Nutrition Research and Practice 2014;8(4):439-444

http://e-nrp.org

Analysis of micromineral contents of school meals

Dongsoon Shin§

Department of Food and Nutritional Science, College of Natural Sciences, Kyungnam University, 7 Kyungnamdaehakro, Masanhappogu, Changwon, Gyeongnam Province 631-701, Korea

BACKGROUND/OBJECTIVES: Korean ordinary diets are referred to be good for human health in worldwide. However it is uncertain whether they provide microminerals enough for growth and health of teenagers. A main purpose of this study was to identify micromineral contents in school meals.
MATERIALS/METHODS: The fifty cuisines were collected from elementary schools and middle schools in Gyeongnam area. The contents of Fe, Zn, Cu and Mn among microminerals were analyzed by using ICP-OES method. Data were expressed as mean, standard deviation and range value and linear regression analysis performed.
RESULTS: Fe level of Pangibuseotpaprika-salad was the highest among side-dishes (average 346.6 μg) and Zn level of Sullung-tang was highest among soups (average 229.1 μg). Cu level of Buchu-kimchi was the highest among kimchies (average 217.5 μg) and Mn level of Gumeunkongyangnyum-gui was highest among side-dishes (average 198.4 μg). Generally cooked-rices as main dish had relative smaller amounts of microminerals than the other cuisines. The results showed that the ratio of Cu : Fe : Zn was approximately 12 : 4 : 1 and the relationship between Fe versus Zn or Fe versus Cu was significantly positive.
CONCLUSION: Comparing to Korean Dietary Recommended Intakes (KDRI) level, school meals provided not sufficient amount (< 25% DRI) of Fe, Zn or Mn, while they did excessive amount (> 125% DRI) of Cu.

Nutrition Research and Practice 2014;8(4):439-444; doi:10.4162/nrp.2014.8.4.439; pISSN 1976-1457 eISSN 2005-6168

Keywords: Microminerals, ICP-OES method, school meals

INTRODUCTION

Minerals in human nutrition are basically required for electrolytes in extracellular and intracellular fluids. Particularly intracellular fluid, the site of major metabolic activities, needs more the maintenance of optimal amount and concentration of minerals [1]. As the life expectancy increase, some chronic diseases are epidemic all around world. Especially, cardiovascular disease, arthritis and diabetes mellitus type II are prevalent in young people as well as in elderly. In recent, these diseases are referred being related with mineral status in the body through immune system [2].

Even though the trace amount of minerals which exist under 100 mg in the body, they perform vital roles for metabolic functions. For example, microminerals such as zinc (Zn), copper (Cu) and iron (Fe) are important for enzyme cofactors, stabilizers of organic molecules or participants in redox reactions. Therefore either a deficit or excess of any of them should be harmful for health [3]. In addition, interaction between minerals may influence their bioavailability, although they are not serious in physiological level. These interactions could lead to nutrient imbalance and increase the need for balanced intake of minerals. For example, intake of Fe and calcium (Ca) represses the absorption of Zn, while Cu intake does not [4,5]. As a matter of fact, a good source of one mineral may be a poor source of another, e.g. meats are rich of Fe, but deficit of Ca [6]. Some studies suggested that Fe, Zn as well as ascorbic acid and carbohydrates influenced Cu bioavailability [7]. Moreover according to species manganese (Mn) could decrease Fe absorption in animals but not humans [8].

Generally Korean ordinary diets are referred to be good for human health in worldwide. However it is uncertain whether they provide microminerals enough for growth and health of teenagers. The aim of this research is to identify the contents of Fe, Zn, Cu and Mn of cuisines and relationship between these microminerals in school meals around Changwon area.

MATERIALS AND METHODS

Materials and pretreatment

The fifty cuisine samples among school meals were collected around Changwon. They were homogenized and stored at -80°C until analysis. For the concentration of Fe, Zn, Cu and Mn, five grams of each sample were incinerated at 600°C to obtain ash and were diluted to 25 ml with 5% (v/v) hydrochloric acid solution.

