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RESEARCH ARTICLE

An Assessment of Mineral Contents in Fruits

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ABSTRACT
Fruits are the important sources of minerals. The objective of this study is to determine the amount of ash, iron, calcium, magnesium and chloride in selected fruit samples: banana, grape, litchi, mango, papaya, pineapple, pomegranate and watermelon. A minimum value of ash content was 0.36 % for watermelon and maximum value was 1.705 for banana. The order of fruits with increasing percentage of iron is: watermelon (61.773002×10^{-5} %), and litchi, mango, grape, banana, pomegranate, papaya and pineapple ($101.488695 \times 10^{-5}$ %). A maximum amount of calcium (Ca) was found in the ash solution of fresh papaya (0.0375536%) and minimum amount of Ca was observed in banana (0.0037573%). The results showed that the mineral magnesium (Mg) was ranged from 0.0055316719% (for mango) to 0.031140771% (for papaya) with increasing order: mango, grapes, pineapple, water, pomegranate, litchi, banana and papaya. The experimentally recorded value of chloride as analyzed by argentometric titration using Mohr's method was observed in the order: grape (0.02127 %)< watermelon < papaya < mango <litchi < pineapple < banana < pomegranate (0.1790225 %). The observed results of this study showed that the mineral contents in ash solution of fruit samples are comparable to each other and with the reported values of various authors. The research outcomes will be beneficial for related researchers, fruit consumers and producers.
KEYWORDS: Fruits, ash, calcium, ethylenediaminetetraacetic acid, mineral content

INTRODUCTION
Fruits and vegetables are valuable sources of minerals (Leterme et al., 2006). These are the important sources of macronutrient minerals: calcium (Ca), potassium (K), magnesium (Mg), phosphorus (P) and nitrogen (N), as well as micronutrient minerals: manganese (Mn), copper (Cu), Iron (Fe), zinc (Zn), cobalt (Co), sodium (Na), chlorine (Cl), Iodine (I), fluorine (F), sulphur (S) and selenium (Se). Mineral contents in fruits provide nutrient requirements for animals, increasing the test and quality of fruits (Vicente, et al., 2014). Ash content of fruits represents the amount of all mineral in fruit sample. Iron is required for growth and development of body, oxygen transport and storage (through hemoglobin and myoglobin), deoxyribonucleic acid (DNA) synthesis,

increasing the immune system. Calcium is essential for bone and teeth formation and strengthening. It reduces Osteoporosis (low bone mineral density) and hypertension and increases bone mineral density. Mg is important for protein synthesis, release of energy from muscle storage, regulates body temperature and activates enzymes (Vicente et al., 2014). Chloride is an essential part of digestive juice and needed to keep the proper balance of body fluids. It helps to maintain proper pH, to stimulate stomach, nerve, and muscle cells, facilitates the flow of O_2 and CO_2 within the cell. Fruits and vegetables are the important sources of different minerals. However, the mineral contents of the most commonly available fruits in the market of Pokhara valley is yet unexplored. In this study, ash and mineral content (Fe, Ca, Mg and Cl) of selected fruits were analysed. The findings of this research would provide a valuable information for consumers, producers, related researchers and society.

A large number of studies has been conducted to analyze the nutrient elements, ash and mineral contents in fruits. Azher et al. (2020) analyzed six varieties of apples and presented the percentage of moisture, acidity, pH, reducing sugar and ash content (0.35 to 1.18% per 100 g) in dry fruit samples. Mayer (1997) showed the statistically significant reduction of Mg, Fe, Cu and K in fruits over the 50 years' period from 1930 to 1980, but the water content was increased. Leterme et al. (2006) carried out the study on the mineral content of tropical fruits and unconventional foods of the Andes and rain forest of Colombia and their edible portion was analyzed for the mineral contents. The Ca content (280 to 1242 mg per 100 g) and iron content (0.7 to 8.4 mg per 100 g) of dry edible portion for foliages tree was the highest. Ca and Mg contents 0.231 g and 0.179 g / 100 g dry fruit respectively in the buckthorn fruit had been reported by Brasovanet al. (2009). Zade (2017) carried out the study on determination of the calcium content in rare fruits such as *Eugenia jombolia* and *Cordiasebestina* and reported the results as 15.15 and 16.80 mg / 100 g fruit respectively. Bukva et al. (2019) had conducted the research and presented the result for the iron content of vegetable herbs, spices and fruits (2.91 to 39.27 mg / kg fruit). Similarly, researches related to the mineral content and physico-chemical parameters of fruits and vegetables were conducted by Rahman and Islam (2019), Sultana et al., (2018) and Nonga et al. (2014).

