Internet Journal of Food Safety, Vol.8, 2006, p. 61-65

Appraisal of Magnesium Levels in Pakistani Diet

P. Akhter[1], M. K. Rahman[2*], D. Mohammad[1] and S.D. Orfi[1]
[1]Health Physics Division, Pakistan Institute of Nuclear Science & Technology P.O. Nilore, Islamabad – Pakistan. [2]Department of Physics, University of Engineering and Technology, Lahore, Pakistan

Intake levels of magnesium from typical Pakistani daily diets were determined. Food samples were collected from major cities / districts of the country. Daily diets were prepared and analyzed using Atomic Absorption Spectrometry (AAS). Measured magnesium concentration varies from 370.57 to 1529.47 μg g^{-1} with an average value of 840.16 ± 249.09 μg g^{-1}. It leads to daily intake variation from 218 to 920 mg d^{-1} with an average value of 497 ± 149 mg d^{-1}. The measured values are adequate and safe, as per international standard.

Magnesium is an essential minor element. It is involved in the synthesis of protein and is an important co-factor in more than 300 enzymatic reactions in the human body. It plays part in: bone metabolism, transmission of nerve impulses to muscles, transporting calcium and potassium, getting energy from the carbohydrates, production of body proteins and DNA, regulating blood pressure.

It is present in human body in conjunction with calcium with 2:1 ratio. An adult human body (70 kg) contains about 19 g of Mg, of which approximately 65% is found in bones and teeth. The rest is distributed between the blood, body fluids, organs and other tissues.

Its deficiency and excess in human body leads to a number of diseases, which are commonly known to be associated with heart and brain functions. Low levels / deficiency of magnesium cause irregular heart beat, cardiovascular disease, insomnia, anxiety, nervousness, seizures, fatigue, osteoporosis, high stomach acid, high blood pressure, PMS, depression, asthma, muscle spasms / cramps, sweating, dysmenorrhea, constipation, angina, migraine / headache, etc., whereas high levels / overdose of magnesium are responsible of causing cardiovascular diseases, muscle / joint pains, dry skin, low stomach acid, low blood pressure, depression, fatigue, high cancer risk, diarrhea, osteoporosis, joint / spinal degeneration, dehydration, muscle spasms / cramps (Roth 2005).

Magnesium occurs widely in foods and drinking water. The highest amounts are in nuts, legumes and whole grains. Green vegetables are also good sources. One of the highest sources of magnesium is milk of magnesia taken as a laxative. Just two tablespoons provide 1,000 milligrams, which is more than twice as much as the Recommended Dietary Allowance (RDA) for anyone of any age (Kolski, 1998). The RDA for magnesium is different for men and women in different age groups. Requirement of a man in the age groups of 19-30 years and 31-70 years are 400 mg d^{-1} and 420 mg d^{-1}, whereas women of these age groups need 310 mg d^{-1} and 320 mg d^{-1}, respectively. The requirement of a pregnant women < 19 years, 19-30 years and 31-50 years are 400, 350 and 360 mg d^{-1}, respectively (Kolski 1998). Ingestion of magnesium is safe in appropriate amounts. However, it can be toxic in excessive amounts.

The upper safe ingestion limit of estimated safe and adequate daily dietary intake (ESADDI) of Mg is 350 mg d^{-1}. This maximum does not include any of the Mg obtained from food and water. The intake of Mg was studied for Pakistani population through daily diet. The estimated average daily intake is compared with international standards and correlated with intake of calcium. Results are discussed in this paper.

MERTERIALS AND METHODS

Sample Preparation. To prepare daily diets, food samples were collected from 23 major districts/cities of Pakistan. The collected samples e.g. rice, pulses, meat, vegetables & fruits were washed with tap water, weighed, oven dried and pulverized separately in a commercially available grinder (BRAUN GmbH, Germany). Simulated typical daily diets based on survey of National Institute of Health (NIH), Pakistan (NIH, 1987) were prepared by mixing individually dried food items. A total of 31 daily diets were prepared, which include 12 diets representative of dietary habits of three population groups representing wealthy, middle and poor classes of Karachi, Sialkot, Mianwali and Muzaffarabad districts. Compositions of these diets are given elsewhere (Akhter, 2003).