This work was supported by Kyungnam University Foundation Grant, 2010.
§ Corresponding Author: Dongsoon Shin, TEL. 82-55-249-2347(2901), FAX. 0505-286-2184, E-mail. shinds@kyungnam.ac.kr
Received: March 24, 2014, Revised: April 18, 2014, Accepted: April 18, 2014

Table 1. Micromineral contents per serving size in school meals

Meal menu	Cuisine Sample[2)]	Serving size (g)	Micromineral (μg)			
			Fe	Zn	Cu	Mn
Cooked rices (including myen & juk)	Ssal-bab	146.0	-	-	-	-[ND]
	Yulmu-bab	146.0	22.44 ± 1.64[1)]	44.61 ± 4.33	42.64 ± 1.22	21.86 ± 0.52
	Kongnamul-bab	149.0	28.55 ± 1.97	26.96 ± 5.29	5.83 ± 0.40	8.79 ± 0.64
	Youlmuchaesobibim-bab	149.0	147.01 ± 3.51	67.20 ± 8.28	5.47 ± 0.62	20.67 ± 1.26
	Zazang-myen	150.0	120.87 ± 7.19	50.57 ± 16.59	49.96 ± 1.68	7.62 ± 1.98
	Omelet-rice	181.0	73.31 ± 3.77	36.20 ± 13.84	5.67 ± 0.75	13.45 ± 1.00
	Shoegogijangguk-juk	248.0	162.52 ± 11.58	154.21 ± 39.39	48.65 ± 2.04	28.53 ± 3.78
	Youlmubibim-bab	254.0	115.50 ± 4.51	43.08 ± 12.22	9.43 ± 0.83	21.59 ± 1.58
	Average	177.9	95.74	60.41	23.95	17.50
	SD	46.65	55.53	43.20	21.80	7.72
Soups (guk & tang)	Yubumu-guk	194.0	202.75 ± 21.99	63.60 ± 18.20	2.26 ± 1.08	94.93 ± 10.38
	Yukgaejang	207.0	230.75 ± 23.27	179.24 ± 34.51	35.57 ± 0.76	70.64 ± 7.65
	Gamja-tang	230.0	105.90 ± 10.91	115.17 ± 24.69	14.33 ± 0.59	14.35 ± 2.59
	Doejigogikimchi-jigae	235.0	135.49 ± 14.33	112.18 ± 26.02	14.70 ± 1.04	16.81 ± 3.61
	Hanwuyukgaejang	238.0	282.24 ± 30.74	287.41 ± 58.26	32.04 ± 0.54	30.91 ± 4.80
	Dubudoenjang-guk	242.0	387.19 ± 40.52	181.52 ± 40.91	48.63 ± 2.16	156.80 ± 15.96
	Shoegogi-soup	242.5	69.18 ± 7.73	109.37 ± 24.97	10.62 ± 0.94	18.66 ± 3.35
	Shoegogimu-guk	249.0	273.84 ± 27.50	227.28 ± 51.62	133.43 ± 0.54	5.57 ± 3.20
	Hanbangsamgae-tang	250.0	95.96 ± 10.31	108.58 ± 28.03	17.04 ± 1.24	33.69 ± 5.50
	Urukmaewun-tang	250.0	212.81 ± 21.77	75.56 ± 21.63	15.13 ± 1.32	84.65 ± 10.02
	Gunsaewuawug-guk	250.0	1,571.15 ± 177.89	642.47 ± 146.31	132.74 ± 45.59	76.88 ± 50.38
	Youndubudoenjang-guk	250.0	142.51 ± 14.52	50.30 ± 18.63	19.98 ± 1.02	58.67 ± 7.08
	Sullung-tang	252.0	572.79 ± 53.58	1,132.32 ± 216.59	48.46 ± 3.34	20.45 ± 8.41
	Kimchikongnamul-guk	252.0	366.13 ± 37.20	101.56 ± 25.97	32.65 ± 1.24	89.70 ± 9.59
