Journal of Microbiology, Biotechnology and Food Sciences

Głogowska et al. 2012 : 2 (2) 458-466

REGULAR ARTICLE

CALCIUM AND MAGNESIUM CONTENT IN CANCEROUS AND HEALTHY TISSUES OF GASTROINTESTINAL TRACT

Marta Głogowska[*1], *Dariusz Pabis*[2], *Robert Stawarz*[1], *Grzegorz Formicki*[3]

Address: Mgr. Marta Głogowska

[1]*Department of Vertebrate Zoology and Human Biology, Institute of Biology, Cracow Pedagogical University, 31-054 Cracow, Poland;*

[2]*Department of Pathomorphology, Military Hospital, Cracow, Poland;*

[3]*Department of Physical Zoology and Toxicology, Institute of Biology, Cracow Pedagogical University, 31-054 Cracow, Poland.*

*Corresponding author: aisutram22@o2.pl

ABSTRACT

Studies concerning concentration of biogenic metals in tissues of digestive system are sparse and diversified. The objectives of this study were to determine the mean concentration of biogenic metals: Mg and Ca, in cancerous and normal tissues of digestive system. Research was conducted on samples taken from different segments of human digestive tract. Tissues were taken during biopsy, surgery, and post-mortem from Military Hospital and PROSMED Health Center Patients' located in Cracow. Samples were mineralized by wet digestion. First, they were dried and after dry mass were obtained the samples were put into digestion flasks and 1cm^3 of nitric acid 65% was added to each of them. The samples were heated for about 2 hours, at 105°C. Mineralized material was moved to tubes with a capacity of 10 cm^3 and filled with distilled water up to this volume. The resulting solutions were used to analyze the content of selected elements by FAAS method. The results are expressed in micrograms per gram of dry weight of tissue (µg•g^{-1}d.m.). Average calcium content is higher in the tissues of the gastrointestinal tract of both healthy women (15890,28 µg•g^{-1}d.m.) and men (13040,24 µg•g^{-1}d.m.) in comparison with tumor tissues of the gastrointestinal tract of women (5365,19 µg•g^{-1} d.m.) and men (2459,42 µg•g^{-1}d.m.). Average magnesium content is higher in the

tissues of the gastrointestinal tract of both healthy women (2887,19 µg•g^{-1} d.m.) and men (1112,69 µg•g^{-1} d.m.), in comparison with gastrointestinal cancerous tissues of women (1146,77 µg•g^{-1} d.m.) and men (621,42 µg•g^{-1} d.m.). It was shown that differences between calcium and magnesium contents in the digestive tract tissues depend on the state of health - significantly higher contents of Ca and Mg were present in the tissues of healthy men and women in comparison to the tissues of men and women with digestive tract cancer. Magnesium and calcium have protective properties (they prevent the development of cancer of the stomach and colon).

Keywords: calcium, magnesium, gastrointestinal tract, FAAS method

INTRODUCTION

Absorption from the gastrointestinal tract depends on numerous factors **(Aleksandrowicz, 1973; Kłopotowski, 1998; Manahan, 2006)**. The substance absorbed by the intestines reaches either the lymphatic system directly or the portal circulation system **(Klauder and Petering, 1977)**. The latter system transports blood to the portal vein which leads directly to the liver. The liver is a screening organ as regards xenobiotis where they undergo metabolic processes, which usually reduce their toxicity and secrete these substances and the products of their metabolism back to the intestines **(Editorial article, 2004; Bondariew, 1989)**.

The stomach is the first part of the digestive system, in which substantial absorption takes place. It is a unique organ because of its high content of hydrochloric acid resulting low pH (approximately 1.0), and some substances that are ionic at a pH close to 7 and above, are inert in the stomach and easily pass through the wall. Stomach cancer is one of the most often disease among malignant tumors in Poland and over the World, resulting of morbidity and mortality. The disease affects people over 55 years especially, twice often men than women **(Kotynia, 2006)**. It is believed that the cause of this phenomenon is the protective effect of female hormones that prevent the development of cancer. The data indicate that morbidity and mortality associated with gastric cancer will steadily grow in the future, as was demonstrated by the analysis of recent decades.

