Proceeding of 2nd International Science Postgraduate Conference 2014 (ISPC2014)

CHEMOMETRICS STUDY AND ASSESSMENT OF SELECTED INDIAN DISHES IN TAMAN UNIVERSITI TEKNOLOGI MALAYSIA FOR SOURCING ESSENTIAL MINERAL NUTRIENTS

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Abstract. Purpose of food is primarily to maintain life based on the inherent nutritive and nourishment properties of its content. This study is aimed at examining the mineral content of table ready dishes as remedy for a number of Mineral Deficiency Diseases (MDD). It is a more convenient alternative to conventional supplementation which is less affordable and sometimes harmful. Food samples were collected as served dishes from local restaurants around Taman Universiti Teknologi Malaysia. The dried samples were blended in electric blender made of plastic chamber and stainless steel blade. Optimum wet ashing procedure was adopted with control of heat and proportionate use of Nitric acid and Hydrogen Peroxide. The elements (Ca, Mg, K and Na) were obtained using Flame Atomic Absorption Spectrometry (FAAS). Phosphorus was determined using Inductively Coupled Plasma- Mass spectrometry (ICP-MS).The studied dishes revealed the presence of these elements but in varied quantities. Unsupervised techniques of the Principal Component Analysis (PCA) and Cluster Analysis (CA) were employed to distinguish patterns and groupings among the dishes. The PCA revealed a reduced dimension of the whole variables into two Principal Components responsible for 90% of the total variability. Both PCA scores and CA dendrogram show one large grouping and sets of some independent food samples. While *Banana leaf rice* and *Roti canai* stand out, the other interesting set consisting of Banana Leaf rice, Fish head curry and Nasi Beriani highly correlate positively with Ca, Na, P and K elements. Overall result shows that the Required Dietary Allowance (RDA) for the mineral elements can be met with careful choice of food, hence being, potential remedies for some MDDs.

Keywords Dishes; Mineral Deficiency Diseases; Wet Ashing; Flame Atomic Absorption Spectrometry; Principal Component Analysis; Cluster Analysis

1.0 INTRODUCTION

Foods are chemical stuff which we take for their nourishment and nutritive properties. Foods are eaten raw, cooked or processed. The decisions on how to handle or process foods vary from culture to culture as well as geographical location. However, the common factor in all foods is that they can be classified into nutrient units; macro- and micro-nutrients. The micro-nutrients are the vitamins and minerals.

Minerals are inorganic entities of foods. They play great role in moderating the interactions of fluids in the body. Among the league of mineral elements are those termed 'essential'. The essential elements are those that are needed for normal body functioning. Lack of these elements could lead to abnormal organs functioning and critical diseases [1].

Mineral Deficiency Diseases (MDD) is a health situation where certain mineral element(s) fall short of its essentially needed amount in the body. The consequence could be drastic leading to death or physical and metal damages. About 11% of the burden of global diseases is trace-able to mineral deficiency disease [2]. Similarly, out of 11 million of death of children under the age 15, mineral deficiency diseases account for 40 percent [3].

The mineral malnutrition has been declared as number one risk health of people world-wide [3]. Some of the mineral deficiency disease cases that is of great concern to Malaysia are the incidence of inadequate intake of iron, calcium, magnesium and phosphorus. As a result, about one and over two million patient cases were reported for anaemia and osteoporosis respectively [4].

This study is aimed at quantifying, analyzing and recognizing the general patterns of essential element content of Indian foods eaten in Malaysia. The overall goal of this research is to have indepth report of possibility of sourcing the much needed essential mineral elements from foods as alternative to mineral supplements.

2.0 EXPERIMENTAL

2.1 Sampling

45 samples of food made up of 15 Indian foods eaten in Taman UTM. Three well patronized sample restaurants were chosen for collection. The foods are listed on Table 2.1. The foods were cooked in the restaurants and collected as normal serving dishes. The chosen restaurants complied with standard food recipe.

Table 2.1: Lists of selected Malaysian Indian foods

Code	Foods	Code	Foods	Code	Foods
1	Banana leaf Rice	6	Mamak Rojak	11	Roti Canai
2	Chapati Kima	7	Murtabak	12	Roti Naan (with soup)
3	Fish Head Curry	8	Nasi Beriani	13	Sambar
4	Idli	9	Pongal	14	Teh Tarik
5	Maggi Goreng	10	Rasam	15	Thosai

2.2 Treatment of Sample

The sample packs, which mostly comprise of main food and soup, were collated with polymer material and taken to UTM analytical chemistry laboratory for further actions. The food packs were weighed and the triplicate averages were recorded. Each of the sample packs were blended and then dried in the oven for 72hrs at 100-110^{0}C. The dried samples were weighed and blended into fine particles.