	Sonmandu-guk	346.0	117.94 ± 11.06	49.15 ± 15.29	16.98 ± 1.03	25.47 ± 4.24
	Average	245.8	317.77	229.05	38.31	53.21
	SD	32.56	372.05	290.56	40.74	42.01
Side dishes	Haebalagissimyelchi-bokkum	146.0	296.32 ± 9.79[1)]	74.41 ± 4.45	22.93 ± 0.20	9.04 ± 1.09
	Gangnangkong-jorim	153.0	141.40 ± 14.90	45.64 ± 12.73	46.69 ± 1.16	22.49 ± 3.26
	Gumeunkongyangnyum-gui	194.5	1,072.08 ± 0.00	10.13 ± 0.00	86.22 ± 0.00	4,134.04 ± 0.07
	Pangibuseotpaprika-salad	198.0	3,733.21 ± 437.42	496.19 ± 99.07	855.57 ± 28.37	224.75 ± 23.18
	Nokchasamgyubsal-gui	199.0	169.75 ± 4.08	294.62 ± 6.45	605.28 ± 7.71	22.35 ± 1.57
	Ddukbokki	200.0	19.29 ± 4.50	17.29 ± 7.59	52.55 ± 1.37	2.66 ± 1.73
	Gochujangbulgogi	200.0	134.87 ± 3.87	194.46 ± 7.41	111.64 ± 2.44	13.12 ± 1.33
	Haeparinaengche	200.0	57.14 ± 3.65	13.51 ± 10.90	44.91 ± 0.90	3.27 ± 1.26
	Yimyunsoo-gui	200.5	69.43 ± 3.37	34.71 ± 8.77	75.92 ± 1.88	1.00 ± 0.97
	Kodarimu-jorim	203.0	55.66 ± 8.26	18.09 ± 8.23	3.72 ± 0.51	9.20 ± 2.23
	Gamjabumbuk	204.0	119.33 ± 4.67	22.33 ± 12.54	31.22 ± 1.00	5.05 ± 1.43
	Sigeumchi-namul	204.0	302.09 ± 8.72	162.44 ± 5.86	183.20 ± 1.99	74.82 ± 2.62
	Bulnag-bokkum	207.0	130.47 ± 5.65	74.48 ± 13.44	53.02 ± 1.10	13.93 ± 1.83
	Jogiyangnyum-gui	209.0	66.40 ± 8.34	44.29 ± 11.26	36.61 ± 0.20	4.08 ± 1.34
	Dongas	211.5	65.87 ± 4.94	13.09 ± 15.75	3.27 ± 0.97	1.20 ± 1.61
	Gochumechurial-jorim	213.0	391.74 ± 8.56	96.70 ± 6.52	36.80 ± 0.56	5.10 ± 0.83
	Gogumajulgigalchi-jorim	226.0	40.07 ± 2.31	20.20 ± 8.12	5.58 ± 0.32	16.35 ± 0.91
	Kongnipji	234.0	471.23 ± 15.36	25.73 ± 12.03	23.91 ± 0.23	49.09 ± 2.61
	Dubuyangnyum-jorim	243.0	539.66 ± 11.84	214.30 ± 15.04	17.28 ± 0.85	184.75 ± 3.55
	Samgyubsaljukkumi-bokkum	247.0	306.30 ± 13.10	79.98 ± 7.04	18.03 ± 0.33	17.17 ± 1.77
	Bibimmandu	248.0	49.03 ± 3.09	9.61 ± 10.45	2.70 ± 0.48	12.39 ± 1.00
	Hobag-namul	249.0	154.34 ± 7.20	42.30 ± 8.49	71.28 ± 1.23	45.53 ± 2.53
	Dagdari-jorim	249.0	82.73 ± 3.36	15.89 ± 5.46	14.24 ± 0.31	44.88 ± 2.08
	Mugeunkimchidotorimuk-muchim	255.0	152.79 ± 7.21	33.70 ± 13.19	26.36 ± 0.32	29.89 ± 2.52
	Gungjungddukbokkijabche	258.0	44.71 ± 3.42	74.11 ± 8.27	124.44 ± 1.56	13.08 ± 1.56
	Average	214.1	346.64	85.13	102.13	198.29
	SD	28.92	741.63	112.82	197.22	821.75