In some organs, like the liver, biotransformation usually occurs on a much smaller scale. In addition, intestine contains a rich bacterial flora which may be involved in

xenobiotic's transformation. There are also mechanisms for limiting the metals absorption processes in intestine. These mechanisms include excretion of waste substances into the intestinal lumen, a very quick death and exfoliation of the intestinal mucosa, transporting proteins saturation what limits the rate of transport through membranes. In the case of absorption of metals also there is the possibility of induction of biosynthesis of proteins which bind them in stable complexes hardly penetrating cell membranes **(Sapota, 2008)**. Colon cancer is primarily a disease of industrialized countries. It is a disease of the elderly; the average patient age at diagnosis is about 60 years **(Halpert *et al.*, 2000)**.

The process of calcium absorption occurs in the duodenum and upper jejunum in two stages: the penetration of calcium into the enterocyte and the shift of calcium into the lateral extracellular space. Calcium absorption depends largely on the needs of the body therefore it is increased at a young age and in pregnancy. Factor that directly regulates enterocyte resorptive capacity is the concentration of calcium in the blood plasma **(Konturek, 1990; Ghishan *et al.*, 1989)**. Calcium absorption is dependent on the demands of the body **(Zalewski, 2000)**. Short-chain fatty acids acetate and propionate increase calcium absorption in the colon and rectum of man, and aldosterone causes a rapid increase of Ca^{2+} in the distal colon (in isolated colonic crypts) **(Trinidad *et al.*, 1999; Doolan *et al.*, 1998)**.

Research shows the interactions between Mg, Ca and P in the processes of absorption. Oversupply of P lowers the Ca ions concentration. Increasing consumption of P lowers the absorption of Mg. The increased supply of Ca and P in food rations reduces absorption and increases the demand for Mg **(Szajkowski, 2001)**. Magnesium is reabsorbed along the entire gastrointestinal tract, but mainly in duodenum and jejunum **(Pasternak and Floriańczyk, 1995)**.

MATERIAL AND METHODS

Samples (about 0.5 g) were taken from 54 patients (n=54). 28 of them were malignant tissues (n=28) (25 were from patients with large intestine tumor, and 3 from patients with stomach tumor). Healthy tissues were taken from esophagus, stomach, small intestine and large intestine, and were taken from 26 patients (n=26). Each sample was prepared for determination of calcium and magnesium contents using FAAS method.

Tissues were weighted and dried (until dry mass was obtained), and then were placed into digestion flasks; $1cm^3$ of nitric acid (65%) was added to each of them. The samples were

heated for about 2 hours, at 105°C. After mineralization the dissolved tissues were moved into tubes filled with distilled water and filled up to 10 cm^3 volume. The resulting solutions were used to analyze the content of selected elements by FAAS method. The results were expressed in micrograms per gram dry weight tissue (µg•g-1d.m.).

RESULTS AND DISCUSSION

For hypotheses falsification the U Mann Whitney test was used. The differences between the average content of Ca and Mg in healthy women and men tissues and content of these elements in tissues taken from sick women and men are shown in Figures 1 and 2 and in Tables 1 and 2.

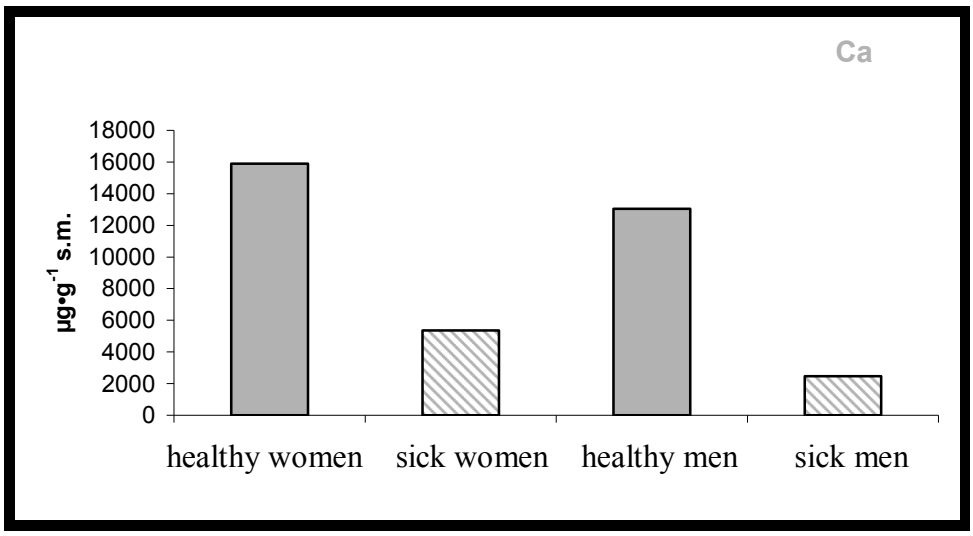

Figure 1 The average contents of calcium in the digestive tract tissues taking from healthy and sick men and women. (µg•g^{-1}d.m.)