2.3 Ashing of Samples

The finely blended samples were wet-ashed with proportionate mixture of Hydrogen peroxide and Nitric acid. 1g of each of the fine sample was put in a flask. 5 mL of Nitric acid was used to soak the sample over-night. The flask was then mounted on the hot plate the next day for ashing process. Moderate temperature between 70 and 85^{0}C was maintained to minimize loss of materials. The heating process continued with intermittent addition of Nitric acid, Hydrogen peroxide and de-ionsed water until about colourless solution is obtained. The resulting digest was then filtered using 0.45µm syringe micro-filters before forwarding for instrumental determination of elements.

2.4 Instrumental Stage

The instrument used for the elements was the Flame Atomic Absorption Spectroscopy. Appropriate cathode lamps were selected for each of the elements of interest. Similarly, optimum operating conditions were fixed. Nitrous and acetylene combination was used as flame source with fixed optimum flow rate. The blank solution was de-ionized water. The sample digests were diluted to appropriate concentrations and filtered with injection 0.45µm filter. Standard concentrations were prepared to obtain corresponding absorbance. ICP-MS was used to determine phosphorus. The plotted values were used to calibrate and hence determine the concentration of the samples in ppm.

2.5 Chemometrics and statistical Analysis

Statistical analysis was done with excel spread sheet for windows to obtain the charts, graphs, mean, standard deviation and range values. The Principal Component Analysis (PCA) and Cluster Analysis (CA) were performed using the Chemometrics software package of the MATLAB, version 4.0 for windows.

3.0 RESULTS AND DISCUSSION

3.1 Element contents of food

The studied foods were found to contain the selected essential elements as seen on figures 3.1 and 3.2. The mean quantities of the elements are in Table 3.1 and the order K> Na > P > Ca > Mg. The composition of the food for the elements is in appreciable quantities. The proportion of the elements in the foods is normal since the order is similar to magnitude of healthy human requirement.

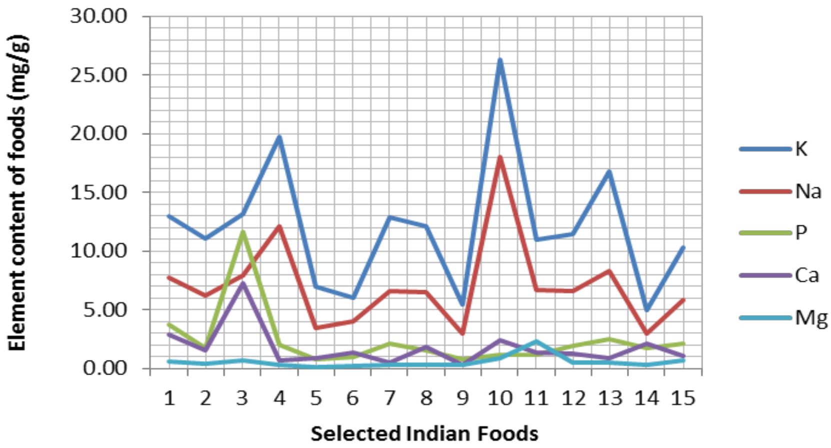

Figure 3.1 : Concentration of essential elements in Indian foods

Table 3.1: Descriptive statistics of essential elements in foods (mg/g)

Statistics	Calcum	Magnessium	Phosphorus	Potassium	Sodium
Mean	1.74	0.54	2.37	12.06	7.06
Median	1.34	0.41	1.72	11.42	6.59
Standard Deviation	1.68	0.52	2.66	5.65	3.85
Kurtosis	8.99	9.92	12.16	1.74	4.26
Skewness	2.78	2.94	3.37	1.11	1.80
Range	6.96	2.18	10.87	21.29	15.09
Minimum	0.28	0.10	0.72	4.96	2.96
Maximum	7.24	2.28	11.59	26.25	18.05

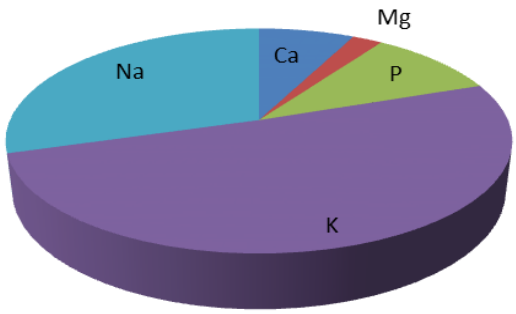

Figure 3.2: Element composition of average food

The calcium to phosphorus molar ratio of the studied food proves to be more normal than the very low ratio prevalent among the Finnish women investigated by [5]. This ratio, however, fall within acceptable level [6]. Moderate calcium to phosphorus ratio in diet has role on serum parathyroid, mineralization of bone as well as calcium metabolism [5]. Similarly, the potassium to sodium ratio in the average studied foods is also within permissible range. The importance of higher potassium to sodium ratio is its protection against heart related problems [7].