Table 1. continued

Meal menu	Cuisine Sample[2)]	Serving size (g)	Micromineral (μg)			
			Fe	Zn	Cu	Mn
Kimchies	Ggaenip-kimchi	176.0	715.62 ± 7.29	93.81 ± 19.13	79.78 ± 1.70	152.50 ± 2.91
	Buchu-kimchi	200.0	187.81 ± 1.67	69.09 ± 7.05	966.27 ± 26.06	42.89 ± 1.19
	Baechu-kimchi	212.0	165.84 ± 3.09	40.67 ± 12.29	25.44 ± 1.35	22.94 ± 0.95
	Youlmu-kimchi	248.0	183.07 ± 5.12	60.53 ± 8.41	12.63 ± 0.95	18.60 ± 1.33
	Mugeunkimchi-muchim	304.0	36.32 ± 1.67	8.59 ± 3.72	3.35 ± 0.51	2.28 ± 0.55
	Average	228.0	257.73	54.54	217.49	47.84
	SD	49.80	263.44	31.99	419.62	60.27

[1)] Mean ± SD
[-] not detectable
[2)] Each ending of Korean cuisine name is referred as cooking method described within parenthesis; -bab (cooked rice), -myen (cooked noodle), -zuk (porridge, gruel), -guk (juicy soup), -tang or -jang (thick soup), -jjigae (stewed with various ingredient), -bokkum (stir-fried), -jorim (hard boiled in spicy soy sauce), -gui (baked), -muchim (seasoned), -namul (seasoned vegetables in usual) etc.

