio of moisture to dry matter was between 0.11 and 0.25 (Figure 12). Carrot had the highest ratio (0.25) than spinach (0.22). Cauliflower was medium (0.16), whereas coriander (0.14), and capsicum (0.13) were lower. Onion had the lowest (0.11) ratio. The statistical significance of the differences was statistically significant ($p \leq 0.05$). Carrot and spinach have higher ratios indicating more moisture dominance and lower ratios in onion indicating higher solid constituents and increased storage stability.

3.10 Ash to Organic Matter Ratio

The ratio of the ash to organic matter was between 0.04 and 0.10 (Figure 13). Coriander had the best ratio (0.10), then

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capsicum (0.09). Cauliflower was at 0.06, then onion and carrot recorded 0.05 and 0.05 respectively. Spinach had the lowest ratio (0.04). The differences were not only statistically significant but also had $p \leq 0.05$. The higher values of coriander and capsicum and lower values of spinach and onion are indicative of the greater contribution of the mineral constituents relative to the organic constituents.

3.11 Correlation analysis

The correlation analysis demonstrated that there were specific relationships between the parameters studied (Figure 14). The content of ash showed a strong positive relationship with the ratio of ash to organic matter (Ash/OM; r = 1.00) and moderate positive correlation with fiber (r = 0.54), nitrogen

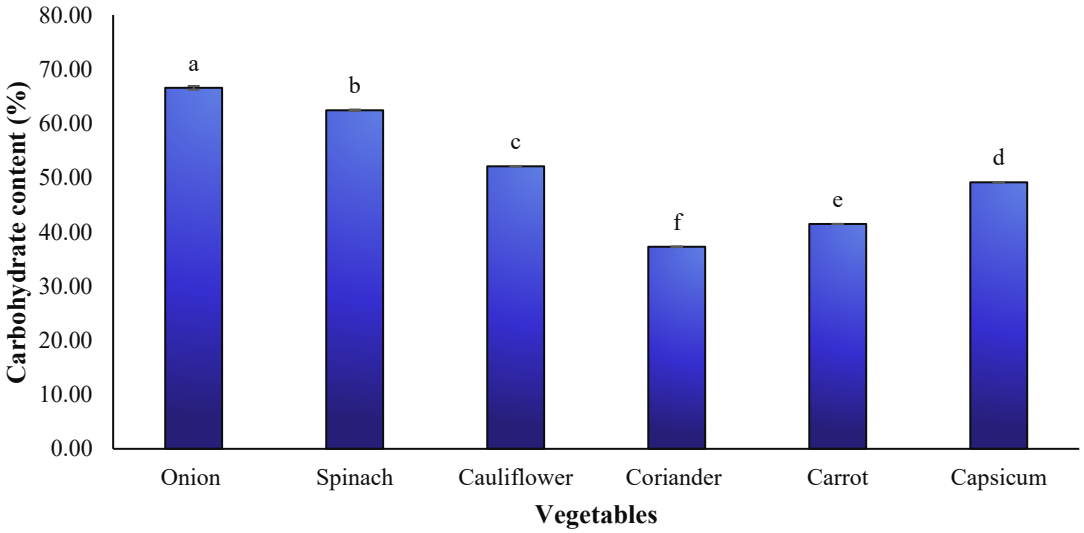


Figure 11. Comparative analysis of carbohydrate content (%) among selected vegetables. Bars represent mean values and different lowercase letters indicate statistically significant differences among treatments according to Tukey's HSD test ($p \leq 0.05$).