MATERIALS AND METHODS

Sample Collection and Study Area

The samples of fruit were collected from the market of Pokhara. Eight fruit samples of different species were selected by random sampling method and then authenticated by the export. The collected samples were washed with tape water thoroughly and then distilled water at last to remove clay, sand, dirt, etc. A mass of collected cleaned fresh fruit samples was measured by means of electric balance with peel and shell. The cleaned fruit samples were stored in refrigerator at selected temperature. The ash and mineral content of selected fruit samples were analyzed in the research laboratory, Department of Chemistry, IoST, Prithvi Narayan Campus, Pokhara.

Analytical Methods: Experimental Procedure

Determination of Total Ash Content

The ash content of fruit samples was determined gravimetrically by using Ranganna's method (Ranganna, 1986). A fixed mass of fruit sample was heated first at 300^oC for few hours, and then heated at 420^oC for overnight or heated at 550^oC for 5-7 hours in the muffle furnace. The ash of sample was cooled in desiccators and weighted. The process of heating, cooling and weighing was repeated till a constant mass was obtained.

Determination of Mineral Iron

The major involving steps for estimation of minerals are: sampling, destruction of organic matter, separation and concentration of element, and determination of specific element. An organic matter present in the sample of fresh fruit was destroyed by ashing, and the resulting ash was dissolved in hydrochloric acid and then filtered to get clear filtrate which was diluted to known volume (250 ml) with distilled water (Government of India, 2015). This solution was taken as a prepared sample solution of the fixed volume.

An amount of iron in ash solution of fresh fruit sample was determined by spectrophotometrically using thiocyanate method. Iron (Fe^{3+}) reacts with excess of thiocyanate (SCN^-) ion to form dark red /blood red complex, $[Fe(SCN)_6]^{3-}$. The absorbance of colored complex solution is directly proportional to the concentration of iron in the sample (Jeffery et al., 1989).

$Fe^{3+} + 6SCN^- \longrightarrow [Fe(SCN)_6]^{3-}$: Thiocyanate complex (Dark red)

First, a calibration curve was constructed by the plotting concentration of standard solution versus absorbance. Then, from the observed absorbance of sample solution, the respective concentration was determined.

Mass of iron in 100 g sample = $\frac{21\varkappa}{20} \times 100$ g = $105\varkappa$ g = % of iron in fresh sample.

Where, $\varkappa$ be the observed concentration of iron from calibration curve in the fruit sample solution of 250 ml prepared by ashing 20 g of fresh fruit.

Determination of Calcium and Magnesium

An amount of calcium and magnesium ions in the ash solution of fresh fruit samples were determined by complexometric titration with EDTA in presence of an indicator, Solochrome Black (Eriochrome Black T). At the end point, the color changes from wine red (magnesium-indicator complex) to blue (free indicator) between pH 7 and 11. On adding the EDTA solution in the ash solution of fresh fruits containing Ca^{++} and Mg^{++} ions in the presence of Erio T indicator, it reacts first with free Ca^{++} ions, then with free Mg^{++}ions, then with calcium -indicator complex, and finally with the magnesium-indicator complex to liberate free indicator.

20 ml of ash solution was titrated with standard (0.005M) EDTA solution in the presence of EBT indicator and basic buffer (pH 7 to 10), to get the corresponding volume of EDTA consumed by both calcium and magnesium ions. At the end point, the color of indicator changes from wine red to blue. An equal volume of the same sample solution was again titrated with EDTA solution in the presence of murexide as an indicator in strongly alkaline medium (10 ml 1M NaOH) to get a volume of EDTA only consumed by Ca^{++} ions. At this end point, the color of indicator (murexide) changes from red to purple. A volume of EDTA required for Mg^{++} ions was calculated by subtracting the volume of EDTA consumed by Ca^{++} ions from volume of EDTA consumed by both Ca^{++} and Mg^{++} ions.