Analytical methods

The diluted sample were run by inductively coupled plasma optical emission spectrometry (ICP-OES) using Perkin-Elmer Optima 3,000DV (Waltham, USA) at the Center for Instrumental Analysis in Kyungnam University. Absorbance for Fe, Zn, Cu and Mn were read at 238.2 nm, 257.6 nm, 327.4 nm, 206.2 nm respectively. To verify analysis accuracy, the standard mineral preparations were run every consecutive experiment and replicated three times per sample. All chemicals used were the product of Junsei Chemical Co. Ltd. (Tokyo, Japan).

Statistics

Using SPSS Statistics 14.0K (IBM, Chicago, USA), descriptive statistics were carried for all variables. The data were expressed as mean and standard deviation, percentage (%) as well as range value from minimum to maximum. And linear regression analysis was performed to determine the relationship between microminerals.

RESULTS

The amount of microminerals was expressed with unit as ug per one serving size of cuisine categorized into four groups as cooked-rice, soup, kimchi and side-dish (Table 1, Fig. 1).

The quantitative contribution of minerals to school meal and %DRI of each microminerals were obtained (Fig. 2). Linear regression showing for relationship between microminerals in all cuisines was expressed in Fig. 3.

The amount of microminerals per serving size of cuisines.

The range of Fe contents per serving size of cuisines was 22.4-3373.2 μg. Among all cuisines Fe level of Pangi-buseotpaprika-salad was the highest, while that of Yulmu-bab was the lowest. In average, Fe level was higher in side-dishes (346.6 μg) than other three cuisine groups. (Fig. 1) The range of Zn contents per serving size of cuisines was 8.6-1,312.3 μg. Among all cuisines, Sullung-tang had the highest Zn value, while Mugeungikimchi-muchim had the lowest. The average Zn level was higher in soup (229.1 μg) than in other groups. The range of Cu contents per serving size of cuisines was 2.3-966.3 μg. Among all cuisines, Buchu-kimchi showed the highest Cu level, while Yubumu-guk showed the lowest. In average, Cu level was higher in kimchi (217.5 μg) than other cuisine groups. The range of Mn contents per serving size of cuisines was 1.0-4,134.0 μg. Among all cuisines, Gumeunkongyangnyum-gui had the highest Mn value, while Yimyunsoo-gui showed the lowest. In average, Mn level was higher in side-dishes (198.4 μg) than other three cuisine groups.

Regarding to Ssal-bab in cooked rice group, there remained no ash after incineration and not detected any minerals.

The ratio of microminerals and % DRI of cuisines in school meals.

Regarding to micromineral contribution of cuisines to those of total diet in school meals, the results showed that each cuisine seems to provide one or two specific microminerals to cooked-rice (Fig. 2). Cooked rices containing relatively a small amounts of microminerals might be supplemented Cu from kimchi, Mn from side-dishes, Zn from soup and Fe from these all three cuisines. Comparing to Korean Dietary Recommended Intakes (KDRI) level of microminerals, school meals have provided insufficient amount (< 25% DRI) of Fe, Zn or Mn, but excessive amount (> 125% DRI) of Cu.

The relationship between microminerals in school meals

Using linear regression, two significant positive relationships were found between Fe versus Zn, and Fe versus Cu in all cuisines. Their coefficient of determinant (R^2) was 24.2%, 28.6%, respectively. Interestingly these graphs show that the ratio of Cu to Fe is 3.13, and that of Zn to Fe is 0.25, and so the ratio of Cu : Fe : Zn are approximately 12: 4 : 1. Therefore it is suggested that through school meals the student may consume twelve folds cooper and four folds iron as if intake of zinc increases. The main sources of these minerals were Buchu-kimchi, Pangibuseotpaprika-salad or Nockchasamgyubsal-gui (Fig. 3).