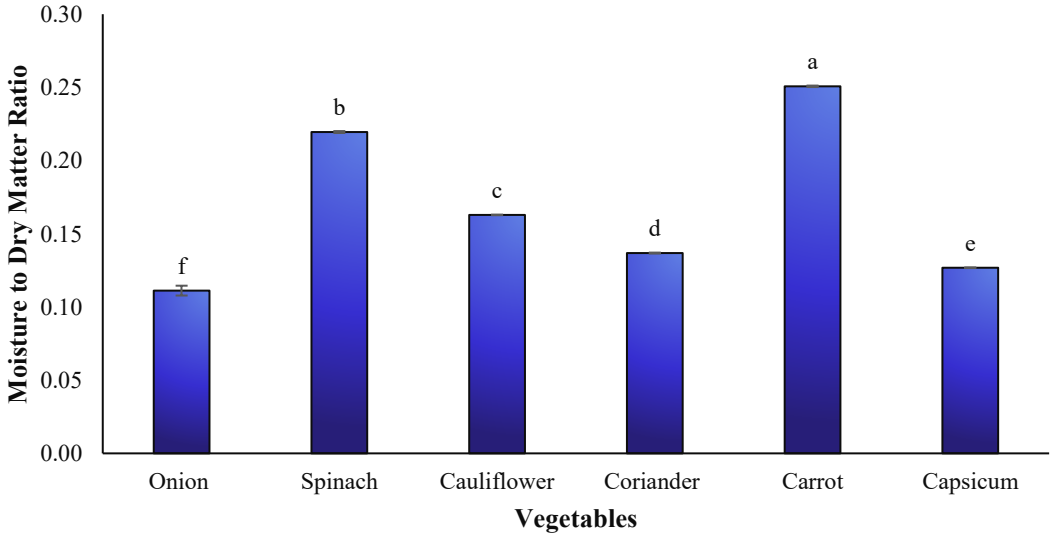


Figure 12. Comparative analysis of moisture to dry matter ratio among selected vegetables. Bars represent mean values and different lowercase letters indicate statistically significant differences among treatments according to Tukey's HSD test ($p \leq 0.05$).

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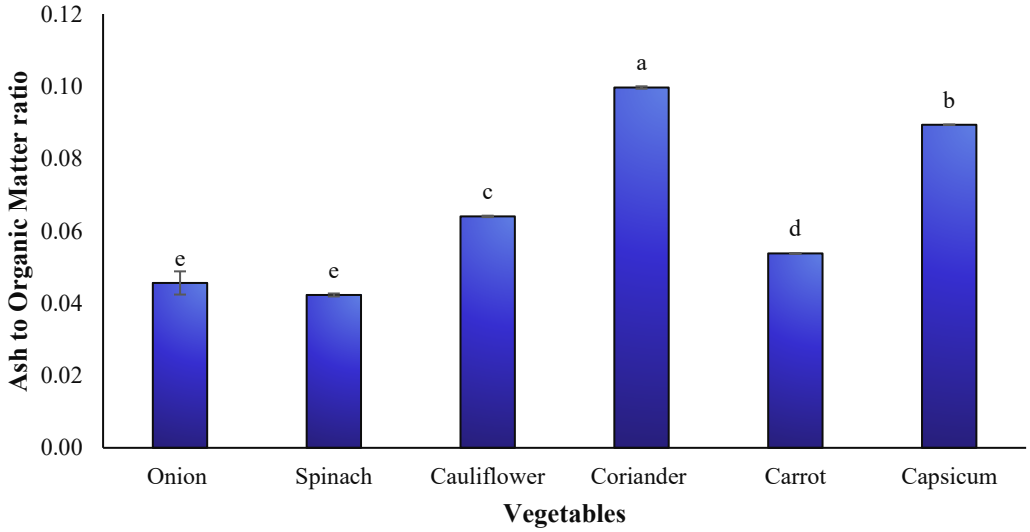


Figure 13. Comparative analysis of moisture to ash to organic matter ratio among selected vegetables. Bars represent mean values and different lowercase letters indicate statistically significant differences among treatments according to Tukey's HSD test ($p \leq 0.05$).

(r = 0.54), protein (r = 0.54), and dry matter (r = 0.48). Conversely, the ash was found to be negatively correlated with moisture, carbohydrates and moderately with M/DM. The moisture content showed mostly negative relationships with other characteristics, such as nitrogen (r = -0.21) and protein (r = -0.21), but a moderate positive correlation with organic matter (r = 0.48). Fiber was also found to have a strong negative relationship with carbohydrates (r = -0.76) and organic matter (r = -0.54), therefore, indicating that fiber is inversely related to energy rich components. Nitrogen and protein showed a perfect correlation (r = 1.00), which went to show that there was a direct biochemical relationship between nitrogen and protein. There were moderate positive correlations between both variables and dry matter (r = 0.21) and negative correlations with organic matter (r = -0.54). There was a strong positive correlation between dry matter and carbohydrates (r = 0.72) and a moderate negative correlation between dry matter and organic matter (r = -0.46). Organic matter was found to be negatively correlated with most of the parameters, especially nitrogen, protein and fiber (r = -0.54), but positively related with carbohydrates (r = 0.72) and M/DM (r = 0.47). Carbohydrates were found to have a negative relationship with ash (r = -0.72), fiber (r = -0.76), nitrogen (r = -0.42) and protein (r = -0.42). In general, the findings indicate that there is a strong inverse relationship between mineral content (ash) and carbohydrate accumulation, with protein-related traits being closely interconnected and aligned with the accumulation of dry matter.

