Kashf Journal of Multidisciplinary Research
Vol: 02 - Issue 11 (2025)
P-ISSN: 3007-1992 E-ISSN: 3007-200X
https://kjmr.com.pk

ASSESSMENT OF CHEMICAL PROFILE OF VARIOUS SEED SPECIES GROWN IN THE LARKANA REGION, SINDH, PAKISTAN

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Article Info

Abstract

In present work a comprehensive analysis was conducted on the chemical profile of ten varieties of seeds (Okra, brinjal, cucumber, Indian squash, bitter gourd, watermelon, melon, papaya, strawberry and sesame) grown in agriculturally significant area of Larkana division, Sindh. The main purpose was to investigate their proximate composition, metal content and bioactive compounds to evaluate their nutritional potential. Seed samples were collected from different locations through the region investigated using standard analytical methods. The results exposed noteworthy distinction in the nutritional composition among seed varieties. The highest average protein level of 14300 mg/100g was exhibited by sesame seed-1, whereas maximum carbohydrate contents of 0.368 mg/100g and 0.365 mg/100g declared in sesame seeds and cucumber seeds respectively. The highest concentration of 20.53 mg/100g of flavonoid and 246.22 mg/kg of were sodium was shown by okra seeds, while maximum concentration of 21.45 mg/100g) was found in strawberry seeds. Bitter gourd displayed the maximum concentration of Ca (628.03 mg/kg), Mg (340.37 mg/kg) and Zn (4.43 mg/kg). The highest level of 150.84 mg/kg of K was measured in papaya seeds, while melon seeds declared the maximum of 3.85 mg/kg of Fe level. The findings reveal that various seeds grown in the Larkana region are important reservoirs of essential nutrient and bioactive compounds. This data is crucial for nutritional planning, promoting local agricultural products, and informing farmers and policymakers about optimizing crop selection for enhanced dietary intake and economic opportunity.

Keywords:

chemical profile, Inductively Coupled Plasma-Optical Emission Spectrophotometry (ICP-OES), flavonoids, Vitamin C, Larkana region

INTRODUCTION

Vegetables are low cost sources of energy, as compared to other food products. Vegetables are affluent in phytochemicals, trace minerals, vitamin C, iron (Fe), calcium (Ca), vitamins, proteins, carbohydrates, and essential nutrients (Ebabhi, and Adebayo, 2022). Nutrients and energy are provided to humans by these vegetables. Important aspects of food selection are quality control and management (Hoque, et al., 2023). As a result, the national as well as international organizations, particularly World Health Organization (WHO) and Food and Agricultural Organization (FAO) have set the suggested levels for this nutrition in the food products for people (Canton, 2021). For a healthy life two types of essential nutrients are required. Moisture level, carbohydrates, fats, fiber, and proteins are macro-nutrients whereas; minerals (Macro and micro minerals), phyto-chemicals and vitamins are micronutrients (Lee, et al., 2021). For human beings and other living beings carbohydrates, lipids and proteins (macronutrients) are wide ranging and instantaneous sources of energy, while water and ash only play a part in mass (Vieira, et al., 2025). Moreover, Ca, K, Na, and Mg are macro elements whereas, Fe, Cu, Mn, Cr, and Zn are micro-minerals present in vegetables. Minerals are significant since they notably contribute to the various metabolic functions in living cells (Matthewman, and Costa-Pinto, 2023). Minerals may be bonded to other micro-molecules or conjugated proteins for instances, polyphenols and phosphates (Sandhia, 2024). Minerals are components of various enzymes because they take part in several metabolic processes in living cells (Alghamdi, et al., 2022). Deficiencies due to micro-nutrient have been observed a foremost health problem all over the world. These deficiency confusions may lead to deprived quality of life. The deficiencies may rise when humans require access to micro-nutrient foods like, fortified foods, fruits, vegetables, and animal products, normally because of low nutritional value or a lack of dietetic selection from some food groups (Bhatla, and Kathpalia, 2023). Pregnant women, lactating women, infants are suffering from micronutrient deficiencies and are considered as weakest groups, because they require higher micronutrient content (Weyh, et al., 2022). Chloride ions and macro minerals (Na, K, Ca & Mg) should be needed to balance extracellular fluid for muscular irritability (Yadav, et al., 2024). Ca may increase the risk of osteoporosis and has harmful impact on health, and has momentous effect on growth (Malik, et al., 2023; Knight, et al., 2024). Vitamin-A and Fe deficiencies are the most widespread forms of micro-nutrient starvation despite Zn deficiency (Kumar, et al., 2022). Reports show that more than 25% of world's population is suffering from Fe deficiency, mostly children and young women. Insufficient consumption of Fe can cause anemia, which reduces hemoglobin or red blood cells (RBCs). Symptoms include reduced exercise tolerance, shortness of breath, weakness, fatigue and tiredness (Gedfie, et al., 2022). Likewise, various enzymes contain Zn as cofactor involved in cell replication, amino acid and nucleic acid metabolism, and gene expression (Clemens, 2022). Furthermore, bioavailability and the metabolism of essential vitamins (A & E) are also based on Zn status (Costa, et al., 2023). Cu is essential for the haematologic and neurological systems as well as important micro-mineral and helps Fe in early phase of hemopoiesis (Gale, and Aizenman, 2024). Lack of Cu may enhance the level of Fe in the liver and vice versa (Nasr, et al., 2021). A few of the metabolic roles of Mn include reproductive functions and metabolism. It plays a role comparable to antioxidant, by protecting cells from damage because of free radicals (Jomova, et al., 2025). Mn also plays a important function in blood clotting, bone and connective tissue growth, and regulation of cellular energy (Taskozhina, et al., 2024). Based on the nutritional complements, large quantity of these macro as well as micronutrients is present in vegetables, which are significant for excellent health (Gush, et al., 2021; Savarino, et al., 2021). Compared to the abovementioned facts, it is significant to launch food composition data of macro and micro-nutrients in frequent vegetables in the Larkana region, which is required for nutritional planning studies.

The investigation of chemical sketch of seeds of vegetables is very important to understand their commercial and nutritional value. Important nutrients such as minerals and vitamins are present in seeds consisting macronutrients for instance fats, proteins, and carbohydrates (Rahaman, et al., 2023). Determining their chemical profile supports to measure their potential for human usage, industrial uses, or livestock feed such as oil extraction. This is mostly applicable in the perspective of food safety and upholding local agricultural products (Vastolo, et al., 2022). The study area is an agriculturally important area. The environmental conditions and local soil, including its particular climate, irrigation practices, soil composition, may directly affect the nutritional level of the crops. Thus, the work focused on this area is fundamental to present particular data on the quality of locally cultivated yield.

The purpose of this work is to conduct a wide – ranging proximate analysis of the seeds from different vegetables grown in the Larkana. This consists of the content of major constituents such as Vitamin-C, Carbohydrates, Proteins, and Flavonoids. Moreover, level of particular minerals and other bioactive compounds are involved may be assessed. The results may provide precious insights for policymakers, researchers, and farmers supporting them to optimize crop managing, improving nutritional ingestion for local people and categorize prospective economic chance for the area.

Materials and Methods

Study Area

The study area (Larkana Division) experiences extremely hot and dry climate with temperature rising over 46 °C from May – August. The area is identified in history high temperature, consisting of record – breaking 53.5 °C in Mohen–Jo–Daro, among the uppermost constantly determined in the Asia. The air in the study area is always extremely dry. From December to January in the winter, the average minimum temperature drops to about 2°C, and frost occurs frequently. The region receives an average of 9 to 13 inches (230 to 330 mm) of rainfall annually, with most of it falling during the monsoon season from June to September. Southwesterly monsoon winds affect the area from mid-February to the end of September, while cool northerly winds take over from October to January. Although upper Sindh is located between two major monsoon systems, it avoids the direct influence of both, leading to a scarcity of rain. Historically, the Indus River's natural flooding compensated for the lack of rainfall, but this has changed due to the construction of dams and barrages. Severe heat-waves are a regular feature of summers in Larkana Division, posing significant health risks (Dhamrah, et al., 2023).