By using equation, $M_1V_1 = M_2V_2$, molarity of Ca^{++} and Mg^{++} can be calculated.

$Mg^{2+} + \underset{\text{EBT (Blue)}}{HIn^{2-}} \longrightarrow \underset{\text{wine red}}{MgIn^-} + H^+$

$Ca^{2+} + \underset{\text{EDTA}}{H_2\gamma^{2-}} \longrightarrow Ca\gamma^{2-} + 2H^+$

$Mg^{2+} + H_2\gamma^{2-} \longrightarrow Mg\gamma^{2-} + 2H^+$

$\underset{\text{Wine red}}{MgIn^{1-}} + H_2\gamma^{2-} \longrightarrow Mg\gamma^{2-} + \underset{\text{EBT (Blue)}}{HIn^{2-}} + H^+$

1 mole of 1M EDTA = 1 mole of Mg^{++} = 1 mole of Ca^{++}

1 ml of 1MEDTA = 0.04078 g Ca^{++}= 0.024305 g Mg^{++}

Percentage of Ca = $\frac{v_{EDTA} \times M_{EDTA} \times V_T \times 0.040078 \times 100}{v_{samp} \times W_{Samp}}$ %= 0.012524375 × v_{EDTA}%

Percentage of Mg = $\frac{v_{EDTA} \times M_{EDTA} \times V_T \times 0.024305 \times 100}{v_{samp} \times W_{Samp}}$ % = 0.007595313× v_{EDTA} %

Where, W_{same} = Mass of fresh sample taken for ashing (20 g)

V_T = Total volume of ash solution (250 ml)

M_{EDTA} = Molarity of EDTA solution (0.005 M)

v_{samp} = Volume of ash sample solution taken in titration (20ml)

v_{EDTA} = Volume of 0.005M EDTA consumed by v_{samp} solution

Determination of Chloride

An amount of chloride in the ash solution of fresh fruit sample was determined from argentometic titration by using Mohr's method in the presence of potassium chromate as an indicator (Jeffery et al., 1989). At the end point, the faint color of silver chromate precipitate changes to brick-red at pH 7 to 10.

$Cl^- + AgNO_3$ (0.01) $\longrightarrow AgCl\downarrow + NO_3^-$

Silver chloride (white ppt)

$K_2CrO_4 + 2AgNO_3 \longrightarrow Ag_2CrO_4\downarrow + 2KNO_3$

Silver chromate (brick-red ppt)

In acidic medium, chromate ions are converted into chromic acid and at higher pH brown ppt. of silver oxide is formed; therefore, the pH was maintained in the suitable range by adding sodium carbonate solution to the reaction mixture solution.

1 mole of $AgNO_3$ = 1 mole of Cl^{-1} = 35.45 g Cl^-

1 ml g 1 N $AgNO_3$ = 0.03545 g of chloride

Percentage of Chloride = $\frac{V_{AgNO_3} \times M_{AgNO_3} \times V_T \times 0.03545 \times 100}{V_{sample} \times W_{sample}}$%

= 0.017725 V_{AgNO3} %

Where, V_{sample} =Volume of ash solution taken in titration = 25 ml

V_T =Total volume of sample solution = 250 ml.

W_{sample} = Mass of sample taken for ashing = 20 g.

S_{AgNO3} = Normality of $AgNO_3$ solution = 0.01 M

V_{AgNO3} = Volume of $AgNO_3$ consumed in titration =..ml

RESULT AND DISCUSSION

Results

The observed values of ash and mineral content of fruit samples are listed in the following tables.

