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Effects of Fiber and Vitamin Food Sources on Mineral Balance

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=ABSTRACT=

Present study was to investigate the effect of dietary vegetable sources such as carrot, peahull and squash on mineral balance of Na, K, Ca, Fe, Cu, Zn and Mg in mice. It would also determine if the kind, level and feeding period of vegetables can affect the mineral balance.

One hundred and thirty mice weighing 29~30g(8 weeks of age) were randomly selected. Ten mice were fed their standard diet, and the others were divided into three experimental groups that were fed standard diet supplemented with carrot, peahull and squash.

Mineral intake and urinary and fecal excretion of minerals were measured to investigate the effect of the kind, level and feeding period of vegetables on absorption rate and balance of minerals.

Body-weight gain was increased in high peahull diet group compared to the control. No significant difference was observed for feed efficiency ratios between different experimental groups and urine volume was increased by vegetable fed group.

Na, Ca, Fe, and Cu intake were lower in high squash-diet fed goup. K intake was higher in carrot fed mice, and Zn, and Mg intake were higher in peahull fed mice. Absorption rate and balance of mineral in control group resulted in positive balance while experimental groups showed negative.

The kind of vegetable, feeding level and feeding period affected the intake of Na, K, Ca, Cu and absorption rate of Cu, Zn and balance of K, Cu, Zn to negative.

In spite of the higher intake of K, Zn and Mg, in experimental groups the absorption rate showed negative balance.

KEY WORDS : carrot · peahull · squash · mineral balance · dietary fiber.

Introduction

There is an overwhelming evidence that dietary fiber is a necessary component of human and animal diets, and its reduction has led to a number of metabolic disorders in the population[1-11]. Dietary fiber is considered to be an important component of nutritionally balanced diet. Epide-

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miologic, clinical, and animal study results suggest that dietary fiber may have a significant role to play in an overall dietary plan designed to reduce the risk for certain diseases, such as heart disease and colon cancer. However, the mechanisms by which fiber may impact chronic disease have not been well defined. Fruits and vegetables have been widely used as a source of dietary fiber. Most vegetarians consume more dietary fiber than non-vegotarians[12)13)]. Unfortunately, many have advocated increased consumption of dietary fiber without consideration of fiber's impact on other nutrients, such as vitamins and minerals.

Dietary fiber could theoretically influence mineral and vitamin bioavailability via several mechanisms[14-46)]. The solubility of minerals may be decreased as a result of ionic or chelation interactions with dietary fiber. Vitamin solubilities could be reduced due to fiber disruption of micellar formation. This possibility with combination of reduced transit times through the gut, entrapment of minerals and vitamins in a fiber matrix and possible changes in gut surface morphology can provide further potential mechanisms for reduced mineral and vitamin bioavailabilities[47)48)49)]. Therefore, to obtain better understanding of the influence of dietary fiber on mineral balance, the present study was designed to examine the influence of vegetable diet on mineral balance in mice.

Materials and Methods

1. Animals and Diets

One hundred thirty SPF male mice weighing 29－38g(8 week of age) were used in this study. All mice were given a standard diet(Table 1) for one week at the beginning of the experiment. After acclimatization, one hundred twenty mice were divided into three experimental groups according to three different kinds of vegetables ; carrot, peahull and squash. The control group of ten mice was fed on standard diet and distilled deionized water ad libitum. The composition of standard diet and experimental diets are shown in table 1, and 2. Each of three experimental group was subdivided into a further two groups by high and low levels of vegetables ; high-carrot diet group (12 mice), low-carrot diet group(10 mice), high-peahull diet group(11 mice), low-peahull diet group(9 mice), high-squash diet group(10 mice) and low-squash diet group(14 mice). The animals were housed individually in plastic cages in a well-ventilated room

Each day during the experiment, the animals were weighed, the amount of food remaining in the food dispensers and cages were weighed and discarded, and newly weighed portions of diet were put in the dispensers. Urine and feces were collected every day and kept frozen and stored

Table 1. Composition of standard diet

Standard diet(Control)	
	g/kg
Corn starch	680
Casein	150
Corn oil	80
Vitamin premix[1)]	11.4
Mineral premix[2)]	36.5
Powdered cellulose	42.1

1)The vitamin premixes supplied(g/kg diet) ; thiamin-HCl, 0.6 ; riboflavin, 0.6 ; pyridoxine-HCl, 0.7 ; nicotinic acid, 3 ; Ca-panthothenate, 1.6 ; folicacid, 0.2 ; biotin, 0.02 ; cyanocobalamin, 0.01 ; retinyl acetate, 0.8 ; DL-tocopherol, 3.8 ; 7-dehydrocholesterol, 0.002 ; menadione, 0.005 ; ascorbic acid, 0.1

2)The mineral premixes supplied(g/kg diet) ; $Ca(H_2PO_4)_2.H_2O$, 20.52 ; $(MgCO_3).Mg(OH)_2.5H_2O$, 7.95 ; $5ZnO.2CO_3.4H_2O$, 0.092 ; $FeSO_4.7H_2O$, 0.124 ; $CuSO_4.5H_2O$, 0.1 ; $MnSO_4.H_2O$, 0.25 ; KI, 0.0013 ; NaCl, 2.3 ; Na_2CO_3, 1.6 ; K_2CO_3. 3.53 ; Na_2SeO_3, 0.00022.