Figure: 1 Map of Study Area of Larkana Division

Seed Sampling

Seeds from various crops, including okra (Abelmoschus esculentus), brinjal (Solanum melongena), cucumber (Cucumis sativus), Indian squash (Benincasa fistulosa or Praecitrullus fistulosus), bitter gourd (Momordica charantia), watermelon (Citrullus lanatus), melon (Cucumis melo), papaya (Carica papaya), strawberry (Fragaria × ananassa), and sesame seed (Sesamum indicum), were randomly collected from various agricultural lands in the Larkana Division. The collection sites included Village Abri, Village Sharifani, Beero Chandio, Baharpur, Goth Mai Makool, Goth Meno, Shah Jo Goth, Goth Hasila, Goth Ranoti, Goth Datal Abro, Goth Dodo Sunhari, Goth Dhamrah, Baqapur, Areja, Wada Mahar, Hamza Jatoi Goth, Damrah, Goth Ranoti, and Farid Abad. These areas are where the study's crops were cultivated. The collected seed samples were subsequently transported to a research institute for the analysis of their chemical parameters.

Table: 1 Collection of Samples of Vegetable Seeds from with Sample Codes from Larkana Division

Sample Name	Sample Code	Larkana Division	
		Taluka	**District**
Okra-1	O-1	Village Abri	Qambar
Okra-2	O-2	Village Sharifani	Qambar
Okra-3	O-3	Beero Chandio	Larkana
Brinjal-1	B-1	Baharpur	Larkana
Brinjal-2	B-2	Village Abri	Qambar
Brinjal-3	B-3	GothMai Makool	Qambar
Cucumber-1	CU-1	Goth Meno	Kamabar
Cucumber-2	CU-2	Shah Jo Goth	Larkana
Cucumber-3	CU-3	Goth hasila	Larkana
IndianSquash-1	IS-1	Beero Chandio	Larkana
IndianSquash-2	IS-2	Shah jo Goth	Larkana
IndianSquash-3	IS-3	Village Sharifani	Qambar
Bitter Guard-1	BG-1	Farid Abad	Larkana
Bitter Guard -2	BG-2	Baharpur	Larkana
Bitter guard -3	BG-3	Goth Hasila	Larkana
Water-melon-1	WM-1	Goth Ranoti	Qambar
Water-melon-2	WM-2	Goth Datal Abro	Qambar
Water-melon-3	WM-3	Goth Dodo Sunhari	Larkana
Melon-1	M-1	Goth Dhamrah	Larkana
Melon-2	M-2	Baqa pur	Larkana
Melon-3	M-3	Areja	Larkana
Papaya-1	P-1	Goth Datal Abro	Qambar
Papaya-2	P-2	Wada Mahar	Larkana
Papaya-3	P-3	Hamza Jatoi Goth	Larkana
Strawbery-1	SB-1	Baqa Pur	Larkana
Strawbery-2	SB-2	Areja	Larkana
Strawbery-3	SB-3	Goth Hasila	Qambar
Sesame Seed-1	SS-1	Damrah	Larkana
Sesame Seed-2	SS-2	Goth Ranoti	Qambar
Sesame Seed-3	SS-3	Goth Datal abro	Qambar

Preparation of Seed Samples by Acid Digestion Method

After collection, the seed samples are cleaned to remove any soil, dust, or other foreign materials. This is usually carried out by washing them first with tap water and then with doubled distilled water (DDW). The excess moisture of cleaned seed samples may be removed by air – drying. Subsequently, an oven is used to dry samples at the temperature range of 60 – 80 °C. The dried samples are then ground into fine powder and then sieved ensure homogeneous size of particles. From powdered samples, 0.5 g was accurately weighed and placed into high – pressure, closed microwave digestion vessel. Conc. Nitric acid (HNO_3) and hydrogen peroxide (H_2O_2) mixture was added to the vessel. Contents of sealed vessel were hated in a programmable microwave digestion system to the temperature range of 180 – 200 °C for 30 minutes. Samples were quickly digested due to the high temperature and high pressure environment while avoiding the loss of volatile heavy metals. After completion of digestion, vessels were cooled and samples were transferred to volumetric flasks. To prevent clogging the ICP-OES instrument due to remaining solid particles, samples were filtered. The clear solution is then diluted with high-purity de-ionized water to a precise final volume. Before the final analysis, analytical blanks and certified reference materials (CRMs) are run to ensure the accuracy and quality of the entire process. The prepared samples of different seeds were then organized for elemental analysis by the ICP-OES (Alhagri, and Albeshry, 2023).

Phenol-Sulphuric AcidMethod for Analysis of Carbohydrates

The total carbohydrate level in plant seeds was determined by the phenol-sulfuric acid method. The process started with extracting soluble sugars by boiling the samples with weak acid to change the polysaccharides into monosaccharides. A phenol solution and a small quantity of extracted sample were then mixed. Then, sulfuric acid was readily added. Sugars were dehydrated by sulfuric acid, changing them into compounds such as furfural or hydroxyl-methylfurfural. The stable orange-yellow color was then created by reacting of these derivatives with the phenol. Color intensity and carbohydrate quantity present in the sample possess direct relation. The UV-Visible spectrophotometer was used to measure the carbohydrate content a wavelength of 490 nm. The carbohydrate concentration was then calculated using standard calibration curve, created with glucose solution of known strength (BM, 2022).

Kjeldahl Method for Protein Analysis

An accurately weighed and finely ground seed sample (2g) was mixed with Conc. H_2SO_4 and a catalyst like copper sulfate. To break down all organic matter, the mixture was heated to high temperature. At this step, ammonium sulfate {$(NH_4)_2SO_4$} was produced from nitrogen present in the organic compounds. After the mixture cools, a strong base, typically sodium hydroxide (NaOH) is added to make the solution alkaline. This addition converts the ammonium sulfate into ammonia gas (NH_3). The ammonia gas is then distilled and collected in a trapping solution, usually boric acid (H_3BO_3) (Goyal, et al., 2022).

The amount of ammonia collected in the boric acid solution is measured by titration with a standardized acid. The volume of acid used in the titration is directly proportional to the amount of nitrogen in the original sample. Finally, the calculated nitrogen content is converted into crude protein content by multiplying it by a specific conversion factor. The most common factor is 6.25, although more precise factors may be used depending on the type of seed (Goyal, et al., 2022).

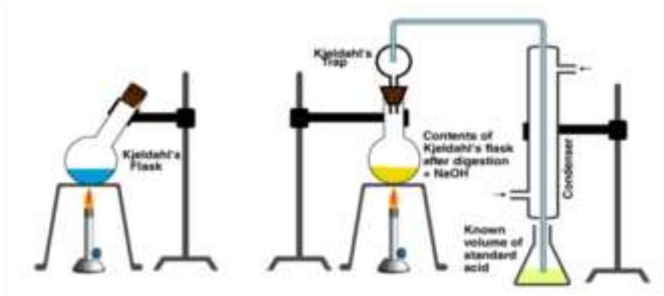

Figure: 2. Kjeldahl Method to Analyze the Concentration of Protein from Vegetable/Fruit Seeds

Method for Flavonoids Analysis

First, seeds are cleaned, dried, and ground into a fine powder to increase their surface area. The powdered sample is then soaked in a polar solvent, such as methanol, ethanol, or their aqueous mixtures. To remove any solid particles, the crude extract was filtered. A portion of the filtered extract of sample was mixed with aluminum chloride ($AlCl_3$) solution. Stable colored complex was produced by reacting $AlCl_3$ with hydroxyl group of the flavonoid molecule. Finally, the intensity of colored complex was determined using UV-Vis spectrophotometer at wavelength of 510 nm. The concentration of flavonoid was measured from calibration graph of rutin (Shraim, et al., 2021).