4. Discussion

In the current research, proximate composition of six commonly consumed vegetables, namely spinach (*Spinacia oleracea*), carrot (*Daucus carota*), cauliflower (*Brassica oleracea*), onion (*Allium cepa*), capsicum (*Capsicum annuum*) and coriander (*Coriandrum sativum*) were examined to determine their nutritional potential and contribution to human dietary needs. The findings showed that there was a high degree of variation in moisture, ash, fiber, protein, nitrogen, and derived nutritional indices, which reflects inherent biological differences, as well as environmental, agronomic and post harvest factors. It is characteristic of plant-based food systems and has been extensively reported in nutritional literature (Nanjera Espinosa et al., 2025). Moisture content is a key determinant of food quality, affecting freshness, shelf life, and susceptibility to microbial spoilage (Preetha & Narayanan, 2020). The moisture content in the current study varied between 10.00% in spinach to 20.00% in carrot. The increased moisture content of carrot is related to its root tissue structure, which is naturally adapted to store water and provide physiological support (Mazza, 2021). The same trends have been reported in which the root vegetables have a higher moisture level than the leafy vegetables (Maseko et al., 2019). On the other hand, spinach and capsicum had lower moisture values because of variations in tissue structure and the ability to retain water (Yang et al., 2024). The causes of these differences might also have been caused

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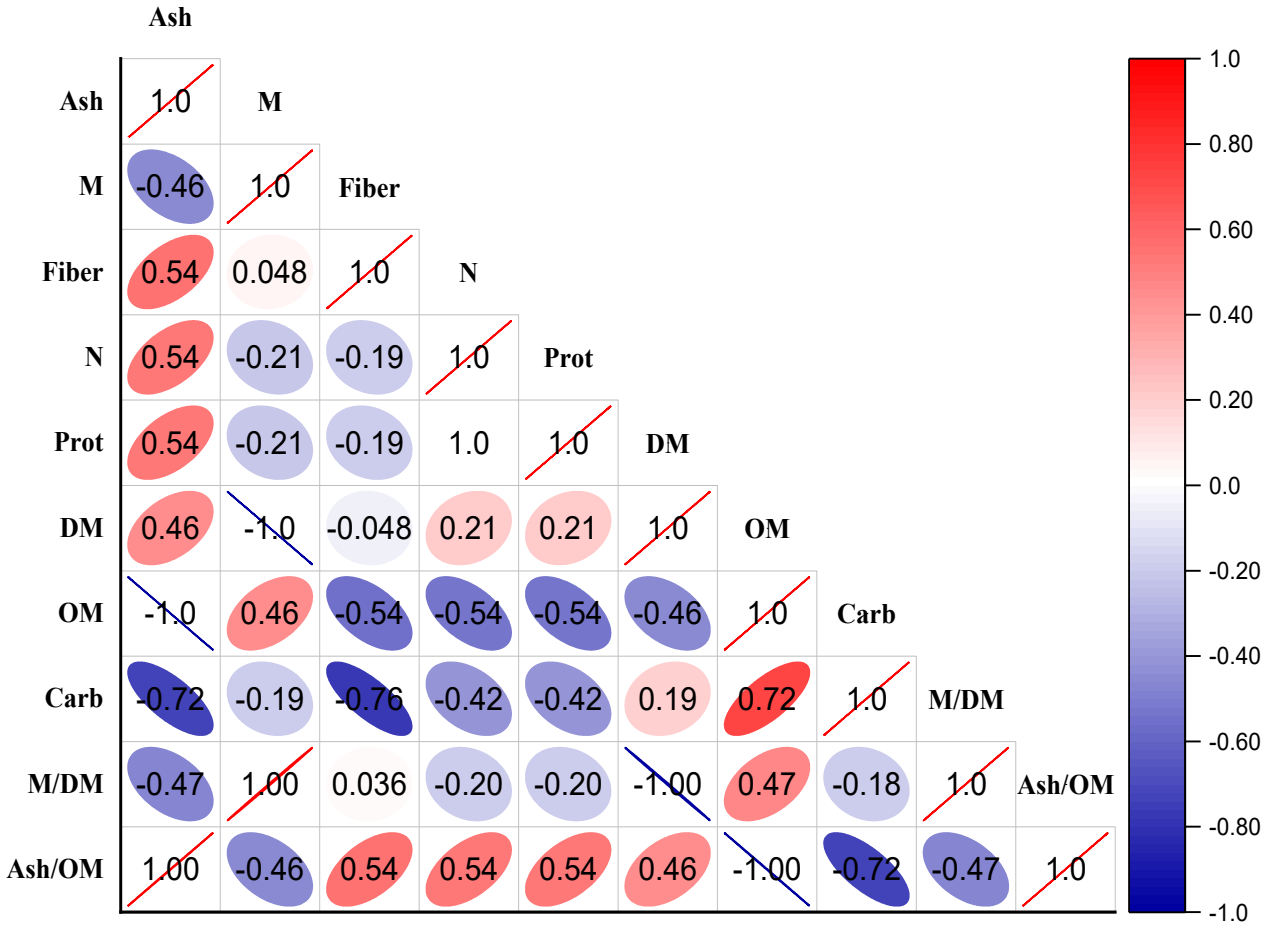