DISCUSSION

During the past century researchers had focused on the effect of nutrition on the control of diseases induced from malnutrition involving the immune response and its modifying agents [9,10]. In recent several studies have reported that the some relationship between minerals, vitamins or phytochemicals and development of some chronic diseases such as cardiovascular

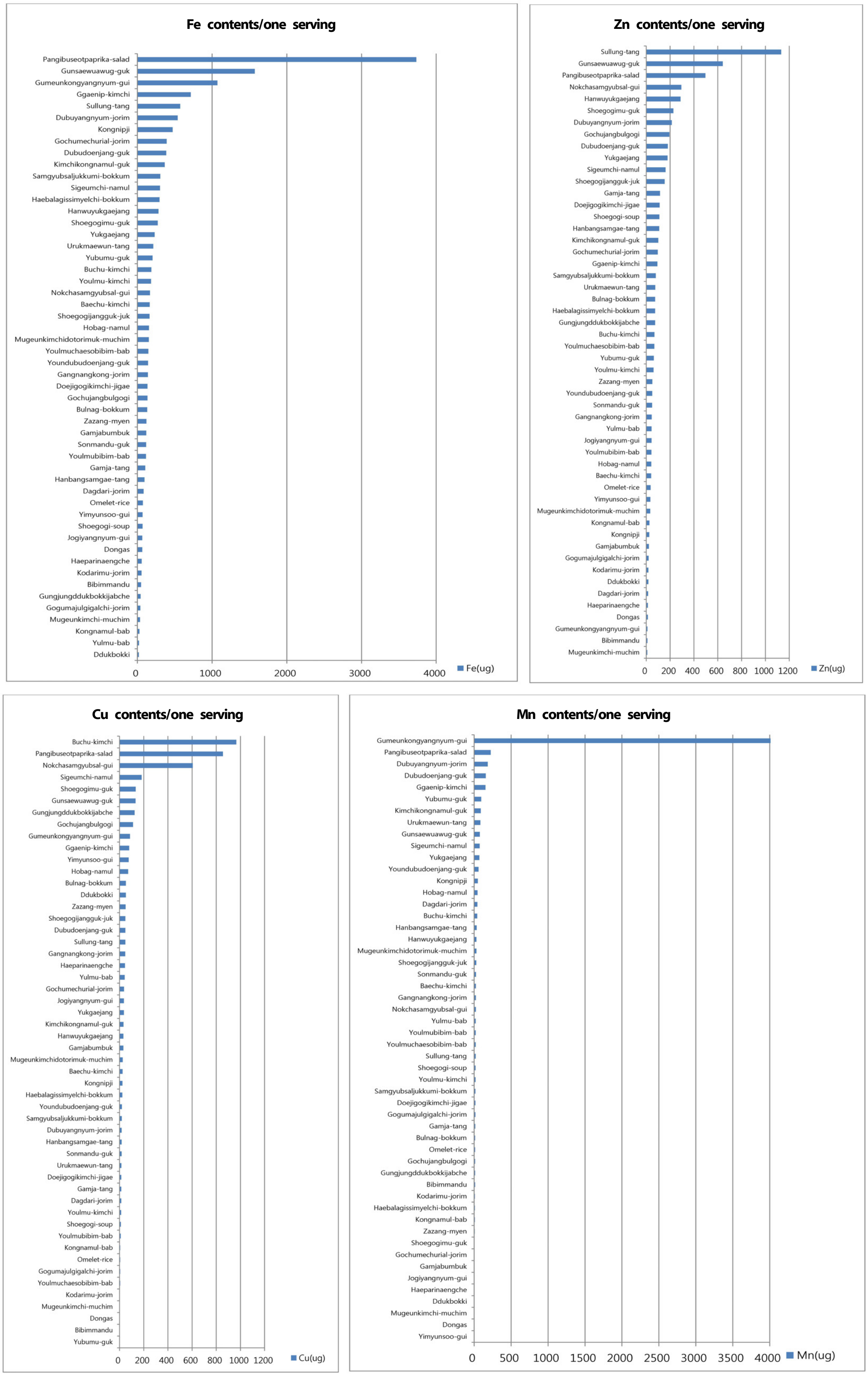

Fig. 1. Micromineral contents per serving size of school meals

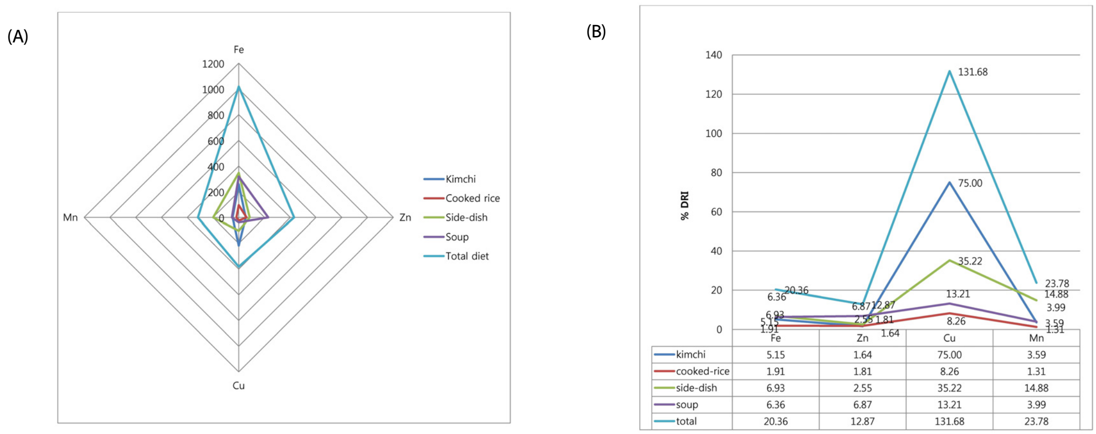

Fig. 2. Contribution of each cuisine to total amounts and % DRI of Fe, Zn, Cu & Mn in school meals. (A) Micromineral amounts (μg), (B) % DRI of each micromineral