Method for Vitamin C Analysis

The iodine titration method was used to determine concentration of Vitamin – C from samples. A sample containing Vitamin C, such as a crushed tablet or a seed extract, is prepared and mixed with a starch indicator. A standardized iodine solution is then slowly added to the sample. As the iodine is added, it immediately oxidizes the Vitamin C to dehydroascorbic acid. In this reaction, the iodine is reduced to colorless iodide ions, so no color change is visible as long as Vitamin C is present. When all of the Vitamin C has been used up, any additional drop of iodine will not react. The starch indicator was used to react with this excess, producing a distinct blue – black complex. The end point of the titration was signaled by the emergence of this color. The volume of iodine solution utilized to achieve the end point was recorded. Using the known concentration of standardized iodine solution as well as volume utilized, the moles of reacted iodine were recorded. Since the reaction had 1:1 molar ratio of Vitamin C and iodine, the moles of vitamin-C in the original sample were measured. The concentration of vitamin C present in the sample was found by converting this value (Nielsen, 2024).

Quality Check

To ensure the reliability of the results quality control and quality assurance measures were applied throughout the entire analysis. Analytical grade chemicals and reagents were used throughout the analytical procedure. Double – distilled water was completely used for all sample processing and dilution including preparation of samples and reagents. For each metal under analysis, calibration curve was created to assure the accurate results. To confirm the contaminants, blanks were also frequently analyzed. Furthermore, equipment was regularly washed with double – distilled water during analysis to prevent cross contamination. The ICP-OES instrument exhibited outstanding sensitivity to determine the level of heavy metals, as displayed by the fact that instrumental detection limit (IDL) was lower than method detection limit (MDL) as well as method quantification limit (MQL). This status of detection limit confirms the instrument's ability to precisely detect as well as quantify even trace level of metals.

Results& Discussion

Sodium (Na)

There is an extensive disparity in Na contents among various seed varieties. The average level for these samples ranged from 1.21 mg/kg to 246.22 mg/kg in Indian squash and okra respectively. This shows that okra absorbed considerably higher Na content compared to all other samples. However, bitter gourd, watermelon, and papaya also have higher Na contents of 46.88 mg/kg, 41.92 mg/kg, and 37.46 mg/kg, respectively. Very little Na content of 1.95 mg/kg, 2.06 mg/kg, and 2.68 mg/kg was observed in seed samples of sesame, cucumber and strawberry respectively. In general, it is evident from the results that some samples absorb minimal Na, while others, particularly, okra absorb notably high level (Table: 2).

As reported sodium (Na) levels were highest in cucumber seeds at 16,300 mg/kg (Murthy, et al., 2022). It was also found in high amounts in okra seeds at 8,570 mg/kg (Umar, et al., 2025) and watermelon seeds at 700 mg/kg (Tabiri, et al., 2016). In contrast, very low levels were reported for Indian squash (3.10 mg/kg) by Shahid, et al. (2024) and melon (0.021 mg/kg) by Jacob, et al. (2015) (Table: 5a, Figure: 3).

Potassium (K)

There is a wide range in the average potassium content among the various samples of vegetable and fruit seeds. The highest average potassium levels were found in Papaya, at approximately 150.84 mg, and Watermelon, at 127.63 mg/kg. On the other hand, the samples with the lowest average potassium content were Sesame Seed, at 18.15 mg/kg, and Bitter Guard, at 22.29 mg/kg. Other samples, such as Brinjal, Indian Squash, and Cucumber, fall in the middle range with average potassium levels between 39 mg/kg and 53 mg/kg. Okra, Strawberry, and Melon also had relatively low average potassium concentrations (Table: 2 & Figure: 3).

According to reports, potassium (K) was most abundant in watermelon seeds at 35,700 mg/kg (Tabiri, et al., 2016) and cucumber seeds at 14,200 mg/kg (Murthy, et al., 2022). Okra seeds contained a moderate amount of 330.0 mg/kg (Umar, et al., 2025), while brinjal seeds had 231.83 mg/kg (Arivalagan, et al., 2013). The lowest reported values were for melon seeds at 0.494 mg/kg (Jacob, et al., 2015) and Indian squash seeds at 77.80 mg/kg (Shahid, et al., 2024) (Table: 5a).

Magnesium (Mg)

Table: 2 shows significant variation in the magnesium content across the different samples. The highest average magnesium levels were found in Bitter Guard, which had an average of 340.37 mg/kg, and Okra, with an average of 270.71 mg/kg while, the lowest average Mg content was observed in Strawberry at 23.77 mg/kg, followed closely by Cucumber and Sesame Seed, with average values of 24.56 mg/kg and 26.28 mg/kg, respectively. Other samples like Papaya, Melon, and Watermelon fall in the middle range, with average magnesium levels ranging from approximately 131 to 160 mg/kg. These results demonstrate that Bitter Guard and Okra are particularly rich in magnesium, while the other samples contain considerably less amount (Figure: 3).

Published reports show that magnesium (Mg) levels were exceptionally high in cucumber seeds at 12,000 mg/kg (Murthy, et al., 2022) and watermelon seeds at 1,500 mg/kg (Tabiri, et al., 2016). Lower amounts were reported for okra (201.17 mg/kg) by Umar, et al. (2025), bitter gourd (44.62 mg/kg) by Hussain, et al. (2024), and brinjal (12.73 mg/kg) by Arivalagan, et al. (2013). The lowest values were in strawberry (0.49 mg/kg) by Mary et al. (2025) (Table: 5a).

Calcium (Ca)

Depending upon analyzed data, there is a wide variation in the Ca content across the different samples of vegetable/fruit seeds. The highest average calcium levels were observed in Bitter Guard, with an average of 628.03 mg/kg, and Papaya, at 470.55 mg/kg. Watermelon also has a high average calcium content of 356.45 mg/kg. In contrast, the least quantity of Ca 24.18 mg/kg, 25.57 mg/kg and 26.07 mg/kg was found in seed samples of strawberry, sesame, and Indian squash respectively. The middle Ca level was found in seed samples of Okra, Brinjal, and Melon. These results show that papaya and bitter gourd are predominantly good sources of Ca, whereas others possess significantly less Ca level (Figure: 3).

Literature displays that Ca was found in very high concentrations in cucumber seeds at 12,000 mg/kg (Murthy, et al., 2022) and watermelon seeds at 1,600 mg/kg (Tabiri, et al., 2016). Okra seeds also contained a notable amount at 191.77 mg/kg (Umar, et al., 2025). In contrast, the lowest values were observed in melon seeds (0.010 mg/kg) by Jacob, et al. (2015) and Indian squash seeds (0.20 mg/kg) by Shahid, et al. (2024) (Table: 5a).