Analytical Methodology. Prepared dietary samples weighing 500 mg were digested in 4 ml mixture (3:1) of HNO_3 - $HClO_4$ and heated at 200°C for four hours. The

*Corresponding author, mailing address: Department of Physics, University of Engineering and Technology, Lahore, Pakistan. Phone: 92-42-682-9204, Fax: 92-42-682-2566. E-mail: khaleeq1953@yahoo.com

temperature of the digested mixture was raised gradually to 300°C till elimination of white fumes of $HClO_4$. The volume was made to 10 ml in 0.1N HNO_3. The acids used were of Aristar grade, BDH. Digestion vessels were cleaned using chromic acid followed by a wash with distilled demineralized water of a very high quality. Blank and Standard Reference Material (SRM) of total diet were run with each batch of the digested samples. Magnesium concentration was determined using Atomic Absorption Spectrometer (AAS) supplied by FMD-4 Carl Zeiss, Germany while adopting standard instrumental condition. Certified SPEX Standards (SPEX Industries, USA) were used. Concentrations were calculated using comparative method.

Quality control. The reliability of magnesium measurement was ensured using following internal and external quality control strategies:

Internal Quality Control: Accuracy and precision of analysis was checked through SRM of total diet "SRM-1548a" obtained from NIST, USA as explained elsewhere (Akhter, 2003). The measured magnesium concentration in the standard was 573 ± 2.24 µg g^{-1}, while the certified value was 580 ± 26.7 µg g^{-1}. It indicates that the magnesium analysis was carried out with an overall average accuracy of -1.23% and precision of 0.39%.

External Quality Control: Validity and authenticity of analytical data was checked through an inter-comparison study with Central Reference Laboratory, Japan where the magnesium measurements were made using ICP-AES technique. The measured inter-laboratory variation using Z-scores values was 0.19. This value is well within the acceptable limit of -2 to +2. Inter-comparison showed a good agreement of results between two laboratories and confirmed validity of our analytical techniques as shown in Fig. 1.

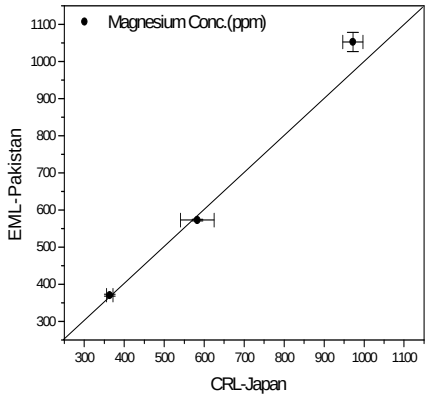

Fig. 1 Magnesium concentration (X ± σ) µg g^{-1} in Pakistani diet. EML-Pakistan verses CRL-Japan.

RESULTS AND DISSCUSSION

Concentrations of magnesium were measured in 31 typical Pakistani diets using AAS technique. Measured data is plotted in the form of frequency distribution along with its Gaussian fit shown in Fig. 2.

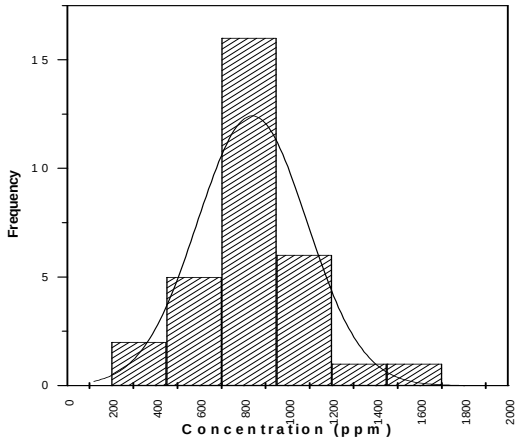

Fig. 2. Magnesium concentrations in typical Pakistani diets.