Table 2. Composition of experimental diets

	Control[a)]	Carrot[b)]	Peahull[b)]	Squash[b)]
		per 100g		
Water	5.4	88.26	80.23	94.55
Crude Protein(g)	21.16	1.2	3.2	1.3
Crude Fat(g)	6.16	0.2	0.1	0.1
Crude Ash(g)	4.01	1.1	0.6	0.8
Crude Fiber(g)	1.2	3.15	12.28	3.47
Vitamin A (ug retinol)	80.7	1230	105	279
B_1(mg)	0.25	0.07	0.15	0.07
B_2(mg)	0.28	0.05	0.13	0.06
Niacin(mg)	3.9	0.9	0.9	0.6
Vitamin C (mg)	0.2	6	55	15
Mineral Na(mg)	121 (159.8)[c)]	24	1	1
K (mg)	216 (199.5)	420	220	330
Ca(mg)	336.3(325.7)	48	62.1	17
Fe(mg)	2.6 (2.5)	0.8	0.9	0.3
Cu(mg)	2.4 (2.5)	0.7	1.3	0.3
Zn(mg)	3.9 (5)	2.06	1.58	1.07
Mg(mg)	188 (164.8)	207.2	396.6	158.2

[a)]Value of analyzed by AOAC method
[b)]Value of calculated by food composition table[52.53)]
PS ; Value of crude fiber analyzed by Enzymatic-gravimetric methods
Value of mineral analyzed by ICP-MS
[c)]Calculated value of mineral in diet

until analysis.

The composition of diet was analyzed by A.O.A.C. method and Na, K, Ca, Fe, Cu, Zn and Mg were measured by Inductively Coupled Plasma Mass Spectrometry(Yokogawa Eleetric, PMS 100).

2. Statistical Methods

Results are expressed as means and the significance of difference between means was tested by *Duncan's multiple range test after analysis of variance* to determine significance of overall treatment effects[54)].

Interactions among each factors in which different kinds of vegetables, the level of feeding and feed period were also analyzed.

Results

Table 3 and 4 show the changes in body-weight gain, amount of feed intake, feed efficiency ratio (FER), urine and feces volume for each control and experimental group. The effect of diets, kind of vegetable, feeding level and feeding period on Na, K, Ca, Cu, Zn, Mg balances of mice is shown in Table 5 and 6.

3. Body-weight gain

Body-weight gain of high-squash diet group was significantly lower than control group for one week feeding period(Table 3). However, there were no significant differences in body-weight

Table 3. Effect of experimental diet on body-weight gain, feed intake, feed efficiency ratio and feces and urine volume.

	N/n(1)	Body-weight gain 1wk	Body-weight gain 2wk	Feed intake 1wk	Feed intake 2wk	Feed efficiency ratio 1wk	Feed efficiency ratio 2wk	Feces volume 1wk	Feces volume 2wk	Urine volume 1wk	Urine volume 2wk
		g/day		g/wk	g/2wk			g/day		ml/day	
Control	(5/5)	3.42^{a}	$3.24^{a(2)}$	33.89	66.84	0.207^{a}	0.231^{a}	4.14^{c}	4.40^{bc}	5.04^{a}	5.10^{b}
High-carrot diet	(6/6)	3.79^{a}	3.43^{a}	34.66 (46.8)	67.38 (46.9)(3)	0.228^{a}	0.239^{a}	5.08^{a}	4.95^{a}	5.08^{a}	4.92^{b}
Low-carrot diet	(5/5)	3.50^{a}	3.25^{a}	33.25 (27.7)	64.95 (31.8)	0.205^{a}	0.244^{a}	4.98^{b}	4.68^{b}	5.00^{a}	4.63^{c}
High-Peahull diet	(6/5)	3.94^{a}	3.55^{a}	35.23 (45.1)	65.79 (44.7)	0.186^{b}	0.230^{a}	5.31^{a}	5.23^{a}	4.96^{b}	4.84^{b}
Low-Peahull diet	(5/4)	3.52^{a}	3.56^{a}	34.37 (31.3)	64.10 (31.8)	0.194^{a}	0.208^{b}	5.33^{a}	5.11^{a}	4.92^{b}	4.75^{c}
High-Squash diet	(5/5)	3.38^{a}	3.19^{ab}	34.91 (50.1)	67.10 (45.7)	0.207^{a}	0.185^{b}	5.17^{a}	4.86^{b}	5.25^{a}	5.18^{a}
Low-Squash diet	(8/6)	3.22^{b}	3.39^{a}	33.83 (34.3)	62.55 (34.0)	0.236^{a}	0.233^{a}	4.59^{b}	4.84^{b}	5.24^{a}	5.38^{a}

(1) Number of mouse during experiment(1wk/2wk)
(2) Values with the same superscripts in the column are not significantly different at 5% level.
(3) Vegetable percent of dietary intake

Table 4. ANOVA statistics for body-weight gain, feed effeciency ratio, and urine and feces volume.