The statistical summary of the distribution of the elements is on Table 3.2. The analysis of the serving food dishes at 95% confidence interval reveals a widely varied content. The high standard deviations show that elements are widely dispersed over mean in one food to another. This observation was further supported by the highly extreme range values. The positive value of kurtosis indicated peaked rather than flat distributions of the elements across foods. The elements distribution is also found to be skewed and hence, tailed towards positive values. This explains the marked difference between the median and mean.

Table 3.2 and Figure 3.3 below show the foods' potential capacity for supplying the essential nutrients. The assessment is based on comparing with the Recommended Dietary Allowance (RDA). Dietary information was obtained from Malaysian and United States dietary guidelines [8], [9] and [10]. The percentage ratios of the maximum average food content of the elements to the RDA upper and lower limit are least in Mg with 49% and 85% respectively. This value is still reasonable for the fact that the studied Indian foods can still good source of the essential elements. The served dish of *Roti canai* contained average of 170 mg of magnesium; it implies a repeated meal of the food is rich enough to meet up the maximum RDA.

Table 3.2: Statistical summary element content of foods (mg per serving dish

Statistics	Calcium	Magnesium	Phosphorus	Potassium	Sodium
Mean	196	51	259	1208	693
Median	102	34	142	1016	607
Standard Deviation	228	49	301	942	542
Kurtosis	2.6	1.7	3.1	2.4	3.1

Skewness	1.8	1.6	2.0	1.6	1.7
Food Minimum	13	11	17	235	138
Food Maximum	800	170	1023	3573	2144
RDA min*	800	200	580	3500	1200
RDA max*	1000	350	1055	4700	1500
%Food max/RDA max	80	49	97	76	143
%Food max/RDA min	100	85	176	102	179

RDA: Required Dietary Allowance

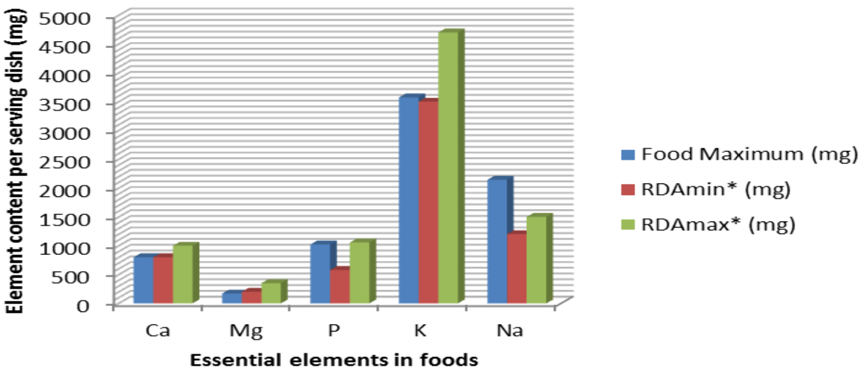

Figure 3.3: Comparison of elements content in food with RDA

3.2 Principal Component Analysis (PCA)

The data matrix for the studied Indian foods is of dimension 15 rows by 5 columns. In an auto-scaled PCA processing outcome [11], the dimensions were reduced with the Eigen value suggesting 2 principal components. The 2PCs still retain the maximal variability of the data. Up to 89.96% variance cumulative was captured by the PCA model.

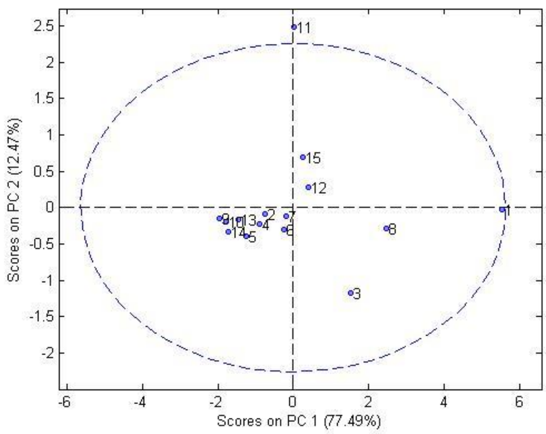

Figure 3.4: Score plots for food patterns

The score plots modeled in Figure 3.4 suggest a grouping with membership of nine food dishes. The other six food dishes are independent samples. They are samples coded 1 and 11 which are *Banana Leaf rice* and *Roti canai* respectively. The spatial positioning of the two samples confirms their extreme values of their contents. The main group containing: 2, 4, 5, 6, 7, 9, 10, 13 and 14 foods. This group lying on the negative axes suggest that majority of the foods have comparable contents. The simultaneous plots of loading and scores in Figure 3.5 below show that the foods: *Banana Leaf rice, Fish head curry* and *Nasi Beriani* have high positive correlation with Ca, Na, P and K elements.