Figure 14. Pearson correlation matrix illustrating relationships among proximate composition parameters of selected vegetables, including ash content (Ash), moisture (M), fiber, nitrogen (N), protein (Prot), dry matter (DM), organic matter (OM), carbohydrate (Carb), moisture-to-dry matter ratio (M/DM), and ash-to-organic matter ratio (Ash/OM). The color gradient represents correlation coefficients ranging from −1 (strong negative correlation; blue) to +1 (strong positive correlation; red), with diagonal values indicating self-correlation.

by environmental factors such as irrigation, humidity and post harvest drying conditions. Nutritionally, lower-moisture vegetables typically have a longer shelf life, and are less perishable (Kishore et al., 2025). Ash content is the total mineral residue, which is an indirect measure of mineral composition. The ash content in the current research was between 4.02-9.06 in onion and coriander respectively. The higher the ash content of coriander and capsicum, the higher the concentrations of essential minerals including calcium, potassium, magnesium and iron (Islam et al., 2022). These minerals are vital in physiological processes such as enzymatic action, nerve conduction and oxygen transportation. Other observations have been made with leafy and aromatic vegetables that tend to exhibit higher mineral content than bulb vegetables. The ash content may vary depending on the soil fertility, application of fertilizers, water irrigation and genetic influences (Brouwer-Brolsma et al., 2020). Crude fiber is a vital part of the diet related to better digestion, glycemic regulation, and lipid metabolism (Razouki et al., 2025). In the current study, the content of crude fiber was wide ranging with coriander having the highest content (25.01%), followed by cauliflower and carrot.

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Coriander has a high fiber content due to its structural composition with high cellulose, hemicellulose, and lignin (Evon et al., 2023). The relative fiber content of cauliflower was also relatively high, which was reported in other studies of cruciferous vegetables (Nowak et al., 2025). Conversely, onion and spinach had lesser levels of fiber, probably because the two have less tissue structure and more moisture. Fiber of vegetables is known to decrease the risk of chronic diseases, such as cardiovascular disorders and colorectal cancer, and this is why the importance of fiber-rich vegetables in daily diets is so great.

Protein content is an essential nutritional parameter needed in the growth, tissue repair, and metabolic processes. The protein content varied between 7.87% in cauliflower and 25.38% in capsicum in the present study. Capsicum had the highest protein content followed by carrot and coriander, which implies that they may contribute to plant-based protein intake (Marinangeli et al., 2022). Active nitrogen metabolism in the course of fruit development may be linked with the relatively high protein content of capsicum. Even though vegetables do not play a major role as direct sources of protein, compared to legumes or animal products, they still contribute significantly to the overall protein intake in the diet, especially among vegetarian groups (Lonnie & Johnstone, 2020). Dry matter content is a measure of total solid contents and a significant measure of nutritional density. Onion and capsicum were higher in terms of dry matter content, thus higher percent of solids whereas carrot and spinach were lower in terms of dry matter content, thus higher percent of solids. Other studies have also reported similar results with the bulb and fruit vegetables having a higher dry matter than leafy vegetables (USDA, 2021).