Table 1

Absorbance and concentration of Fe^{3+} / $[Fe(SCN)_6]^{3-}$ in Standard Solution and Ash Solution of Fresh Fruits

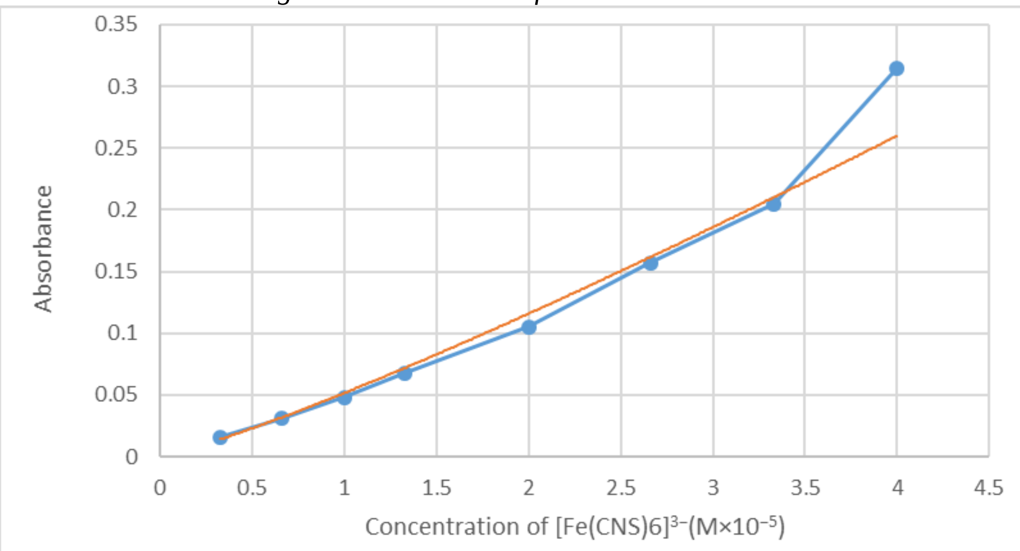
Concentration of Standard Fe^{3+} Solution (M)	Absorbance of $[Fe(SCN)_6]^{3-}$	Name of Fruits	Absorbance of Ash Solution of Fruit	Concentration of Fe^{3+} in Ash Solution of Fruit (M)
0.33×10^{-5}	0.016	Banana	0.022	1.05267×10^{-5}
1.0×10^{-5}	0.048	Grapes	0.020	1.01485×10^{-5}
1.33×10^{-5}	0.068	Litchi	0.015	0.920295×10^{-5}

2.0×10^{-5}	0.105	Mango	0.015	0.920295×10^{-5}
3.33×10^{-5}	0.205	Papaya	0.041	1.406436×10^{-5}
4.0×10^{-5}	0.315	Pineapple	0.043	1.449839×10^{-5}
4.66×10^{-5}	-	Pomegranate	0.040	1.393102×10^{-5}
5.33×10^{-5}	-	Watermelon	0.013	0.882471×10^{-5}

Table 1 presents the observed absorbance of standard solution ofFe^{3+} that is $[Fe(SCN)_6]^{3-}$complex to draw calibration curve and concentration of ash solution (M) of samples from respective recorded absorbance in calibration curve.

Figure 1

Calibration Curve Using Standard Solution of Fe^{3+}



The above graph is the standard calibration curve obtained by plotting relative observed absorbance versus concentration of standard Fe^{3+} [that is $[Fe(SCN)_6]^{3-}$] solution. Absorbance is proportional to the concentration of standard solution.

Table 2

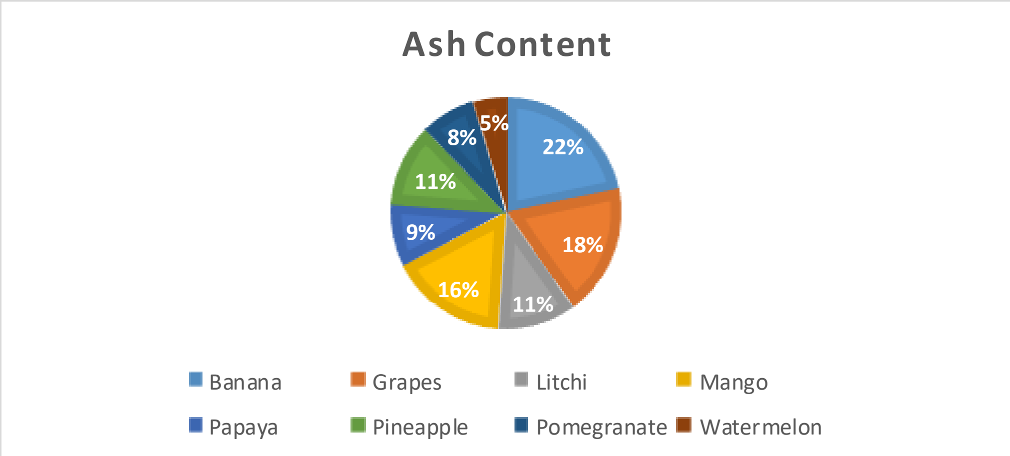
Observed Percentage of Ash, Iron, Calcium, Magnesium and Chloride Content in Fresh Fruits (g /100 g)

