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Cooking Losses of Minerals in Foods and Its Nutritional Significance

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Summary To clarify the cooking losses of minerals (sodium, potassium, phosphorus, calcium, magnesium, iron, zinc, manganese, copper), various food materials were analyzed before and after cooking, and the following results were obtained. (1) The mineral contents of cooked foods in mass cooking were on an average about 60–70 percent of those in raw or uncooked foods. (2) Cooking losses were particularly high in minerals of vegetables. (3) Among various cooking methods, loss of mineral was largest in squeezing after boil and in soaking in water after thin slice, followed by parching, frying and stewing. (4) Cooking losses of minerals in meals cooked in home brought about the similar results as those by the mass cooking procedures. (5) The measures to prevent cooking loss are (a) eating the boiled food with the soup, (b) addition of small amount of salt (about 1% NaCl) in boiling, (c) avoidance of too much boiling, (d) selection of a cooking method causing less mineral loss (stewing, frying or parching).

Key Words cooking loss, mineral, sodium, potassium, calcium, magnesium, iron, zinc, copper, manganese

Nutritional importance of mineral in mammals has been known, and currently, some trace elements have been recognized to be of nutritional importance, for example, cardiovascular disease caused magnesium deficiency (*1*), dermatitis or gustatory decline caused by zinc deficiency (*2*), anemia caused by copper deficiency (*3*) etc. These mineral are only obtained by extragenous source, that is from diets. But in Japan, the recommended allowance of mineral intakes are not yet set up except iron and calcium. Reports on mineral intake of Japanese are not found so much (*4–10*). On the other hand, it is considered that cooking causes much loss of minerals from food stuff as is the case of water soluble vitamins (*11–14*). Thus all minerals contained in food materials is not available from prepared diets. There is few reports on cooking losses of minerals (*15, 16*), especially on trace elements.

In this report, cooking lossess of minerals (Na, K, P, Ca, Mg, Fe, Zn, Cu, Mn) by different cooking methods are demonstrated.

MATERIALS AND METHODS

Materials. (I) Mineral loss in mass cooking: Eight meals from primary school lunch and 6 meals from university cafeteria in Kyoto, Japan and materials of these meals before cooking were selected as the sample for mineral analyses of mass cooking.

(II) Mineral loss in home cooking: Five meals were cooked in home on the same menu of the mass cooking. Brosilicate glass panns were used in all experiments to avoid exogenous mineral contamination.

(III) Mineral loss of rice: Three kinds of cooked rice from primary school lunch, 2 kinds of cooked rice from university refectory, 2 kinds of rice cooked in home, half-cooked packed rice, pre cooked rice, and rice soaked in water before boiling were prepared for mineral analyses.

(IV) Mineral loss of pork and spinach cooked by different cooking methods, as shown Table 1.

Determination method of mineral. The materials were homogenized by mixer after addition of double distilled water (about 500–1,000 ml in total volume). A part of the homogenate (25–50 ml) was put into the Kjeldahl flask containing nitric acid and then digested by heating. After half digestion perchloric acid was added, and heated again to make color less solution. Na, K, Ca, Mg, Fe, Zn, Cu and Mn concentrations were measured using the atomic absorption spectrophotometer (Shimadzu Co., Kyoto Japan). P was measured by Chen's method (*17*).

RESULTS AND DISCUSSION

Mineral loss in mass cooking

Sodium, potassium, phosphorus, calcium, magnesium, iron, zinc, manganese and copper concentrations of primary school lunch and meals of university cafeteria and materials of these meals before cooking are shown in Table 2.

The ranges of cooking loses in these mineral were 0–85%, and sometimes iron concentration showed higher than pre-cooked value. This phenomena may be caused by contamination from pan used in cooking. Cooking loss was particularly high in minerals of vegetables, and largest in squeezing after boiling and thin slice soaked in water, followed by parching, frying and stewing.