The content of organic matter, as the total organic substances, including carbohydrates and proteins, was the highest in spinach and onion. The relatively homogeneous distribution of organic matter among vegetables indicates that all samples are principally composed of organic biochemical compounds, which are consistent with general plant tissue composition (FAO, 2019). The amount of carbohydrates differed significantly, and onion and spinach reported the highest amount. This implies that there will be increased storage of soluble carbohydrates that will act as primary energy reserves in plant tissues (Li et al., 20. The decrease in the carbohydrate in coriander and carrot can be explained by the increased distribution to the structural components of food such as fiber. The species type, stage of maturity, and metabolic activities are strong factors that influence the variation of carbohydrates in vegetables (Slavin and Lloyd, 2012). The moisture to dry matter ratio provides insight into water–solid balance. The higher ratios in carrot and spinach mean that the foods have greater moisture dominance, and as such, have a shorter shelf life. High moisture vegetables are normally more susceptible to microbial food spoilage and post-harvest degradation. The ratio of ash to organic matter is a measure of the contribution of minerals compared to organic biomass. The fact that coriander and capsicum have higher values implies that the mineral density is higher, whereas the values of spinach and onions are lower, which means that the organic constituents are predominant. The contents of minerals in vegetables depend on the properties of the soil, availability of nutrients, and the efficiency of plants in absorbing the nutrients (White and Broadley, 2009). In general, the observed variations in the proximate composition and derived parameters are predisposed by the genetic, environmental, and agronomic factors. The nutritional composition is substantially influenced by soil fertility, climatic conditions, irrigation practices, post-harvest handling, etc. (Gruda et al., 2025; Coradi et al., 2020). The sample preparation by using sun-drying could have also interfered with the parameters that are dependent on moisture. Nutritionally, the findings reveal the significance of dietary diversity since none of the vegetable species alone can supply all the necessary nutrients in sufficient quantities (Imathiu, 2021). An increase in the consumption of locally grown vegetables can play a substantial role in nutritional security and enhancement of the health of the population.

5. Conclusion

The current study assessed the proximate composition of six commonly consumed vegetables, i.e., spinach (*Spinacia oleracea*), carrot (*Daucus carota*), cauliflower (*Brassica oleracea*), onion (*Allium cepa*), capsicum (*Capsicum annuum*), and coriander (*Coriandrum sativum*), through the standard AOAC analytical methods. The results indicated that all the vegetables that were selected have significant nutritional value, especially in the composition of protein, mineral (ash) and dietary fiber. Capsicum was found to be the richest source of protein whereas coriander was found to contain the highest crude fiber and ash contents indicating their high potential as mineral and fiber rich nutrition components. Carrot contained the most moisture content hence it was reflective of its content in key nutrients. Such differences in proximate composition may be attributed to genetic factors, the fertility of the soil, environmental factors, agricultural practices as well as post-harvest handling techniques. Despite these differences, the overall results support the fact that locally grown vegetables are worthy, accessible and cost-effective sources of the necessary nutrients. This research paper highlights that there is a need to enlarge daily dietary intakes of a wide array of vegetables to improve the nutritional quality, enhance metabolic health and reduce the risk of micronutrient deficiencies and diet-related chronic diseases. The findings are also useful baseline data to nutritionists, researchers, and policymakers in formulating dietary guidelines and nutritional interventions

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using food. It is also indicated that more research is required to investigate seasonal changes, the interaction of soil and plant, and how agronomic practices can be optimized to maximize their health benefit and agronomic value.

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8. Conflict of Interest

The authors declare no conflict of interest.

9. Authors' Contribution

Kainat Designing the study, collecting and organizing data, analyzing and interpreting the findings, and drafting as well as revising the manuscript. Uroosa and Iqra Designing the study, organizing the data, reviewing the manuscript and supervising. Tehmina Mirjat, Khair-un-nisa and Hina Shahzadi Collecting and organizing the data. Khadija Ghani and Arifa collecting the data designing the methodology.

10. SDGs Addressed

This study supports United Nations SDGs, particularly SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being), and SDG 12 (Responsible Consumption and Production), by highlighting the nutritional value of commonly consumed vegetables and promoting dietary diversity for improved food security, public health, and sustainable food systems.

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