Name of Fruits	Ash Content (g/100 g)	Percentage of Iron(g/100 g)	Percentage of Calcium (g/100 g)	Percentage of Magnesium (g/100 g)	Percentage of Chloride(g/ 100 g)
Banana	1.7050	73.68774×10^{-5}	0.003757310	0.023545460	0.1666150
Grapes	1.4300	71.039955×10^{-5}	0.011271933	0.011392965	0.0212700
Litchi	0.8600	64.42065×10^{-5}	0.016281681	0.017469210	0.0939425
Mango	1.2850	64.42065×10^{-5}	0.011271933	0.005316719	0.0921700
Papaya	0.6800	98.450520×10^{-5}	0.037553614	0.031140771	0.0903975
Pineapple	0.9000	101.488695×10^{-5}	0.01252437	0.01215250	0.14400275
Pomegranate	0.6000	97.517175×10^{-5}	0.0050096	0.013671558	0.1790225
Watermelon	0.3600	61.773002×10^{-5}	0.012912027	0.012912027	0.0549475

Table 2 gives the experimentally recorded percentage values of ash, iron, calcium, magnesium and chloride content in the fresh fruit samples by using standard methods. An amount of iron in different samples was calculated from the observed absorbance of $[Fe\ (SCN)_6]^{3-}$ complex in spectrophotometer and respective concentration from calibration curve.

Figure 2

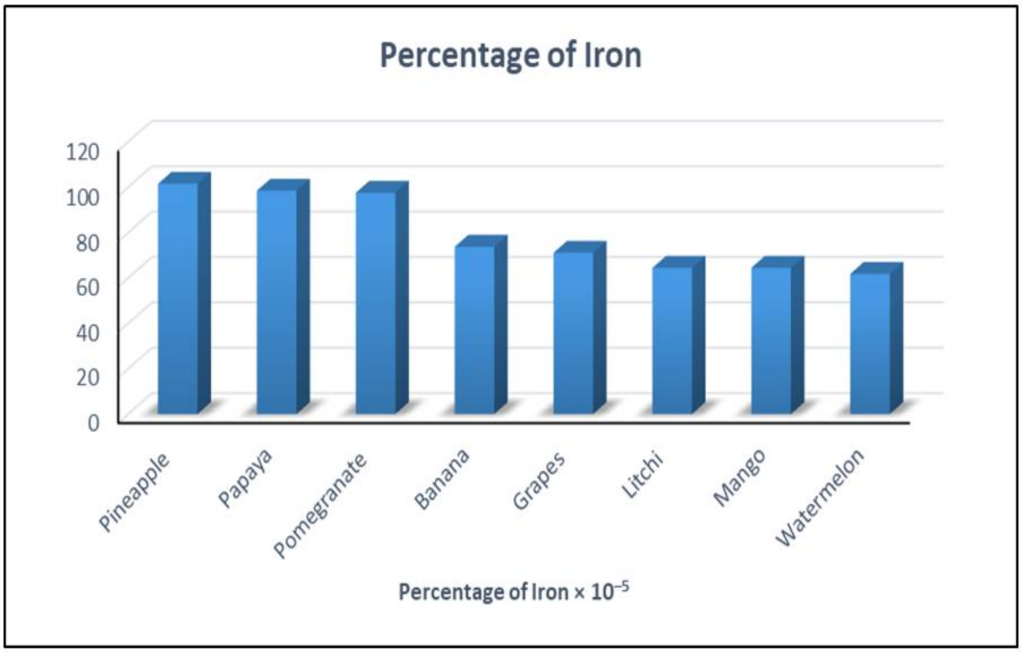
Relative Proportion of Ash Content in Fruit Samples



The relative proportion of total amount ash content in different fruit samples is shown in Figure 2. The sample of watermelon contains a minimum amount of ash whereas the mango contains a maximum amount among the experimental samples.