Mineral loss in home cooking

The cooking losses of minerals in meals cooked in home brought about the similar results as those by the mass cooking procedures as shown in Table 2. These range were 0–71% and average cooking losses was 24%.

Mineral loss in rice

The mineral concentrations in several cooked rice for primary school lunch

Table 1. Experimental materials and methods.

(I) Cooking loss at mass cooking
- 8 kinds of menu in school lunch
  - a) boiled potato and meat
  - b) boiled spinach and bean sprout
  - c) boiled fish cake and konnyaku
  - d) soured cucumber
  - e) curry stew
  - f) fried spinach mackerel
  - g) salad
  - h) fried egg
- 6 kinds of meals served at university refectory
  - a) boiled mackerel
  - b) hamburgersteak 1
  - c) hamburgersteak 2
  - d) boiled hijiki
  - e) miso soup
  - f) soured fried sardine

(II) Cooking loss at home cooking
- 5 kinds of meals cooked at home
  - a) boiled mackerel
  - b) hamburgersteak 1
  - c) curry stew
  - d) boiled hijiki
  - e) vegetable salad

(III) Cooking loss of rice
- 5 kinds of rice and cooked rice
  - a) rice R at university refectory
  - b) rice S at university refectory
  - c) rice A at school lunch
  - d) rice B at school lunch
  - e) rice C at school lunch

(IV) Cooking losses in pork and spinach in various methods at model experiment
- a) cooking methods of spinach
  - raw
  - raw thin slice soaked in water (30 min)
  - parch from raw (2 min)
  - parch after boil (2 min)
  - boil in distilled water (1 min)
  - boil in distilled water (2 min)
  - boil in distilled water (3 min)
  - boil in 1% NaCl solution (3 min)
  - boil in 5% vinegar solution (3 min)
  - steam heat (4 min)
  - micro-wave heat (200 watt, 80 sec)
  - micro-wave heat (600 watt, 40 sec)
- b) cooking methods of pork
  - raw
  - parch thin slice (2 mm slice, 2 min)
  - patch thick slice (1 cm slice, 2 min)
  - boil in distilled water (2 mm slice, min)
  - boil in tap water (2 mm slice, 2 min)
  - boil in 1% NaCl solution (2 mm slice, 2 min)
  - boil in 5% vinegar solution (2 mm slice, 2 min)
  - boil with soy sauce (50 g block, 80 min)
  - stewing (50 g block, 240 min)
  - boil with high pressure pan (50 g block, 10 min)
  - fry without flour (1 cm slice, 90 sec)
  - fry with wet flour (1 cm slice, 90 sec)
  - steam heat (1 cm slice, 90 sec)
  - macro-wave heat (50 g block, 200 watt, heat 90 sec)
  - micro-wave heat (50 g block, 600 watt, heat 60 sec)

Table 2. Changes of mineral contents in various menu before and after cooking.