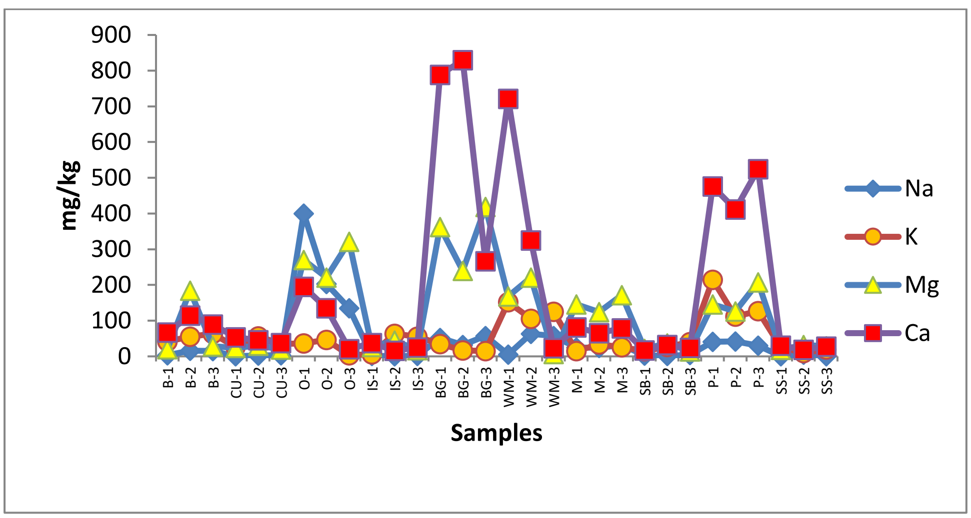

Figure: 3 Level of Macro Elements (Mg/Kg) Present in Various Samples of Vegetable/Fruit Seeds

Aluminum (Al)

Table: 2 shows a wide range in the average aluminum content across the various samples. The highest average aluminum levels were found in Bitter Guard, at approximately 31.15 mg/kg, and Papaya, at 22.26

mg/kg. On the other hand, the samples with the lowest average aluminum content were Watermelon (0.77 mg/kg), Cucumber (1.19 mg/kg), and Strawberry (1.44 mg/kg). Other samples like Melon, Indian Squash, Okra, Brinjal, and Sesame Seed had average aluminum levels ranging from approximately 2.77 to 6.94 mg/kg. it is evident from the results that papaya and bitter gourd are rich in Al content, whereas other samples have considerably less level (Beshaw, et al., 2022), (Table: 2, Figure: 4a), (Table: 5b).

Iron (Fe)

The analyzed results show the extensive range in the average Fe level through various seed samples. The maximum average Fe contents of 3.85 mg/kg and 2.96 mg/kg were found in melon and cucumber respectively. High average Fe content was also determined in brinjal and watermelon with concentration of 2.65 mg/kg and 2.48 mg/kg, respectively. On the contrary, seed samples having lowest Fe content were okra (0.62 mg/kg), bitter gourd (0.63 mg/kg), and sesame (0.72 mg/kg). These results show that seed sample with high Fe content are; melon, cucumber, brinjal, and watermelon (Table: 2, Figure: 4a).

The reported results of Fe show that highest content was found in watermelon seeds at 120.00 mg/kg (Elbagory, et al., 2025). The Cucumber (102 mg/kg) by Murthy, et al. (2022), and papaya (67.73 mg/kg) by Vinha, et al. (2024) also displayed high levels of Fe. Lower levels of Fe were reported in bitter gourd (2.55 mg/kg) by Hussain, et al. (2024), okra (2.4 mg/kg) by Panhwar, et al. (2022) and Indian squash (1.239 mg/kg) by Mishra, and Das (2015). The strawberry seeds declared the lowest level of 0.015 mg/kg as reported by Mary et al., (2025) (Table: 5b).

Tin (Sn)

An analysis of the data reveals a significant extension in the Sn concentrations across the samples. The highest average Sn levels were found in Bitter Gourd and Melon, measuring approximately 86.01 mg/kg and 73.01 mg/kg, respectively. In contrast, Cucumber contained the lowest average Sn content, with a value of just 4.62 mg/kg, followed by Strawberry at 11.29 mg/kg. Papaya, Indian Squash, and Watermelon also contained notable amounts of Sn, with averages ranging from around 31 mg/kg to 53 mg/kg. The overall findings suggest a substantial difference in Sn accumulation among these various seed varieties (Table: 2, Figure: 4a).Tin was only reported for cucumber (0.115 mg/kg) and papaya (0.229 mg/kg), according to Okonwu, and Muonekwu (2019) and Vinha, et al. (2024), respectively (Table: 5b).

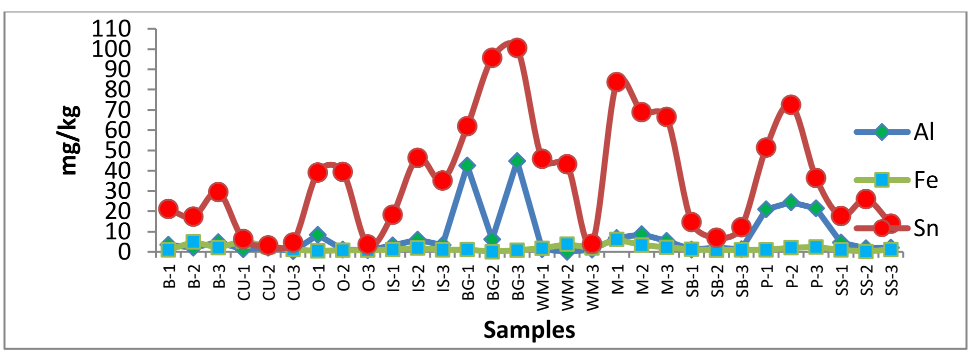

Figure: 4a Level of Heavy Metals (Mg/Kg) Present in Various Samples of Vegetable/Fruit Seeds

Zinc (Zn)

Based on the data you provided, there is a wide range in the average zinc content across the various samples. The highest average zinc levels were found in Bitter Guard, at approximately 4.43 mg/kg, followed by Okra, with an average of 2.32 mg/kg, and Melon, at 2.10 mg/kg. On the other end of the spectrum, the samples with the lowest average zinc content were Sesame Seed (0.13 mg/kg), Cucumber (0.19 mg/kg), and Papaya (0.25 mg/kg). These results indicate that Bitter Guard is a particularly rich source of zinc, while the other samples contain considerably less (Table: 2, Figure: 4b).

Zinc (Zn) levels varied significantly as reported in the literature. The highest concentration was in cucumber seeds at 66 mg/kg (Murthy, et al., 2022) and papaya seeds at 28.56 mg/kg (Vinha, et al., 2024). Lower levels were seen in okra (2.7 mg/kg) by Panhwar, et al. (2022) and bitter gourd (4.21 mg/kg) by Hussain, et al. (2024). The lowest values were in brinjal seeds at 0.158 mg/kg (Arivalagan, et al., 2013) and Indian squash seeds at 0.085 mg/kg (Mishra, and Das, 2015) (Table: 5b).

Manganese (Mn)

Based on the analyzed data (Table: 2), there is a wide range in the average Mn content across the various samples. The highest average Mn levels were found in Melon, at approximately 1.72 mg/kg, and Bitter Gourd, with an average of 1.43 mg/kg. Papaya and Watermelon also have high average Mn content at 1.21 mg/kg and 1.05 mg/kg, respectively. On the contrary, the samples with the lowest average Mn content were Sesame Seed (0.08 mg/kg), Strawberry (0.18 mg/kg), and Brinjal (0.24 mg/kg). These results indicate that Melon, Bitter Guard, Papaya, and Watermelon are particularly high in manganese content, while the other samples contain considerably less content (Table: 2, Figure: 4b).

Manganese (Mn) was highest in papaya seeds at 72.0 mg/kg (Vinha, et al., 2024), followed by watermelon seeds (15.80 mg/kg) and melon seeds (15.00 mg/kg) by Elbagory, et al. (2025) as reported. The lowest levels were reported for brinjal seeds at 0.0009 mg/kg (Bushra, et al., 2022), and low values were also seen in Indian squash seeds (0.455 mg/kg) by Mishra, and Das (2015) (Table: 5b).

Selenium

An examination of the results given in Table: 2 reveal a noticeable spread in the selenium (Se) content among the various samples. Strawberry and Indian Squash stand out as having the highest average concentrations, measuring approximately 0.237 mg/kg and 0.192 mg/kg, respectively. In contrast, the lowest average Se levels were observed in Watermelon at just 0.022 mg/kg, followed by Papaya at 0.044 mg/kg. The remaining samples, including Melon, Bitter Guard, Okra, Sesame Seed, Brinjal, and Cucumber, contained moderate amounts of Se, between 0.049 mg/kg and 0.151 mg/kg. These findings suggest that while most samples have relatively low Se content, Strawberry and Indian Squash are notably richer in Se content (Table: 2, Figure: 4b).