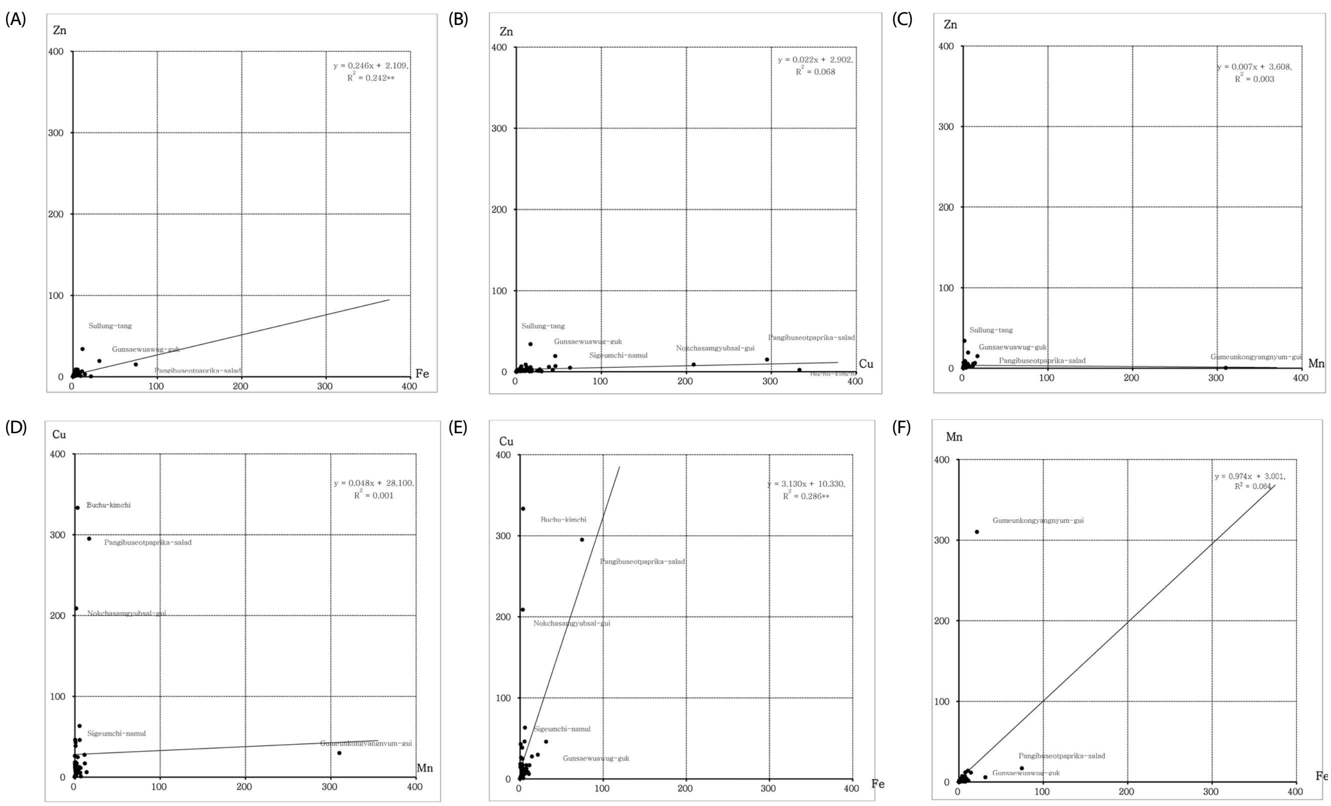

Fig. 3. Relationship between microminerals in school meals. (A) Fe & Zn, (B) Cu & Zn, (C) Mn & Zn, (D) Mn & Cu, (E) Fe & Cu, (F) Fe & Mn. The unit of all microminerals is percentage of DRI (% DRI).

disease and diabetes mellitus are intimately existed [11-13]. These two diseases are associated with obesity which is referred a stimulator to produce and secret pro-inflammatory cytokines TNF-a, IL-6, but to reduce anti-inflammatory cytokines like adiponectin.[14]. Inflammation is a kind of catabolic mechanism to keep body weight within acceptable range [6] or a kind of immune responses against obesity [15]. In immune system, relations between Fe, Zn, Cu and Mn are interconnected primarily through antioxidant function. In general these microminerals are important for enzyme cofactors, stabilizers of organic molecules or participants in redox reactions [16]. Fe is existed under 100 mg in the body, and one of the antioxidants which function to make metabolite being reduced states [17]. Zn is needed for enzymes as many two hundred or more to function in the body [18]. Those functions are related to DNA or RNA synthesis, cell growth and development, antioxidants defenses, immune function and acid-base balance for maintaining optimal health. And Cu is essential for energy metabolism, neurotransmitter regulation, collagen synthesis, and for antioxidant defense against free radicals. Deficiencies of Cu are associated with accelerated bone mineral loss and increased blood pressure and cholesterol levels. Higher doses of Cu may lead liver damage, coma and death. Mn is a cofactor for many enzymes with importance for carbohydrate metabolism, protein digestion and metabolism, biotin function, cartilage regeneration, and free radical defense. Mn deficiency causes decreased fertility, higher susceptibility to seizures, and bone fractures. The toxicities of ingested Mn result in tremor, delayed movement, and rigidity due to nervous damage [17].

Still there are some informational gaps about the role of micronutrients in human health and lacks of studies on biological endpoints that reflect sufficient or insufficient body stores of them. In addition there should be needed to identify and quantify the effects of interactions between micronutrients and interactions between micronutrients and other food components, the food matrix, food processing such as cooking [19-22].

In this study Fe and Zn contents in soups were almost double of those in kimchies and side-dishes, and that of cooked rice with grains was the lowest among all foods. The Mn content was also higher in kimchies and side-dishes than in cooked rice with grains as well as in soup. In side-dishes, Mn content was high, but Cu content was relatively low. However comparing to Korean Dietary Reference Intakes (KDRI) level of microminerals, average school meal as a lunch set provided insufficient supply (< 25% DRI) of Fe, Zn or Mn, but did excess (> 125% DRI) of Cu, especially from kimchies. All these results could be applicable as a fundamental data estimating optimal micromineral contents and their relative ratios in typical school meals for healthy adolescents.

In conclusion, the contents of Fe, Zn and Mn provided from school meals were not sufficient for teenagers in Gyeongnam area. In contrast Cu contents were excess when compared with KDRI for both 9-11 year-old and 12-14 year-old students. Moreover the results showed that students consumed twelve folds of Cu and four folds of Fe as their intake of Zn increase. Therefore in the field of school meal, substantial alterations to the menus should be considered to ensure the nutrient value of cuisines in the future. At the same time, it should be the right time to think over on determining the dietary reference intakes of microminerals as well as their relative ratios for Korean teenagers.

ACKNOWLEDGMENTS

I appreciated to M. Choi and M. Park for their help for collecting and pretreatment of food samples in this study.