Figure 3

Graphical Representation of Percentage (g/100g) of Iron in Sample of Fruits



The percentage (g/100 g) of iron in edible portion of eight experimental fruits in bar diagram is represented in Figure 3. The observed iron content is relatively greater in papaya, pineapple and pomegranate samples than that of others.

Figure 4

Graphical Representation of Percentage of Calcium (g/100g) in Sample of Fruits

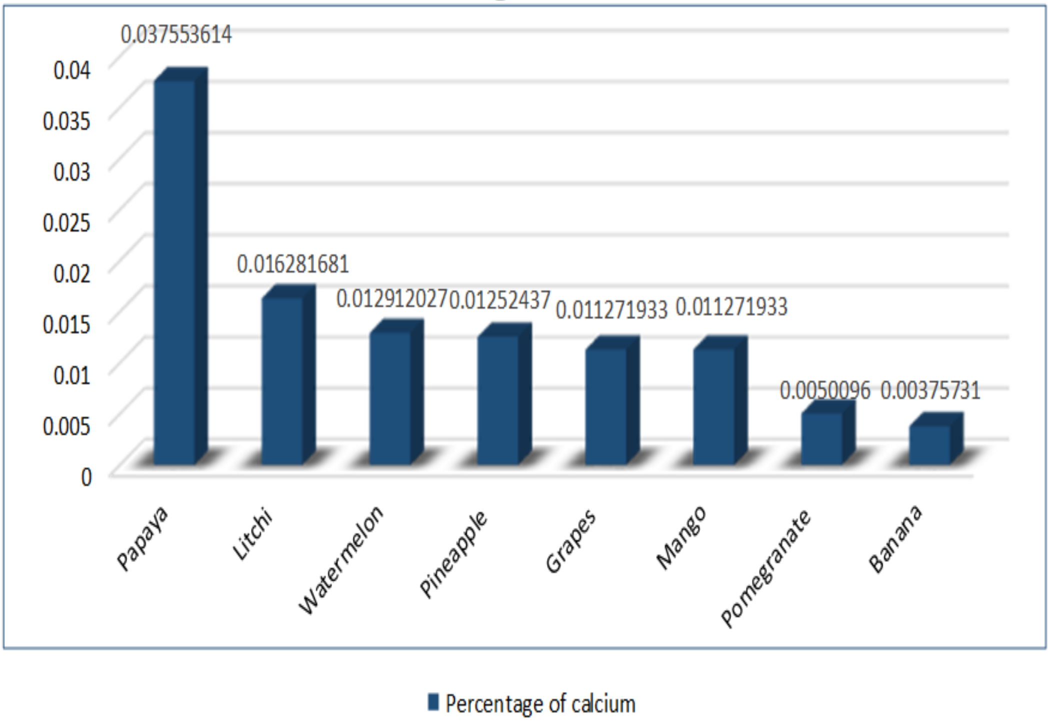


Figure 4 shows the percentage of mineral calcium content in eight samples of fruit in a decreasing order from papaya to banana.