The graph shows that the distribution is skewed to right (0.38) having a degree of kurtosis of 1.013. Statistical analysis on the data was made for different types of diets representing food habits of various socioeconomic strata of the country. Summary of analytical results for median, arithmetic mean ± standard deviation (AM ± SD), geometric mean $\times\div$ geometric standard deviation (GM $\times\div$ GSD), observed range, 95% confidence interval (AM ± 2SD) and student t-test ($m \pm t_{0.975} \frac{\sigma}{\sqrt{n-1}}$), Where m is the mean value, σ is standard deviation and n is number of samples are listed in Table 1. The data shows that Mg concentration varies from 371 to 1529 µg g^{-1} with a median value of 865 µg g^{-1}. It has AM ± SD of 840 ± 249 µg g^{-1} and GM $\times\div$ GSD of 803 $\times\div$ 1.37 µg g^{-1}. The observed minimum value 371 µg g^{-1} lie well within the 95% confidence interval of 342 - 1338 µg g^{-1}, whereas maximum value 1529 µg g^{-1} is an outlier, with one data point. The estimated average using the Student's t-distribution is 840 ± 93 µg g^{-1}. The measured concentration is used to calculate daily intake value of magnesium for Pakistani population by multiplying total food content of the day. Details are listed in Table 2.

Table 1. Magnesium concentration (μg g^{-1}) from Various Pakistani Diets

Sr. #.	Statistical analysis	All diets	Diet "R"	Diet "A"	Diet "B "	Diet "C "
1	No. of samples	31	19	4	4	4
2	Median	865	890	806	745	648
3	AM ± SD	840 ± 249	901 ± 263	786 ± 193	762 ± 247	684 ± 201
4	GM $\times\div$GSD	803 $\times\div$ 1.37	860 $\times\div$ 1.40	767 $\times\div$ 1.24	732 $\times\div$ 1.38	662 $\times\div$ 1.30
5	Observed range	371 - 1529	371 - 1529	541 - 988	507 - 1052	514 - 927
6	95% confidence interval	342 - 1338	376 - 1426	399 - 1172	269 - 1256	282 - 1086
7	Student t-test	840 ± 93	901 ± 130	786 ± 355	762 ± 453	684 ± 369

Table 2. Daily Intake of Magnesium (mg d^{-1}) from Various Pakistani Diets

Sr. #.	Statistical analysis	All diets	Diet "R"	Diet "A"	Diet "B "	Diet "C "
1	No. of samples	31	19	4	4	4
2	Median	516	520	478	436	380
3	AM ± SD	497 ± 149	536 ± 160	462 ± 95	450 ± 143	387 ± 106
4	GM $\times\div$GSD	475 $\times\div$ 1.37	511 $\times\div$ 1.40	454 $\times\div$ 1.24	433 $\times\div$ 1.38	387 $\times\div$ 1.30
5	Observed range	218 - 920	218 - 920	340 - 552	303 - 626	307 - 523
6	95% confidence interval	200 - 795	216 - 856	272 - 652	164 – 737	186 - 609
7	Student t-test	497 ± 55.44	536 ± 79.2	462 ± 174.6	450 ± 263.1	387 ± 194.5

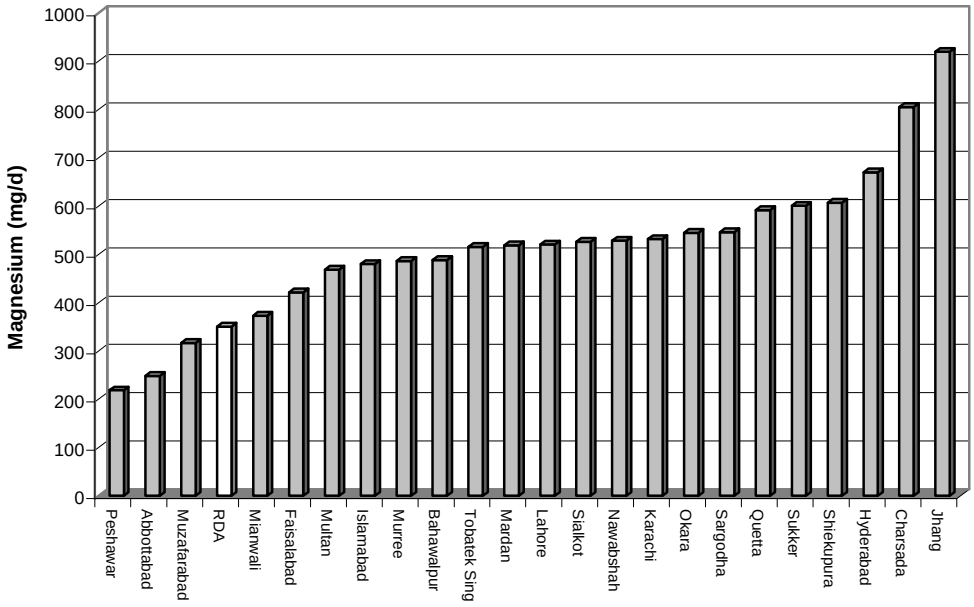

Fig. 3. Magnesium intake in various cities of Pakistan.