Menu		Na (mg)	K (mg)	P (mg)	Ca (mg)	Mg (mg)	Fe (mg)	Zn (mg)	Mn (μg)	Cu (μg)	Average (%)
Mass cooking process (primary school)											
boiled potato &		460	500	79	2.3	16	.7	.8	83	120	
meat	loss (%)	27	2	10	34	20	19	50	64	29	29
boiled spinach &		360	140	43	33	24	.66	1.2	320	100	
bean sprout	loss (%)	22	55	28	8	47	6	8	14	52	27
boiled fish cake &		980	230	75	15	15	.62	.6	240	46	
konnyaku	loss (%)	2	15	23	6	0	6	40	25	4	13
soured cucumber		500	340	6.5	10	17	.23	.41	40	71	
	loss (%)	35	39	35	23	60	67	21	69	18	41
curry stew		980	800	150	43	23	.79	2.0	400	140	
	loss (%)	11	11	6	36	4	10	9	5	18	12
fried mackerel		310	160	100	31	11	.28	.31	83	48	
	loss (%)	45	16	17	11	8	36	21	20	9	21
china style salad		590	150	24	13	8.4	.35	.40	150	48	
	loss (%)	2	27	31	43	14	20	0	17	41	22
fried egg		360	320	140	13	14	.53	.53	180	58	
	loss (%)	0	11	7	28	22	40	51	49	52	29
Average cooking	loss (%)	18	22	20	24	22	25	25	33	28	24
Mass cooking process (university refectory)											
broiled mackerel		580	380	190	3	17	.59	.6	36	72	
	loss (%)	8	30	10	79	19	18	40	40	26	32
hamburgersteak 1		1400	220	220	26	25	1.5	2.2	350	62	
	loss (%)	12	50	4	7	31	17	61	27	69	31
hamburgersteak 2		230	190	82	2.4	9.6	2.0	1.8	104	72	
	loss (%)	42	24	12	4	4	−80	5	4	6	2
moiled hijiki		800	190	27	65	34	1.8	.3	403	25	
	loss (%)	33	79	67	57	56	−50	85	54	74	54
miso soup		520	86	29	14	8.7	.85	.29	130	110	
	loss (%)	26	46	49	69	42	−165	41	40	8	17
soured fried		440	170	100	14	16	.47	.91	90	74	
sardine	loss (%)	33	32	17	7	6	69	−75	1	38	14
Average cooking	loss (%)	26	43	26	37	26	−32	26	28	37	25

and university refectory are determined. Figure 1 shows a part of results.

Cooking losses of magnesium and manganese in rice were largest, followed by phosphorus, copper and potassium. A large part of cooking loss in rice was brought about by soaking in water and washing, in addition of boiling.

But, sodium, calcium and iron contents increased over than pre-cooked rice. Table 3 shows mineral contents of tap water. Sodium, potassium, calcium, magnesium iron and zinc were found, and between them sodium and calcium were

Table 2. (continued)

Menu		Na (mg)	K (mg)	P (mg)	Ca (mg)	Mg (mg)	Fe (mg)	Zn (mg)	Mn (μg)	Cu (μg)	Average (%)
Home cooking process											
broiled mackerel		599	298	94	1.5	28	.58	.46	—	49	
	loss (%)	30	20	38	21	59	2	39	—	12	28
hamburgersteak 1		218	87	43	2.1	6.9	.54	.76	—	32	
	loss (%)	54	67	66	47	59	46	71	—	41	56
curry stew		1030	348	134	42	9.8	.93	1.5	—	109	
	loss (%)	14	8	6	19	1	22	17		5	8
boiled hijiki		1037	469	57	60	39	.39	.14	—	43	
	loss (%)	19	3	0	9	33	52	61	—	4	23
salad		215	271	16	215	7.3	.29	.25	79	33	
	loss (%)	30	13	16	30	12	17	0	25	49	21
Average cooking	loss (%)	29	5	25	25	33	28	38	25	22	24