Figure 5

Graphical representation of Percentage of Magnesium (g/100g) in Sample of Fruits

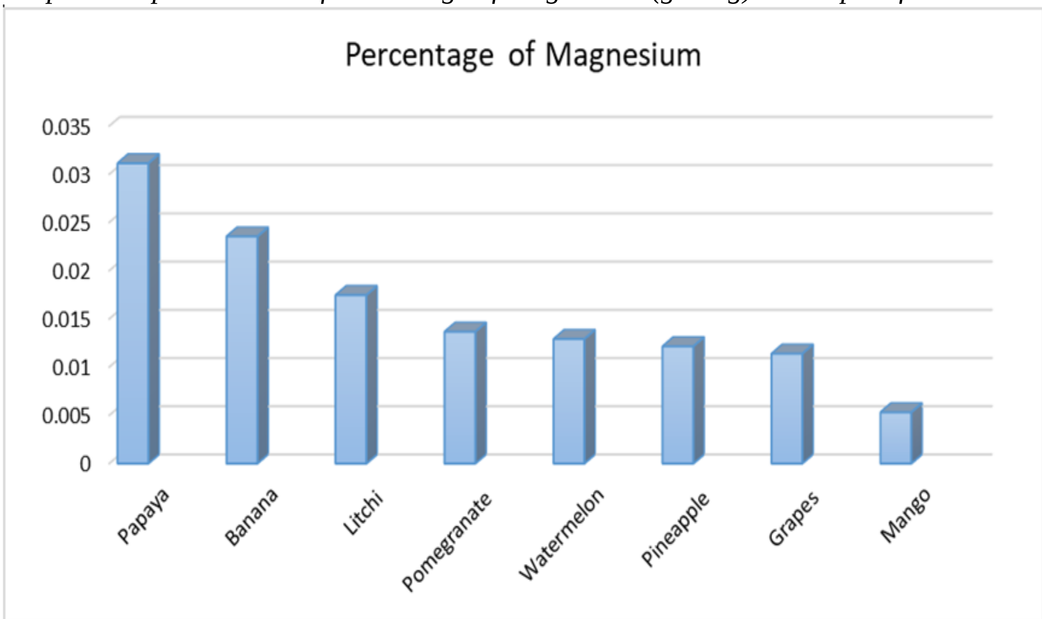
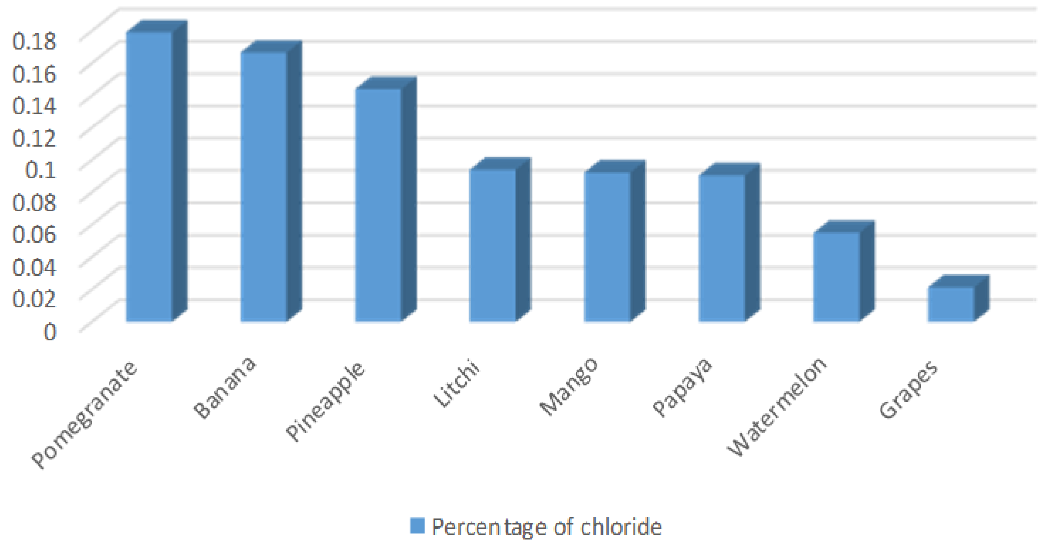


Figure 5 gives the relative percentage content of magnesium in different experimental fruits in an observed order. Mango has the lowest and papaya has the highest percentage of Mg among the experimental samples.

Figure 6

Graphical Representation of Percentage of Chloride (g/100g) in Sample of Fruits



A graphical representation of the percentage of chloride in the eight experimental samples of fruits in a decreasing order of the percentage of chloride is presented in Figure 6.

Discussion

The results of the study presented in Table 2 show that the experimentally observed amount of ash in the fresh fruit samples represents the mineral content and inorganic residue in it. The ash content ranges from 0.0360 % for watermelon to 1.7050 % for banana. The samples with an increasing order of ash are watermelon, pomegranate, papaya, litchi, pineapple, mango, grapes and banana (Table 2 & Figure 2). These recorded values of ash in fresh fruits are comparable with each other and with the reported values by Gbarakoro et al. (2020).