Table 2 shows that daily intake of Mg varies from 218 to 920 mg d^{-1} with median value of 516 mg d^{-1}. Estimated daily average value of Mg using the measured concentration is 497.4 ± 148.9 mg d^{-1}, whereas estimated average using the Student's t-distribution is 497.4 ± 55.44 mg d^{-1}.

Average daily intake estimated through 19 representative diets was 536 ± 160 mg d^{-1}, while estimation of 12 dietary samples representative of dietary habits of wealthy, middle and poor classes of Sialkot, Mianwali, Karachi and Muzaffarabad districts were 462 ± 95, 450 ± 143 and 387 ± 106 mg d^{-1}, respectively. These values show that the Mg intakes of various socio-economic strata are significantly different from each other. The nutrition hygiene of group "A" seems comparatively better than "B" followed by "C".

To see intra-country variation, magnesium levels of various cities are compared with RDA value and are shown in Fig. 3. The Fig.3 shows that minimum magnesium intake (218 mg) is received by the population of Peshawar area and maximum magnesium intake (920 mg) is received by the population of Jhang area. Intake levels of only 3 localities out of 23 cities are below the RDA values. The minimum intake is about 0.4 times lower than the RDA value of 350 mg whereas maximum intake is about 1.6 times higher. The measured average value 497 mg is about 1.4 times higher of RDA value.

A comparison of daily dietary estimates of the Pakistani population with reference Caucasian population and other reported values in the literature are given in Table 3.

Table 3. Magnesium levels in the diets of various countries

Country	Mg levels (mg d^{-1})	Reference
Philippines*	130	Natera 2000
Vietnam*	130	Nguyen 2000
Thailand	190	IAEA 1992
Japan*	210	Kawamura 2000
Brazil	230	IAEA 1992
Canada	247	IAEA 1992
Italy	250	IAEA 1992
Netherland	258	IAEA 1992
USR	270	IAEA 1992
Turkey	280	IAEA 1992
USA	290	IAEA 1992
Switzerland	295	IAEA 1992
Global Intake	300	IAEA 1992
India	300	IAEA 1992
Spain	300	IAEA 1992
Sweden	300	IAEA 1992
Bangladesh*	320	Miah 2000
ICRP	340	ICRP 1975
China*	360	Wang 2000
Finland	360	IAEA 1992
Iran	380	IAEA 1992
Sudan	420	IAEA 1992
Pakistan	497	Present study

*median values

The Table shows that intake of magnesium is lowest in Philippine and Vietnam (130 mg) and highest in Pakistan (497 mg) followed by Sudan and Iran etc. The values in Pakistan are almost 1.5 times to those recommended by ICRP and 1.65 times of Global intake.

To see influence of calcium on the magnesium absorption, Ca/Mg ratio was calculated using the published estimates of calcium of these dietary samples elsewhere (Akhter 2004) and compared with international standards listed in Table 4.

Table 4. Comparison of magnesium and calcium intake levels with international standards

Countries	Magnesium (mg d^{-1})	Calcium (mg d^{-1})	Ca/Mg ratio	Reference
RDA	350	800	2.29	Wang 2000
ICRP value	340	1100	3.24	ICRP 1975
Pakistan	497	487	0.98	Present work

The estimated Ca/Mg ratio of the present study is 0.98, whereas estimated ICRP and RDA values are 3.24 and 2.29. Comparison with these international standards shows that Ca/Mg ratio in Pakistani diet is low due to less intake level of calcium. Although, Mg content in Pakistani diet is within normal range. This imbalance of calcium and magnesium ratio could be a leading cause of heart and brain related diseases in Pakistan. As magnesium plays part in contraction of muscles and calcium helps in their relaxation (Roth 2005). Therefore, needs improvement in calcium intake levels to fight these diseases. However, further studies are needed to support this fact.