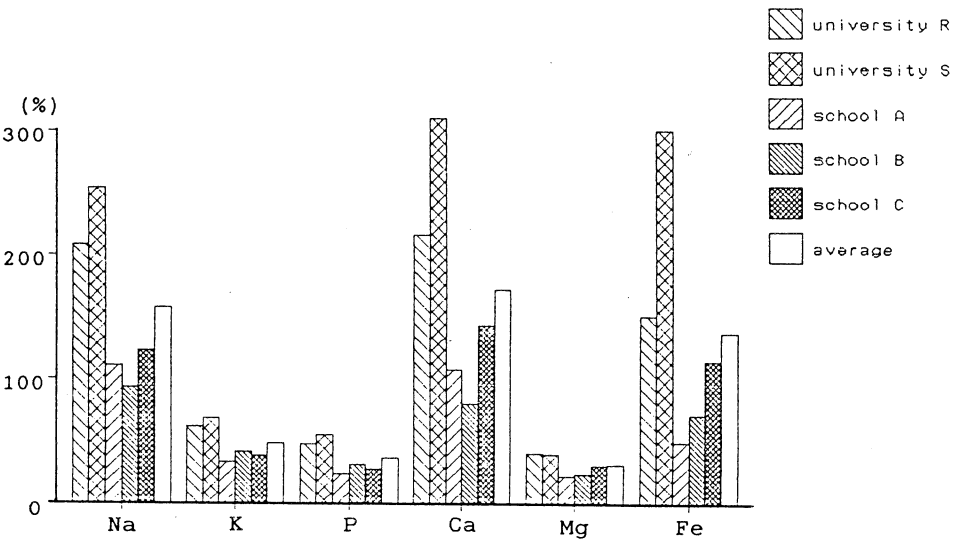

Fig. 1. Remain percentage of mineral content in rice after cooking.

especially high. From this fact, these phenomena may be caused by contamination of tap water or pan used for cooking.

Model experiments for mineral losses of pork and spinach cooked by different cooking methods

Mineral contents of spinach and pork in pre- and post-cooked sample by different cooking methods are shown in Tables 4 and 5.

Table 3. Mineral contents of tap water. (ppm)

	Na	K	P	Ca	Mg	Fe	Zn	Mn	Cu
tap water A	9.7	1.8	—	13.0	2.5	0.12	0.022	—	—
tap water B	15.0	1.6	—	2.6	3.2	—	0.22	—	—

Table 4. Cooking losses of minerals in spinach by various cooking methods.

Cooking method		Na	K	Ca	Mg	Fe	Zn (mg/100 g)
raw		16	490	25	35	1.7	0.23
raw thin slice dipped		5.1	255	18	17	0.16	0.1
in water	loss (%)	68.1	48.0	28.0	51.4	90.6	56.5
parch from raw		11	247	19	17	0.2	0.15
	loss (%)	31.3	49.6	24.0	51.4	88.2	34.0
parch after boil		7.6	208	6.3	6.0	0.15	0.13
	loss (%)	52.5	57.6	74.8	82.9	91.2	43.5
boil (1 min)		7.5	208	19	8.3	0.47	0.11
	loss (%)	53.1	57.6	24.0	76.3	72.4	52.2
boil (2 min)		4.5	137	17	5.8	0.24	0.1
	loss (%)	71.9	72.0	32.0	83.4	85.9	56.5
boil (3 min)		6.9	135	10	4.5	1.2	0.12
	loss (%)	56.9	72.4	60.0	87.1	29.4	47.8
boil in 1% NaCl		12.0	206	11.0	7.9	0.25	0.12
(1 min)	loss (%)	25.0	58.0	56.0	77.4	85.3	47.8
boil in 5% CH_3COOH		6.6	174	15	4.9	0.16	0.05
(1 min)	loss (%)	58.8	64.5	40.0	86.0	90.6	78.3
steam		6.3	194	13	7.6	0.11	0.16
	loss (%)	60.6	60.4	48.0	78.3	93.5	30.4
microwave							
slow heat		9.1	232	15	7.7	1.7	0.13
	loss (%)	43.1	52.7	40.0	78.0	0.0	43.5
quick heat		7.0	243	10	7.9	0.88	0.19
	loss (%)	56.3	50.4	60.0	77.4	48.2	17.4

Cooking loss of spinach minerals in squeezing after boiling or in thin slice was highest, followed by boiling in tap water, in 5% sodium acetate, in 1% salt solution, heating with steam, microwave heating and parching. Cooking losses of minerals in spinach were largest in iron and magnesium, followed by in potassium, sodium, zinc and phosphorus.

Cooking loss of mineral of thin slice pork in boiling was largest, followed by boiling in 1% acetic acid, heating with steam, stewing, frying without flour, frying with dry flour, boiling in 1% salt, microwave heating and frying with wet flour. Cooking loss of minerals in pork was largest in zinc, followed by sodium, potassium, calcium, iron, magnesium and phosphorus. In these samples, cooking loss

Table 5. Cooking losses of minerals in pork by various cooking methods.