REFERENCES

1. Oh MS, Uribarri J. Electrolytes, water, and acid-base balance. In: Shils ME, Shike M, Ross AC, Caballero B, Cousins RJ, editors. Modern Nutrition in Health and Disease. 10th ed. Philadelphia(PA): Lippincott Williams & Wilkins; 2006. p.149.
2. Moreira DC, de Sá JS, Cerqueira IB, Oliveira AP, Morgano MA, Quintaes KD. Evaluation of iron, zinc, copper, manganese and selenium in oral hospital diets. Clin Nutr. Forthcoming 2013.
3. McArdle MA, Finucane OM, Connaughton RM, McMorrow AM, Roche HM. Mechanisms of obesity-induced inflammation and insulin resistance: insights into the emerging role of nutritional strategies. Front Endocrinol (Lausanne) 2013;4:52.
4. Whitney EN, Cataldo CB, Rolfes SR. Understanding Normal and Clinical Nutrition. 6th ed. Belmont (CA): Wadsworth; 2002.
5. August D, Janghorbani M, Young VR. Determination of zinc and copper absorption at three dietary Zn-Cu ratios by using stable isotope methods in young adult and elderly subjects. Am J Clin Nutr 1989;50:1457-63.
6. Solomons NW, Jacob RA. Studies on the bioavailability of zinc in humans: effects of heme and nonheme iron on the absorption of zinc. Am J Clin Nutr 1981;34:475-82.
7. Turnlund JR, Scott KC, Peiffer GL, Jang AM, Keyes WR, Keen CL, Sakanashi TM. Copper status of young men consuming a low-copper diet. Am J Clin Nutr 1997;65:72-8.
8. Finley JW. Manganese absorption and retention by young women is associated with serum ferritin concentration. Am J Clin Nutr 1999;70:37-43.
9. Feigin RD. Interaction of nutrition and infection: plans for future research. Am J Clin Nutr 1977;30:1553-63.
10. Cunningham-Rundles S. Effects of nutritional status on immunological function. Am J Clin Nutr 1982;35:1202-10.
11. Champagne CM. Magnesium in hypertension, cardiovascular disease, metabolic syndrome, and other conditions: a review. Nutr Clin Pract 2008;23:142-51.
12. de Oliveira Otto MC, Alonso A, Lee DH, Delclos GL, Jenny NS, Jiang R, Lima JA, Symanski E, Jacobs DR Jr, Nettleton JA. Dietary micronutrient intakes are associated with markers of inflammation but not with markers of subclinical atherosclerosis. J Nutr 2011;141:1508-15.
13. Emanuela F, Grazia M, Marco de R, Maria Paola L, Giorgio F, Marco B. Inflammation as a link between obesity and metabolic syndrome. J Nutr Metab 2012;2012:476380.
14. Aljada A, Mohanty P, Ghanim H, Abdo T, Tripathy D, Chaudhuri A, Dandona P. Increase in intranuclear nuclear factor κB and decrease in inhibitor κB in mononuclear cells after a mixed meal: evidence for a proinflammatory effect. Am J Clin Nutr 2004;79: 682-90.
15. Wellen KE, Hotamisligil GS. Inflammation, stress, and diabetes. J Clin Invest 2005;115:1111-9.
16. Hatada EN, Krappmann D, Scheidereit C. NF-κB and the innate immune response. Curr Opin Immunol 2000;12:52-8.
17. Fleet JC, Replogle R, Salt DE. Systems genetics of mineral metabolism. J Nutr 2011;141:520-5.
18. Gropper SS, Smith JL, Groff JL. Microminetals. In: Gropper SS, Smith JL, Groff JL, editors. Advanced Nutrition and Human Metabolism. 5th ed. Belmont (CA): Wadsworth/Cengage Learning; 2009. p.469-525.
19. Wardlaw GM, Hampl JS, DiSilvestro RA. Trace minerals. In: Wardlaw GM, Hampl JS, DiSilvestro RA, editors. Perspectives in Nutrition. 6th ed. New York (NY): McGrawHill; 2004. p.413-44.
20. de Oliveira Otto MC, Alonso A, Lee DH, Delclos GL, Jenny NS, Jiang R, Lima JA, Symanski E, Jacobs DR Jr, Nettleton JA. Dietary micronutrient intakes are associated with markers of inflammation but not with markers of subclinical atherosclerosis. J Nutr 2011; 141:1508-15.
21. Lönnerdal B. Dietary factors influencing zinc absorption. J Nutr 2000;130:1378S-83.
22. Harvey LJ, McArdle HJ. Biomarkers of copper status: a brief update. Br J Nutr 2008;99 Suppl 3:S10-3.