Table 1 The calcium content in the gastrointestinal tract tissues taken from healthy and sick men and women . (µg•g^{-1}d.m.)

	HEALTHY WOMEN	SICK WOMEN	HEALTHY MEN	SICK MEN
	494,39	1308,90	4944,56	1042,01
	1180,37	1650,79	1327,18	992,63
	458,01	1319,21	1301,47	965,01
	1078,81	1816,55	719,75	2087,50
	8172,22	910,75	482,00	657,06
	11401,73	1756,06	15276,76	3810,94
	29042,34	777,88	464,72	1665,93
	23941,52	1951,72	17825,99	1045,84
	827,72	1700,71	131494,87	3287,24
	1003,69	2824,13	1259,83	1489,12
	919,27	52262,36	1167,93	655,25
	1053,04	5063,18	585,98	1046,91
	1087,87	621,94	1385,67	3531,57
	4805,64	998,03	420,29	3542,92
	1168,90	1101,22	1359,39	4442,76
	885,08	1002,52	794,12	1197,83
	1550,96	1440,40	804,69	1316,10
	671,00	904,68	983,05	3904,17
	532,89	491,95	861,79	7161,75
	29252,37	948,01	515,78	1545,30
	153050,52	293,60	1113,26	5310,24
	107958,80	1786,54	18239,36	860,24
	51727,00	40770,20	10088,36	463,62
	341,08	5063,18	183525,50	724,18
	5890,20		1216,18	666,36
	1349,86		966,82	1492,51
	774,15		1401,09	798,62
	4308,52		1156,06	1357,01
			1124,76	874,17
			707,91	1588,15
			732,30	17238,37
				1939,98
the aritmetic mean	15890,28	5365,19	13040,24	2459,42
standard deviation	35090,56	12842,82	39469,50	3126,70

Average calcium content is higher in the tissues of the gastrointestinal tract of both healthy women (15890,28 µg•g^{-1}d.m.) and men 13040,24 µg•g^{-1}d.m.), than in tumor tissues of gastrointestinal tract of women (5365,19 µg•g^{-1}d.m.) and men (2459,42 µg•g^{-1}d.m.) (Figure 1, Table 1).

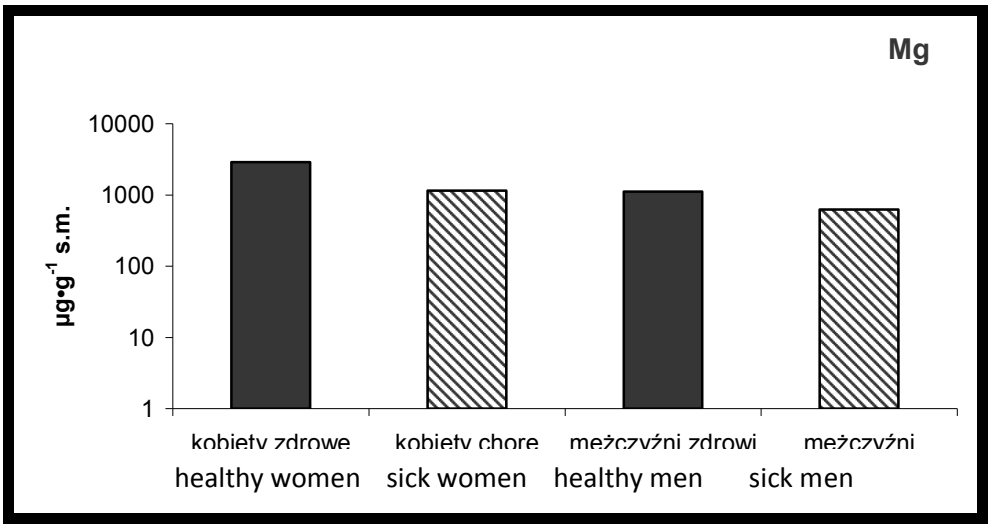

Figure 2 The average contents of magnesium in the digestive tract tissues taking from healthy and sick men and women. (µg•g^{-1}d.m.)

Table 2 The magnesium content in the gastrointestinal tract tissues taken from healthy and sick men and women. (µg•g^{-1}d.m.)