Cooking method	Na	K	P	Ca	Mg	Fe	Zn
							(mg/100g)
raw	31	638	191	1.3	23	1.0	4.3
parch thin slice	14	541	193	0.98	22	0.99	1.9
loss (%)	54.8	15.2	−1.0	24.6	4.3	1.0	55.8
parch thick slice	24	523	178	1.0	22	0.79	1.7
loss (%)	22.6	18.0	6.8	23.1	4.3	21.0	60.5
boil distilled water	8	147	80	0.61	11	0.52	1.1
loss (%)	74.2	77.0	58.1	53.1	52.2	48.0	74.4
boil tap water	16	270	80	0.63	12	0.78	1.7
loss (%)	48.4	57.7	58.1	51.5	47.8	22.0	60.4
biol in 1% NaCl	49	324	79	0.71	11	0.62	1.2
loss (%)	−58.1	49.2	58.6	45.4	52.2	38.0	72.1
boil in 5% CH_3COOH	15	221	149	0.35	9.7	0.33	0.73
loss (%)	51.6	65.4	22.0	73.1	57.8	67.0	83.0
boil with soy sauce	22	387	73	0.63	19	0.53	1.6
loss (%)	29.0	39.3	61.8	51.5	17.4	47.0	62.8
stewing for long time	13	251	129	0.6	7.8	0.66	0.99
loss (%)	58.1	60.7	32.5	53.8	66.1	34.0	77.0
boil by high pressure	4.9	247	105	0.49	15	0.53	2.1
pan loss (%)	84.2	61.3	45.0	62.3	34.8	47.0	51.2
fry without flour	7.5	290	189	0.61	13	0.39	0.68
loss (%)	75.8	54.5	1.0	53.1	43.5	61.0	84.2
fry with flour	9.3	251	219	0.96	23	0.5	3.6
loss (%)	70.0	60.7	−14.7	26.2	0.0	50.0	16.3
fry with wet flour	16	734	92	1.0	26.0	0.63	4.4
loss (%)	48.4	−15.0	51.8	23.1	−13.0	37.0	−2.3
steam	27	210	184	0.43	11	0.66	1.2
loss (%)	12.9	67.1	3.7	66.9	52.2	34.0	72.1
microwave							
slow heat	11	506	135	1.1	19	0.95	2.3
loss (%)	64.5	20.7	29.3	15.4	17.4	5.0	46.5
quick heat	8.9	376	180	0.78	14	1.0	2.2
loss (%)	71.3	41.1	5.8	40.0	39.1	0.0	48.8

was dependent on the type of cooking method irrespective of the type of mineral.

Cooking loss of minerals is suspected to be caused by outflow of minerals from food materials.

The measures to prevent cooking loss of minerals are (a) eating the boiled food with the soup, (b) addition of small amount of salt (about 1% NaCl) in boiling, (c) avoidance of too much boiling, and (d) selection of a cooking method causing less mineral loss (stewing, frying or parching).

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DISCUSSION-CONTRIBUTION

Speaker: Kimura, M.

Question: Müller, H. R.

Mineral contents of studied meals and foods show great variability from <100 to $>200\%$. What is considered 100% level?

Answer: The increase of sodium, calcium, and iron in cooked foods may be caused by contamination from mineral of tap water or pan used in cooking.

Speaker: Kimura, M.

Question: Puwastien, P. (Thailand)

How do you express your results before you calculate the losses due to processing? Should it be on dry weight basis? Wet weight basis? I think we should consider the values on dry wet basis. Because moisture changes the values greatly. And I do not think contamination from water can change the values so much.

Answer: We usually calculate on wet weight basis and there is no problem usually. We used wet digestion method with nitric acid and perchloric acid usually for mineral determination.