Reported results show that data for selenium is minute in mentioned seeds. It was detected in papaya seeds at 0.302 mg/kg (Vinha, et al., 2024), cucumber at 0.039 mg/kg (Okonwu, and Muonekwu, 2019), and melon at 0.0122 mg/kg (Enujiugha, et al., 2023). It was not reported for the other seeds (Table: 5b).

Chromium (Cr)

An examination of the provided data reveals a significant difference in Cr concentrations across the analyzed samples. The samples with the highest average levels of this element were Bitter Gourd and Okra, with concentrations of 0.19 mg/kg and 0.1017 mg/kg, respectively. This stands in stark contrast to Cucumber, which had the lowest average chromium content at just 0.005 mg/kg. While Bitter Gourd and Okra were notably high in chromium, other samples like Papaya, Melon, Brinjal, and Watermelon contained more moderate amounts, ranging from 0.038 mg/kg to 0.056 mg/kg. These results clearly indicate that Bitter Gourd and Okra are considerably richer in chromium compared to the other samples studied (Table: 2, Figure: 4b).

The reported chromium (Cr) content in the various seeds shows a highly inconsistent distribution, with one sample having an exceptionally high value while all others contain very low or undetectable levels. Chromium levels varied considerably. Papaya seeds had an extremely high concentration of 203.5 mg/kg (Vinha, et al., 2024). Other notable levels were in watermelon (1.10 mg/kg) and melon (1.00 mg/kg), both reported by Elbagory, et al. (2025), and Indian squash at 0.8 mg/kg (Yaqub, et al., 2021). The lowest reported value was for brinjal seeds, at less than 0.010 mg/kg (Bushra, et al., 2022) (Table: 5b, Figure: 4).

Nickel (Ni)

A review of the nickel data shows a wide range of concentrations across the samples. The highest average levels were found in Bitter Gourd, at approximately 0.1617 mg/kg, which is significantly higher than all other samples. Melon, with an average of 0.064 mg/kg, and Okra, at 0.0389 mg/kg, also had relatively high concentrations. In contrast, Cucumber and Sesame Seed had the lowest average Ni content, both at around 0.0048 mg/kg. Overall, the findings indicate that nickel levels vary greatly, with Bitter Gourd being a standout due to its high concentration (Table: 2, Figure: 4b).

The reported nickel content across the various seeds is quite inconsistent, with data available for only a limited number of the samples. Among those with reported values, there is a significant range in concentration. Nickel concentrations were highest in Indian squash seeds, at 4.1 mg/kg (Yaqub, et al., 2021), followed by cucumber at 0.456 mg/kg (Okonwu, and Muonekwu, 2019) and papaya at 0.575 mg/kg (Vinha, et al., 2024). Bitter gourd had 1.98 mg/kg (Yap, et al., 2019). The lowest levels were in brinjal (0.00021 mg/kg) by Bushra, et al. (2022) and strawberry (0.074 mg/kg) by Bednarek, et al. (2006) (Table: 5b).

Lead (Pb)

An evaluation of the supplied data reveals a wide disparity in the lead (Pb) concentrations across the samples. Pb was not detected in any of the samples of Watermelon, Melon, or Papaya. For the samples where Pb was present, the highest average level was observed in Bitter Gourd, at approximately 0.0283 mg/kg. The samples with the lowest average lead content were Sesame Seed and Strawberry, with mean values of 0.0013 mg/kg and 0.0023 mg/kg, respectively. These findings indicate that while many samples contained lead, its concentration was highest in Bitter Gourd and undetectable in a significant portion of the samples. The reported Pb content in the various seeds shows a clear division between a single sample with a high concentration and the rest of the samples with much lower levels (Table: 2).

Lead is a heavy metal that can be toxic. Its levels were highest in bitter gourd seeds at 1.46 mg/kg (Yap, et al., 2019). Other seeds had much lower levels, with okra at 0.10 mg/kg (Omokaro, et al., 2023), watermelon at 0.11 mg/kg (Elbagory, et al., 2025), and cucumber at 0.055 mg/kg (Okonwu, and Muonekwu, 2019). The lowest values were in brinjal (0.00073 mg/kg) and sesame seed (0.0161 mg/kg) by Bushra, et al. (2022) and Eghbaljoo, et al. (2022), respectively. The wide variability in the data, particularly the high value for bitter gourd, could indicate differences in soil contamination or the plant's ability to absorb and accumulate Pb (Table: 5b, Figure: 4b).

Arsenic (As)

A review of the analyzed arsenic data shows significant gaps. No data was available for Watermelon, Melon, Strawberry, Papaya, or Sesame Seed, making it impossible to evaluate the arsenic levels for these samples. For the samples where data was provided, the highest average arsenic content was found in Indian Squash at 0.0633 mg/kg. Bitter Gourd and Brinjal also contained notable levels, averaging 0.0253 mg/kg and 0.0203 mg/kg, respectively. The remaining samples, Okra and Cucumber, showed lower concentrations, with both averaging below 0.009 mg/kg. These findings suggest that arsenic levels are highly variable across the different sample types for which we have information (Table: 2, Figure: 4b).

Arsenic is another toxic element. The reported arsenic (As) content (Table: 5b) in the various seeds shows a significant disparity, with one sample having an extremely high value while the others contain only trace amounts. The highest concentration was reported in papaya seeds at 22.8 mg/kg (Vinha, et al., 2024). Other reported values were low, including cucumber (0.021 mg/kg) by Okonwu, and Muonekwu (2019), watermelon (0.08 mg/kg) and melon (0.08 mg/kg) by Elbagory, et al. (2025). The lowest reported value was for strawberry at 0.0011 mg/kg (Bednarek, et al., 2006) (Table: 5b).

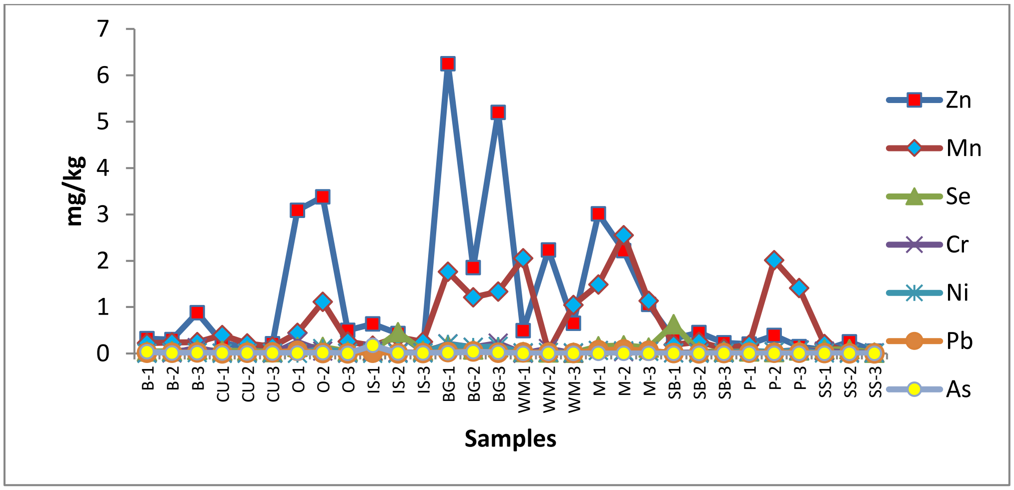

Figure: 4b Level of Heavy Metals (Mg/Kg) Present in Various Samples of Vegetable/Fruit Seeds

Table: 2 Concentration (mg/kg) of metals in different seeds cultivated in the region of Larkana Division