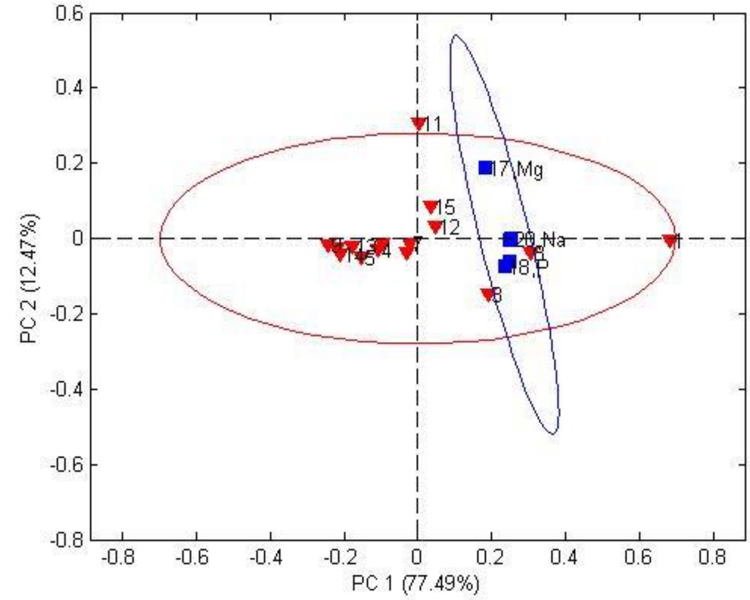

Figure 3.5: Score plots for food patterns

3.3 Cluster Analysis

Hierarchical Cluster Analysis was performed using ward's method [11] by measuring samples closeness in terms of variance weighted distance between cluster centres.

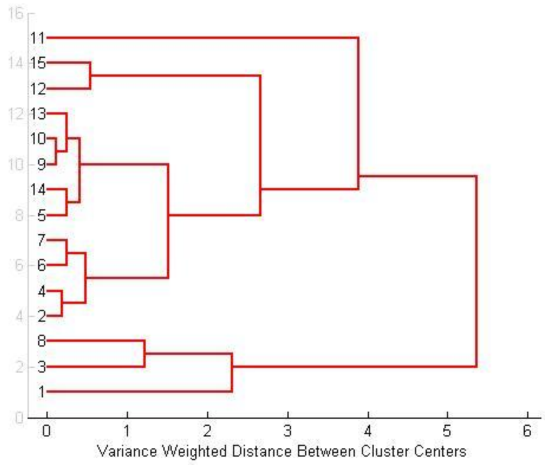

Figure 3.6: Dendrogram for food clusters

The dendrogram in Figure 3.6 illustrates the clustering pattern of the food samples. Just as in PCA, there is a large cluster of 9 food sample members and 6 non clustered food samples with samples 1 and 11 at extreme ends. However, the dendrogram further shows the large clusters to contain two sub-clusters based on food closeness in terms of weighted element contents. Sub-cluster I includes 2, 4, 6 and 7 while the sub-cluster II includes 5, 9, 10, 13 and 14. Dendrogram of the cluster analysis gives clear picture of food closeness or substitutability based on their element contents. The order of food pairing substitutability or neighbourhood is *Pongal* and *Rasam* > *Chapati Kima* and *Idli* > *Mamak Rojak* and *Murtabak*, *Maggi goreng* and *Teh tarik* > *Roti naan with soup* and *Thosai* > *Fish head curry* and *Nasi beriani*.

4.0 CONCLUSION

The research findings clearly revealed that all the Indian foods studied have appreciable presence of all the studied elements. The *Banana leaf rice* and *Fish head curry* contain high values of both calcium and phosphorus per serving dish. Magnesium content is highest in *Roti canai* and *Banana leaf rice*. Potassium and Sodium record highest values in *Banana leaf rice* and *Nasi beriani*. Some of the foods can reliably supply the much needed essential elements.

Both Malaysian Required Nutrient Intake (RNI) and United States Required Dietary Allowance (RDA) standards can be met with careful choice of the standard foods. In addition, the standard daily intake can be met by repeating same meals identified to contain the needed meal.
Chemometrics studies reveal that larger set of foods are similar in terms of element contents. There are still two independent foods (*Banana leaf rice* and *Roti Canai*) unique in terms of the element proportion. Substitutability of closely similar foods in terms of weighted element contents can be deduced from the cluster analysis performed on the sampled food dishes.

The studied foods can be exploited in confronting the menace of Mineral deficiency diseases as well as promoting cheaper and practicable sound health culture.

ACKNOWLEDGEMENT

We acknowledge the funding through GUP grant no 02J10 as well as the research facilities and opportunity by the Universiti Teknologi Malaysia (UTM). We also appreciate the opportunity given by the Federal university of Technology, Minna, Nigeria to study PhD in UTM.

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