The percentage of iron (g/100 g) was minimum for watermelon (61.773002×10^{-5} %) and maximum for the sample of pineapple ($101.488695 \times 10^{-5}$ %) with an increasing order: watermelon, litchi = mango, grapes, banana, pomegranate, papaya and pineapple as presented in Table 2 and Figure 3. Some of these observed values of iron are relatively higher than that of reported by different authors. The submitted values of Fe for banana, grapes, mango, papaya, pineapple, pomegranate and watermelon by Vicente et al. (2014) was 0.26, 0.36, 0.13, 0.10, 0.29, 0.30 and 0.24mg/100 g respectively. According to Mayer (1997), the iron contents for banana, grapes and pineapple were 0.03, 0.03 & 0.02 mg/100 g respectively. Nielsen (2010) reported the values of iron for apple and banana that were less than 1 mg / 100 g. Farid and Enani (2010) stated that the concentration of iron (µ g/ L) for apple, orange and mango juices from Saudi Arabia as 325.36, 316.27 and 463.5 respectively.

An amount of calcium and magnesium in the ash solution of fresh fruit samples were determined by complexometric titration with EDTA in the presence of specific indicators. The calcium content was maximum in the papaya samples (0.037553614 %) followed by litchi, watermelon, pineapple, mangoes = grapes, pomegranate and banana (0.00375731%) like as shown in Table 2 and Figure 4. These values are agreeable with analyzed values reported by many researchers. The experimentally observed values of Ca for banana, grapes, mango, papaya, pineapple, pomegranate and watermelon were 5, 10, 10, 24, 13, 3 and 7mg/100 g (Vicente et al., 2014). The recorded values of calcium for apple and banana were 6.0 and 6.0 mg/100 g (Nielsen, 2010) whereas Mayer (1997) reported the values for banana, grape and pineapple that were 6.0, 13.0 and 18.0 mg /100g respectively. The experimentally analyzed values were well acceptable and comparable with the standard values. Similarly, the experimentally recorded value of magnesium by complexometric titration was between 0.005316719 % (for mango) and 0.031140771 % (for papaya). The papaya and banana contain relatively more amount of magnesium; litchi, pomegranate, watermelon, pineapple and grapes contain intermediate % of calcium, and the mango contains relatively less amount of magnesium among eight experimental samples of fresh fruits as shown in Table 2 and Figure 5. Vicente et al. (2014) reported the analyzed value of Mg for banana, grapes, mango, papaya, pineapple, pomegranate and watermelon as 27, 7, 9, 10, 12, 3 and 10 mg /100 g raw fruit respectively. The recorded values of Fe, Ca and Mg are more or less comparable with the reported values of these minerals by Farina et al. (2020) from the study of six varieties of mangoes in which Fe, Ca and Mg ranged from 9.16 to 12.40, 0.66 to 0.90 and 0.26 to 0.47 mg/100g respectively.

An amount of chloride in the ash solution of fresh fruit samples as determined by argentometic titration using Mohr's method in the presence of potassium chromate as an indicator are presented in Table 2 and Figure 6. The percentage content of chloride is in the order: pomegranate (0.1790225%) > banana > pineapple > litchi > mango> papaya > watermelon > grapes (0.021200 % g/ 100 g). The observed results of the ash and mineral content parameters were analyzed using standard methods that are in agreement with the standard values of USDA (2009) and previously published results by different researchers. The submitted results from the observed experimental data for the percentage of ash and minerals: Fe, Ca, Mg and Cl are the amount in grams per 100 grams' edible portion of fresh fruits.

CONCLUSIONS AND RECOMMENDATIONS

A percentage of ash content and minerals: iron, calcium, magnesium and chloride of fresh fruits such as banana, grapes, litchi, mango, papaya, pineapple, pomegranate and watermelon were determined in the chemistry research laboratory of Prithvi Narayan Campus, Pokhara using standard methods. The observed results of these fruits are comparable to each other and with the previously published results of various researchers. The observed iron content in the edible part of fresh fruits was greater than that of reported values by other researchers, but did not cross the recommended tolerable amount. From the observed data and submitted results, it is concluded that the experimental fruits are the important sources of minerals.

The present research provides the observed experimental data of percentage of ash and mineral content of eight fruits, which will be helpful for related researchers, consumers, producers and many more. More specific researches including heavy and toxic metals of series of edible fruits are recommended for further studies.

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