Code	Na	K	Mg	Ca	Al	Zn	Mn	Fe	Se	Sn	Cr	Ni	Pb	As
B-1	3.51	41.45	19.98	66.80	3.54	0.32	0.225	1.013	0.042	21.12	0.007	0.0033	0.019	0.039
B-2	15.60	55.67	184.57	114.25	2.07	0.30	0.238	4.908	0.05	17.28	0.007	0.0205	0.014	0.009
B-3	14.79	63.26	28.82	88.88	4.68	0.88	0.242	2.029	0.076	29.52	0.126	0.0143	0.026	0.013
CU-1	0.38	26.96	23.81	53.34	1.25	0.24	0.394	5.357	0.059	6.24	0.006	0.0019	0.004	0.008
CU-2	2.30	56.48	30.37	45.19	2.04	0.11	0.219	2.446	0.06	3.12	0.007	0.0051	0.015	0.009
CU-3	3.50	34.59	19.49	37.15	0.29	0.21	0.149	1.064	0.027	4.50	0.002	0.0073	0.023	0.007
O-1	400.31	36.56	270.35	194.87	8.43	3.09	0.443	0.422	0.143	39.13	0.250	0.0043	0.060	0.008
O-2	203.13	46.41	221.10	134.79	1.15	3.38	1.112	0.715	0.141	39.36	0.050	0.1036	0.007	0.017
O-3	135.23	3.43	320.69	19.94	0.78	0.50	0.261	0.725	0.042	3.59	0.005	0.0088	0.003	0.001
IS-1	1.55	5.87	26.52	37.21	3.15	0.64	0.171	1.041	0.06	18.34	0.054	0.0057	0.016	0.172
IS-2	0.53	63.12	44.44	15.85	6.04	0.43	0.357	1.884	0.460	46.41	0.023	0.0031	0.003	0.006
IS-3	1.56	55.65	17.27	25.16	3.27	0.05	0.252	0.946	0.057	35.20	0.013	0.0099	0.011	0.012
BG-1	51.34	34.90	362.57	788.50	42.60	6.25	1.760	1.043	0.173	61.89	0.211	0.199	0.028	0.017
BG-2	32.07	17.16	240.10	829.40	6.15	1.85	1.209	0.060	0.086	95.60	0.135	0.132	0.042	0.035
BG-3	57.23	14.82	418.43	266.20	44.70	5.20	1.335	0.799	0.135	100.54	0.224	0.154	0.015	0.024
WM-1	4.98	151.63	167.84	721.72	1.27	0.49	2.050	1.713	0.031	45.82	0.005	0.016	0.021	ND
WM-2	63.40	105.77	221.20	324.44	0.01	2.23	0.046	3.808	0.023	43.24	0.104	0.025	0.013	ND
WM-3	57.37	125.50	6.69	23.18	1.03	0.65	1.045	1.929	0.013	3.87	0.005	0.017	0.012	ND
M-1	24.49	15.17	145.31	81.04	6.76	3.01	1.486	6.157	0.152	83.63	0.064	0.062	0.071	ND
M-2	24.23	34.12	123.82	65.47	8.75	2.22	2.550	3.236	0.175	68.93	0.034	0.059	0.087	ND
M-3	31.91	25.47	171.86	78.38	5.31	1.06	1.135	2.164	0.127	66.48	0.048	0.047	0.058	ND
SB-1	2.53	14.83	21.49	16.52	1.05	0.32	0.189	1.222	0.633	14.73	0.018	0.006	0.009	0.002
SB-2	1.33	26.48	36.01	32.32	2.02	0.45	0.249	0.715	0.044	6.98	0.020	0.004	0.003	0.003
SB-3	4.18	40.34	13.82	23.71	1.24	0.23	0.104	1.025	0.035	12.15	0.011	0.010	0.008	0.002
P-1	40.75	214.49	145.81	475.80	20.91	0.20	0.189	0.905	0.045	51.33	0.054	0.053	0.014	ND
P-2	41.63	111.23	126.14	411.33	24.40	0.39	2.014	2.084	0.027	72.45	0.034	0.040	0.014	ND
P-3	30.01	126.80	207.04	524.53	21.47	0.15	1.412	2.294	0.061	36.47	0.079	0.066	0.019	ND
SS-1	0.61	26.13	18.80	30.59	4.59	0.08	0.205	0.943	0.084	17.72	0.054	0.006	0.006	0.002
SS-2	4.87	9.17	31.54	18.52	1.67	0.25	0.025	0.140	0.092	25.93	0.023	0.004	0.002	0.001
SS-3	0.38	19.15	28.49	27.60	2.06	0.05	0.014	1.079	0.017	13.93	0.013	0.009	0.002	0.001

Vitamin C

An analysis of the vitamin C content in the provided seed samples shows a clear distinction between several varieties. The highest average vitamin C concentrations were found in Strawberry Seed and Okra Seed, which had mean values of 21.45 mg/100g and 19.36 mg/100g, respectively. On the other end of the scale, Melon Seed had the lowest average content at just 2.12 mg/100g, making it the least rich source of vitamin C among the samples. Other seeds like those from Brinjal, Papaya, Sesame Seed, and Indian Squash showed moderate levels, typically ranging from about 10 mg/100g to 17 mg/100g. This data demonstrates a considerable variation in the vitamin C content depending on the type of seed (Table: 3, Figure: 5).

Reported levels of Vitamin C were found highest in papaya seeds, at a remarkable 726 mg/100g (Ali, and Serce, 2022). Other seeds with high reported vitamin C content were cucumber (143.360 mg/100g) by Šic

Žlabur, et al. (2021) and sesame seed (175 mg/100g) by Wada, et al. (2021). The lowest amount was found in brinjal at 6.83 mg/100g (Omoniyi, and Alli, 2021) (Table: 6).

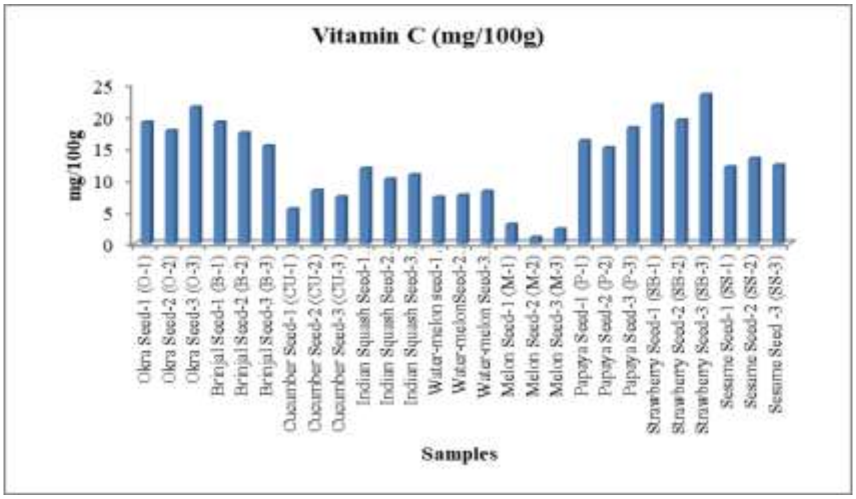

Figure: 5 Vitamin-C Content Present in Various Samples of Vegetable/Fruit Seeds

Carbohydrates

A careful examination of the carbohydrates data reveals that the highest concentrations were found in Sesame Seed and Cucumber Seed, with average values of 0.368 mg/100g and 0.365 mg/100g, respectively. On the other hand, the seeds of Melon had the lowest carbohydrate content, averaging just 0.154 mg/100g. The remaining samples, including Okra, Brinjal, and Papaya seeds, contained moderate levels of carbohydrates, typically ranging between 0.186 mg/100g and 0.222 mg/100g. Notably, the data for Water-melon seed was provided with slight variations in spelling, but the content remained low, with an overall average of approximately 0.159 mg/100g. This analysis shows a clear divide between the high-carbohydrate samples and the lower-concentration varieties (Table: 3, Figure: 6).