HEALTHY WOMEN	SICK WOMEN	HEALTHY MEN	SICK MEN
362,03	663,13	279,38	386,44
491,53	911,14	420,31	648,87
389,56	718,39	419,06	423,47
388,43	804,60	438,56	377,59
681,36	1536,57	337,26	588,27
6034,52	981,22	550,02	410,51
4023,01	653,56	280,20	423,63
6705,02	1117,50	438,34	569,51
433,25	637,79	377,85	904,05
440,27	1642,05	230,79	351,35
385,14	7543,15	400,96	675,87
473,67	717,33	674,72	535,61
467,27	497,23	556,60	648,87
548,95	881,87	576,09	773,66
452,29	906,08	463,33	622,12
420,52	822,31	476,50	790,23
1161,88	880,03	8620,74	754,99
437,28	730,44	6189,25	2155,18
459,95	844,68	3771,57	1035,97
5747,16	899,00	540,00	502,88
4470,01	219,34	439,67	624,69
33525,10	311,86	576,21	277,45
10057,53	1885,79	458,32	678,99
287,36	717,33	457,81	568,98
547,69		511,31	573,85

	634,95		445,15	585,47
	315,94			413,04
	499,55			453,41
				523,22
				671,90
				447,00
				488,23
the aritmetic mean	2887,19	1146,77	1112,69	621,42
standard deviation	6520,43	1413,54	1995,59	324,97

Average magnesium content is higher in the tissues of the gastrointestinal tract of both healthy women (2887,19 $\mu g \cdot g^{-1}$d.m.) and men (1112,69 $\mu g \cdot g^{-1}$d.m.) than in cancerous tissues both of women (1146,77 $\mu g \cdot g^{-1}$d.m.) and men (621,42 $\mu g \cdot g^{-1}$d.m.) (Figure 2, Table 2).

Mean concentration of calcium was higher in stomach tumor (2185.166 $\mu g \cdot g^{-1}$ dry mass) compared with healthy tissues (999.885 $\mu g \cdot g^{-1}$ dry mass). It shows too low level of this element in healthy tissues of people with cancer, what can induce carcinogenesis in stomach, moreover some results suggested that Ca has protective properties against stomach cancer **(Yang *et al.*, 1998)**. Contrary mean concentration of Ca is higher in adjacent normal tissues of large intestine than in tumor. It is proved that both high dietary intake and supplementation of Ca can decrease risk of large intestine cancer **(Yang *et al.*, 1997, Bennett and Pochapin, 2004)**. Higher level of magnesium in adjacent normal tissues of stomach and large intestine compared with tumor suggested that this metal similarly as Ca has protective function against cancer, but literature data are ambiguous. The oesophageal mucous membrane is characterized by the lowest average calcium content (1006.425 $\mu g \cdot g^{-1}$ d.m.). The large intestine mucous membrane has the highest calcium content, compared to the other sections of the gastrointestinal tract (29922.583 $\mu g \cdot g^{-1}$ d.m.), which corroborates claims about the inhibiting Ca effect on carcinogenesis in large intestine cells (high Ca content in the mucous membrane of healthy persons prevents carcinogenic lesions. The lowest average magnesium value occurs in the oesophageal mucous membrane (401.279 $\mu g \cdot g^{-1}$ d.m.). This value is only slightly higher in the small intestine mucous membrane (476.162 $\mu g \cdot g^{-1}$ d.m.), as the rate of magnesium ion removal is higher than the rate of its absorption from the gastrointestinal tract.

CONCLUSION

Calcium and magnesium were present in the tissues of healthy gastrointestinal tract (esophagus, stomach, small intestine, large intestine) and in tumor tissues (stomach and large intestine). It was shown that differences between calcium content and magnesium content in the tissues of the digestive tract depends on the state of health. Significantly higher contents of Ca and Mg were discovered in the tissues of healthy men and women in comparison to the cancerous tissues both men and women. Magnesium and calcium have a protective properties (prevents the development of cancers of the stomach and colon).

REFERENCES

ALEKSANDROWICZ, J. 1973. *"Metale życia" a ochrona środowiska człowieka.* Warszawa-Kraków: Państwowe Wydawnictwo Naukowe, 1973, p. 9-35.

BENNETT, M. – POCHAPIN M. D. 2004. *Rak jelita grubego*. Poznań: Dom Wydawniczy REBIS, 2004, p. 65-170.