Although the estimated average of 497 mg seems higher than the RDA and ICRP recommended limits but it may not be toxic if we consider its upper safe limit of ESADDI value, which is 350 mg d^{-1} in addition to magnesium intake from food i.e RDA (350 mg) + ESADDI (350 mg). The other fact is that our diet is plant based and enriched with phytate and fibers. Intake of tea is also very common in Pakistan. The presence of phytate, fiber, tannin and polyphenols in daily diet and tea may reduce absorption of Mg to a minor extent (NIH 2002).

Conclusion

Analytical data for magnesium levels in the Pakistani diet have been determined. Daily dietary intake of adult population has been found to be 497 ± 55 mg d^{-1}. Apparently this value looks higher than the RDA value of 350 mg d^{-1}, but it is well below the ESADDI value. Therefore, considered safe for human consumption and does not pose any health hazard. However its ratio with calcium is disturbed and needs further studies to improve / fight heart and brain related problems, before any conclusion is drawn.

Acknowledgement

The authors are thankful to D.G. PINSTECH for his keen interest, financial/administrative support and guidance, International Atomic Energy Agency (IAEA) for partial financial assistance and CRL Japan for provision of inter-comparison facilities, during this study. Thanks are also due to Messers N. Ashraf and N. Z. Baloch for their kind co-operation.

REFERENCES

1. Akhter P., Orfi S. D. and Ahmad N., Estimation of caesium levels in Pakistani diet, Journal of Environmental Radioactivity (JENR), vol. 67, no. 2, pp. 109-118, March 2003.
2. Akhter P., Mohammad D., Orfi S. D. and Ahmad N., Estimate of strontium and calcium in Pakistani diet, Journal of Environmental Radioactivity(JENR), vol. 73, no. 3, pp. 247-256, March 2004.
3. International Atomic Energy Agency (IAEA), Human dietary intakes of trace elements: A global literature mainly for the period 1970-91. IAEA/NAHRES-12, Vienna, 1992.
4. International Commission on Radiological Protection (ICRP), Report of the task group on Reference Man, ICRP Publication 23; Pergamon Press, Oxford, UK, 1975.
5. Kawamura H., Shiraishi K. and Yukawa M., Studies in Japan on ingestion and organ content of trace element of importance in radiological protection. Final. Research Co-ordination Meeting of IAEA Reference Asian Man Project (Phase 2), Vietnam, 26–30 June 2000.
6. Kolski S., Vitamin and minerals, http:\\www.drkoop.com\, December 1998.
7. Miah F.K., Ingestion and organ content of trace element of importance in radiological protection, Final. Research Co-ordination Meeting of IAEA Reference Asian Man Project (Phase 2), Vietnam, 26–30 June 2000.
8. Natera E.S., Studies in the Philippine on the ingestion and organ content of trace element of importance to radiological protection, Final. Research Co-ordination Meeting of IAEA Reference Asian Man Project(Phase 2), Vietnam, 26–30 June 2000.
9. National Institute of Health (NIH), National nutrition survey report (1985-87), Islamabad, Pakistan, 1987.
10. National Institute of Health (NIH). Facts about dietary supplements: Clinical Nutrition Service, Warren Grant Magnuson Clinical Centre, Office of Dietary Supplements, USA, http://www.cc.nih.gov/ccc/supplements/ironref.html, 2002.
11. Nguyen M.S., Ingestion and organ content of trace element of importance in radiological protection, Final. Research Co-ordination Meeting of IAEA Reference Asian Man Project (Phase 2), Vietnam, 26–30 June 2000.
12. Roth R., DRI / RDA for Calcium & Magnesium + Vitamin A, D, K., Acu-cell nutrition, http:www.Acu.cell.com, 2005.
13. Wang J.X., Chen R.S. and Zhu H.D., Studies in China on Ingestion and Organ Content of Trace Element of Importance in Radiological Protection, Final meeting of IAEA Coordinated Research Project of Reference Asian Man (Phase-2), Vietnam, 26-30 June 2000.