Reported contents of carbohydrates were most abundant in cucumber seeds at 23,870 mg/100g (Li, et al., 2021) and okra seeds at 8,261 mg/100g (Rodriguez-Jimenez, et al., 2018). Sesame seed also had a high concentration of 18,110 mg/100g (Srivastava, et al., 2023). Indian squash seeds had the lowest carbohydrate content at just 3.66 mg/100g (Ashiq Hussain, et al., 2014) (Table: 6).

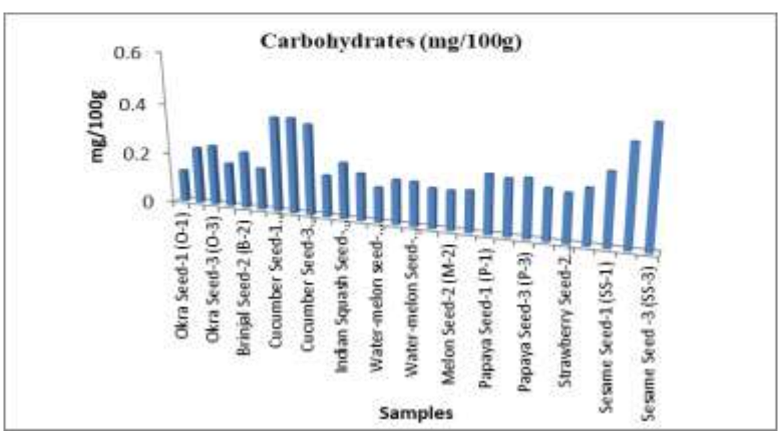

Figure: 6 Carbohydrate Content Present in Various Samples of Vegetable/Fruit Seeds

Flavoinoids

Based on the provided data, the average flavonoid content varies significantly among the different seed samples. Okra Seed shows the highest average concentration at 20.53 mg/100g. Other samples with a high concentration include Indian Squash Seed and Water-melon Seed, which had an average of 17.51 mg/100g and 13.70 mg/100g respectively. In contrast, the lowest average flavonoid content was found in Brinjal Seed, at 12.60 mg/100g, and Cucumber Seed, at 12.27 mg/100g. The analysis indicates that while most samples have a moderate flavonoid level, Okra Seed is a particularly rich source of this compound (Table: 3, Figure: 7).

Flavonoids, known for their antioxidant properties, were reported in massive quantities in cucumber seeds at 90,830 mg/100g (Olennikov, and Kashchenko, 2023). Okra seeds also reported high concentration of 3,680 mg/100g (Jiang, et al., 2025). Brinjal seeds contained 2,840 mg/100g (Murthy, et al., 2022), while the lowest amount was found in Indian squash at 136.9 mg/100g (Suranto, et al., 2023) (Table: 6).

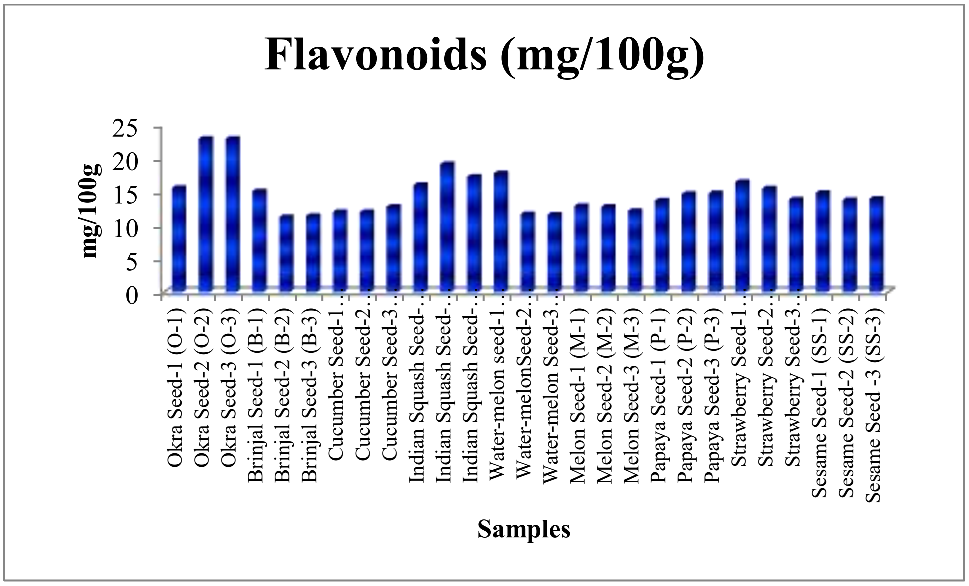

Figure: 7 Flavonoid Content (Mg/100g) Present in Various Samples of Vegetable/Fruit Seeds

Protein

Upon examining the data, a wide range of protein content is evident across the different seed types. Sesame Seeds stand out as the most protein-rich sample by a significant margin, with a maximum of 14300 mg/100g. Other high-protein samples include Papaya Seed (13,100 mg/100g) and Sesame Seed (12,100 mg/100g). Conversely, the lowest average protein levels were found in Okra Seed at 7,767 mg/100g and Strawberry Seed at 8,433 mg/100g. The remaining samples, such as Cucumber, Melon, and Indian Squash, had moderate protein levels, clustering between 9,400 and 11,433 mg/100g. Overall, the findings show a clear hierarchy of protein concentration, with sesame Seeds being a particularly potent source (Table: 3, Figure: 8).

Protein content reported was highest in watermelon seeds (25,600 mg/100g) by Khalid, et al. (2021) and melon seeds (25,000 mg/100g) by Matsuane, et al. (2023). Cucumber seeds also had a significant amount at 21,040 mg/100g (Li, et al., 2021). The lowest protein levels were reported for papaya seeds at 520 mg/100g (Rahman, et al., 2021) (Table: 6).

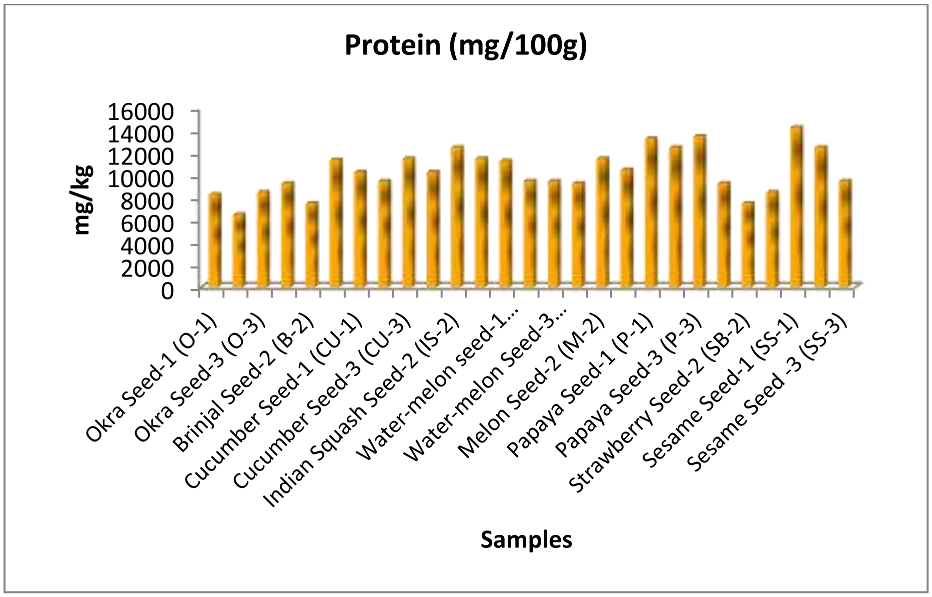

Figure: 8 Protein Content (Mg/100g) Present in Various Samples of Vegetable/Fruit Seeds