BONDARIEW, L. G. 1989. *Pierwiastki śladowe-dobre i złe zarazem*. Warszawa: Wydawnictwo Czasopism i Książek Technicznych Not-Sigma, 1989, p. 13-26.

DOOLAN, CH. M. – O'SULLIVAN, G. C. – HARVEY, B. J. 1998. Rapid effects of corticosteroids on cytosolic protein kinase C and intracellular calcium concentration in human distal colon. In *Molecular and Cellular Endocrinology*, vol. 138, 1998, no. 1-2, p. 71–79.

Editorial article 2004. Is it just the liver? In *The Journal of Laboratory and Clinical Medicine*. 2004, 144, p.169-172.

GHISHAN, F. K. – ARAB, N. – NYLANDER, W. 1989. Characterization of calcium uptake by brush border membrane vesicles of human small intestine. In *Gastroenterology*, vol. 96, 1989, no1, p. 122-9.

HALPERT R. D. – FECZKO P. J. 2000. *Radiologia przewodu pokarmowego*. Lublin: Wydawnictwo Czelej, 2000, p. 79-296.

KLAUDER, D. S. – PETERING, H. G. 1977. Anemia of lead intoxication: a role for copper. In *Journal of Nutrition*, vol. 107, 1977, no. 10, p. 1779-1785.

KŁOPOTOWSKI, J. 1998. Ostre zatrucia innymi związkami chemicznymi. In BOGDANIK, T. *Toksykologia kliniczna*. Warszawa: Wydawnictwo Lekarskie PZWL, 1998, p. 263-380.

KONTUREK, S. 1990. Układ trawienny. In TRACZYK, W.Z., TRZEBSKI, A. *Fizjologia człowieka z elementami fizjologii stosowanej i klinicznej*. Warszawa: Państwowy Zakład Wydawnictw Lekarskich, 1990, p. 271-342.

KOTYNIA, J. 2006. Rak żołądka. In MAŁECKA-PANAS, E. *Zarys gastroenterologii*. Łódź: Wydawnictwo Uniwersytetu Medycznego, 2006, p. 49-55.

MANAHAN, S. E. 2006. *Toksykologia środowiska, aspekty chemiczne i biochemiczne.* Warszawa: Wydawnictwo Naukowe PWN, 2006, pp. 102-122, 146-176.

PASTERNAK, K. – FLORIAŃCZYK, B. 1995 *Metale życia*. Lublin: Wydawnictwo Folium, 1995, p. 9-32.

SAPOTA, A. 2008. Drogi wchłaniania, metabolizm i wydalanie ksenobiotyków. In PIOTROWSKI, J. K. *Podstawy toksykologii*. Warszawa: Wydawnictwa Naukowo-Techniczne, 2008, p. 63-86.

SZAJKOWSKI, Z. 2001. Reakcja między Mg, Ca i P w żywieniu pracowników fizycznych, umysłowych oraz emerytów. In ORŁOWSKI, J. *Interakcje ksenobiotyków*. Poznań: Dział Wydawnictw Uczelnianych Akademii Medycznej im. Karola Marcinkowskiego, 2001, p. 173-175.

TANAKA, T. 1997. Effect of diet on human carcinogenesis. In *Critical Reviews in Oncology/ Hematology*, vol. 25, 1997, no. 2, p. 73-95.

TRINIDAD, T. P. – WOLEVER, T. M. S. – THOMPSON, L. U. 1999. Effects of calcium concentration acetate, and propionate on calcium absorption in the human distal colon. In: *Nutrition*, vol. 15, 1999, no. 7-8, p. 529-533.

YANG, CH. Y. – CHENG, M. F. – TSAI, S. S. – HSIEH, Y. L. 1998. Calcium, Magnesium, and Nitrate in Drinking Water and Gastric Cancer Mortality. In: *Japanese journal of cancer research : Gann.*, vol. 89,1998, no. 2, p. 124-130.

YANG, CH.Y., CHIU, H.F., CHIU, J.F., TSAI, S.S., CHENG, M.F. 1997. Calcium and Magnesium in Drinking Water and Risk of Death from Colon Cancer. In: *Japanese journal of cancer research : Gann.*, vol. 88, 1997, no. 10, p. 928-933.

ZALEWSKI, T. 2000. Fizjologia rozwojowa przewodu pokarmowego. In ZALEWSKI, T.: *Choroby przewodu pokarmowego*. Warszawa: Akademia Medyczna, 2000, p. 14-29.