Table: 3. Concentration of Vitamin C, Carbohydrates and Flavoinoids in various seeds grown in Larkana Region

Samples Names	Vitamin C (mg/100g)	Carbohydrates (mg/100g)	Flavonoids (mg/100g)	Protein (mg/100g)
Okra Seed-1 (O-1)	19.02	0.126	15.62	8300
Okra Seed-2 (O-2)	17.69	0.224	22.98	6500
Okra Seed-3 (O-3)	21.36	0.237	22.98	8500
Brinjal Seed-1 (B-1)	19.02	0.172	15.11	9300
Brinjal Seed-2 (B-2)	17.35	0.222	11.25	7500
Brinjal Seed-3 (B-3)	15.32	0.164	11.43	11400
Cucumber Seed-1 (CU-1)	5.45	0.37	12.01	10300
Cucumber Seed-2 (CU-2)	8.35	0.372	12.01	9500
Cucumber Seed-3 (CU-3)	7.35	0.353	12.79	11500
Indian Squash Seed-1 (IS-1)	11.79	0.162	16.07	10300
Indian Squash Seed-2 (IS-2)	10.12	0.217	19.18	12500
Indian Squash Seed-3 (IS-3)	10.79	0.182	17.29	11500
Water-melon seed-1 (WM-1)	7.28	0.135	17.79	11300
Water-melonSeed-2 (WM-2)	7.62	0.171	11.69	9500
Water-melon Seed-3 (WM-3)	8.22	0.17	11.61	9500
Melon Seed-1 (M-1)	3.04	0.153	12.916	9300
Melon Seed-2 (M-2)	1.02	0.151	12.807	11500
Melon Seed-3 (M-3)	2.3	0.158	12.162	10500
Papaya Seed-1 (P-1)	16.11	0.225	13.716	13300
Papaya Seed-2 (P-2)	15.02	0.216	14.725	12500
Papaya Seed-3 (P-3)	18.15	0.224	14.825	13500
Strawberry Seed-1 (SB-1)	21.68	0.194	16.525	9300
Strawberry Seed-2 (SB-2)	19.35	0.184	15.525	7500
Strawberry Seed-3 (SB-3)	23.32	0.209	13.889	8500
Sesame Seed-1 (SS-1)	12.02	0.273	14.889	14300
Sesame Seed-2 (SS-2)	13.35	0.38	13.798	12500
Sesame Seed -3 (SS-3)	12.32	0.45	13.98	9500

Statistical Analysis

Based on the provided data, all the listed pairs of variables show a strong positive correlation, as indicated by a correlation coefficient greater than 0.45. A positive correlation means that as the concentration of one metal increases in a sample, the concentration of the other metal in the pair also tends to increase. The strength of this relationship varies, with the strongest correlation observed between Zn and Ni (r=0.8207), and the weakest among the listed pairs being between Ca and Cr (r=0.4693). All of the correlations are statistically significant at both the 0.05 and 0.01 levels, because their p-values are all much less than 0.01. This low p-value indicates that the observed correlations are highly unlikely to be due to random chance, providing strong evidence of a genuine relationship between the concentrations of these metal pairs. The p-value for the Zn-Ni pair, for example, is 2.79×10^{-8}, which is extremely low, underscoring the high statistical significance of their correlation.

The positive correlation between certain metals can be attributed to several factors. First, they might share common geochemical or environmental sources. For example, if the soil or water in a particular area is rich in multiple minerals, plants growing there will likely absorb all of them in parallel. Second, some metals may be absorbed and transported within the plant through the same physiological pathways or transporters. For instance, plants often have non-specific transporters that can take up multiple metal ions that have similar ionic charges or sizes, leading to their co-accumulation. Lastly, these positive correlations could also be a result of human activities. For instance, some fertilizers or pesticides contain multiple trace elements, or industrial pollutants might introduce a mixture of heavy metals into the environment, leading to their simultaneous accumulation in food sources.

Table: 4.Correlation Coefficient of Metals in Seeds of Vegetables Which Are only Positively Correlated with each other Significant at 0.05 and Significant at 0.01 Levels

Variable 1	Variable 2	Correlation Coefficient	P-value	Significant at 0.05	Significant at 0.01
Zn	Ni	0.8207	2.79×10^{-8}	Yes	Yes
Zn	Cr	0.7904	2.03×10^{-7}	Yes	Yes
Al	Ni	0.7620	9.95×10^{-7}	Yes	Yes
Mg	Zn	0.7513	1.72×10^{-6}	Yes	Yes
Mg	Ni	0.7301	4.67×10^{-6}	Yes	Yes
Sn	Ni	0.7053	1.35×10^{-5}	Yes	Yes
Mg	Cr	0.6876	2.69×10^{-5}	Yes	Yes
Ca	Ni	0.6531	9.15×10^{-5}	Yes	Yes
Al	Cr	0.6491	1.04×10^{-4}	Yes	Yes
Al	Zn	0.6481	1.08×10^{-4}	Yes	Yes
Mg	Al	0.6299	1.91×10^{-4}	Yes	Yes
Cr	Ni	0.6286	1.99×10^{-4}	Yes	Yes
Mn	Sn	0.6208	2.52×10^{-4}	Yes	Yes
Zn	Sn	0.6179	2.75×10^{-4}	Yes	Yes
Al	Sn	0.6084	3.61×10^{-4}	Yes	Yes
Mg	Sn	0.6012	4.42×10^{-4}	Yes	Yes
Sn	Pb	0.5837	7.09×10^{-4}	Yes	Yes
Mg	Ca	0.5834	7.15×10^{-4}	Yes	Yes
Mn	Ni	0.5757	8.72×10^{-4}	Yes	Yes
Ca	Sn	0.5658	1.12×10^{-3}	Yes	Yes
Sn	Cr	0.5644	1.16×10^{-3}	Yes	Yes
Mn	Pb	0.5599	1.29×10^{-3}	Yes	Yes
Na	Cr	0.5464	1.79×10^{-3}	Yes	Yes
Ca	Al	0.5391	2.11×10^{-3}	Yes	Yes
Ca	Mn	0.5130	3.74×10^{-3}	Yes	Yes
Na	Mg	0.5116	3.85×10^{-3}	Yes	Yes
Ca	Cr	0.4693	8.88×10^{-3}	Yes	Yes

Conclusions

This study successfully characterized the chemical profiles of seeds from ten key vegetable and fruit species grown in the Larkana region. The findings reveal that these seeds are not merely agricultural by-products but are significant reservoirs of essential macronutrients, micronutrients, and bioactive compounds. The analysis demonstrated substantial variation in nutritional value among the species. For instance, sesame seeds emerged as an exceptional source of protein, bitter gourd seeds were rich in calcium, magnesium, and zinc, and strawberry seeds contained the highest level of Vitamin C. The data generated provides a critical foundation for nutritional planning and underscores the potential of these seeds to contribute to food security and dietary diversity in the region. Furthermore, the identification of seeds with high concentrations of specific nutrients, like flavonoids in okra, points to potential commercial applications in the functional food and pharmaceutical industries. It is recommended that future research focus on agronomic practices to optimize the nutritional quality of these seeds and investigate their bioavailability. Ultimately, this work highlights the importance of utilizing local genetic resources and provides valuable insights for farmers, policymakers, and researchers aiming to enhance both the nutritional intake of the local population and the economic returns from agricultural produce.

Acknowledgements

Authors are thankful to the Institute of Chemistry, Shah Abdul Latif University Khairpur, as well as National Center of Excellence in Analytical Chemistry University of Sindh.

Conflict of Interest

Authors declare no conflict of interest

Funding (if any)

There was no any funding source

Author Contribution

Ms. Rubina Naz Mirani Collected Samples, Did experimental work, and prepared initial draft of the paper whereas, Prof. Dr. Ghulam Qadir Supervised the whole work.

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