Sources	Body-weight gain	Feed effeciency ratio	Feces	Urine
Diet(A)	NS	NS	*	*
Level(B)	NS	NS	*	*
Period(C)	NS	NS	NS	NS
A×B	NS	NS	*	*
A×C	NS	NS	*	*
B×C	NS	NS	*	*
A×B×C	NS	NS	NS	*

*Significant at 5% level. NS : Not significant.

gain, and FER nor in kind of vegetable, feeding level and feeding period between the experimental groups as shown in Table 4.

4. Feces and Urine Volume

It was observed that a highest feces volume was in high-peahull diet group(Table 3).

As shown in Table 4, the kind of vegetables and level of feeding affected the feces volume, but there was no difference in feeding period.

Urine volume was higher in Squash fed group than in standard diet fed control group for two week feeding period(Table 3). It was also observed that effected in urine volume between kind of vegetables and level of feeding. However, feeding period did not affect it(table 4).

5. Mineral balances

Na intakes in all experimental groups were significantly lower than that of the control group.

Table 5. Mineral metabolism during experimental diet

Parameter		Control	Carrot		Peahull		Sqaush	
			higt	low	higt	low	higt	low
Na 1wk	Intake	5.86^{a}[1)]	3.74^{c}	4.43^{b}	3.37^{c}	4.10^{b}	3.03^{d}	3.57^{c}
(mg/day)	% absorp.	[2)]5.3^{a}	-1.9^{d}	-1.4^{c}	-2.1^{d}	-2.4^{d}	-3.3^{f}	-2.2^{d}
	Balance	[3)]0.33^{a}	-0.08^{d}	-0.05^{cd}	-0.08^{d}	-0.01^{cd}	-0.01^{cd}	-0.09^{d}
2wk	Intake	5.78^{a}	3.63^{c}	4.18^{b}	3.18^{d}	3.82^{c}	3.09^{d}	2.96^{de}
	% absorp.	5.9^{a}	-2.8^{d}	-9.4^{f}	-6.3^{c}	-2.4^{d}	-6.5^{c}	-2.4^{d}
	Balance	0.16^{a}	-0.02^{d}	-0.05^{cd}	-0.01^{c}	-0.10^{d}	-0.02^{c}	-0.08^{d}
K 1wk	Intake	9.78^{cf}	15.05^{a}	12.55^{d}	10.57^{c}	10.19^{c}	13.27^{c}	12.19^{d}
(mg/day)	% absorp.	4.2^{a}	-1.6^{cd}	-2.4^{d}	-0.6^{c}	-1.5^{cd}	-1.6^{cd}	-2.4^{d}
	Balance	0.40^{a}	-0.09^{d}	-0.02^{d}	-0.08^{d}	-0.11^{c}	-0.11^{c}	-0.16^{c}
2wk	Intake	9.64^{c}	14.64^{a}	12.59^{c}	9.87^{c}	9.51^{c}	12.57^{c}	11.63^{d}
	% absorp.	5.9^{a}	-7.5^{c}	-9.5^{c}	-1.7^{c}	-4.9^{d}	-1.5^{c}	-2.3^{c}
	Balance	0.55^{a}	-0.12^{c}	-0.09^{c}	-0.16^{c}	-0.40^{c}	-0.19^{d}	-0.26^{d}
Ca 1wk	Intake	15.50^{a}	9.54^{c}	11.52^{c}	10.26^{d}	11.76^{c}	8.40^{c}	9.72^{d}
(mg/day)	% absorp.	6.5^{a}	-2.1^{c}	-1.6^{d}	-3.1^{c}	-1.3^{d}	0^{d}	-1.2^{d}
	Balance	0.08^{a}	-0.05^{b}	-0.18^{c}	-0.35^{c}	-0.16^{c}	-0.20^{c}	-0.10^{b}
2wk	Intake	15.29^{a}	9.27^{d}	10.85^{d}	9.63^{d}	10.97^{c}	8.50^{de}	8.13^{c}
	% absorp.	6.4^{a}	-0.1^{d}	-1.9^{d}	-1.0^{d}	-2.1^{d}	-4.7^{c}	0^{d}
	Balance	0.12^{a}	-0.15^{c}	-0.21^{c}	-0.09^{c}	-0.16^{c}	-0.02^{c}	-0.14^{d}
Fe 1wk	Intake	0.126^{a}	0.087^{d}	0.099^{c}	0.092^{c}	0.102^{b}	0.072^{e}	0.082^{d}
(ug/day)	% absorp.	2.4^{a}	-2.3^{c}	-0.1^{d}	-0.1^{d}	-3.9^{c}	-9.7^{c}	-1.2^{c}
	Balance	0.003^{a}	-0.001^{b}	-0.005^{c}	-0.012^{d}	-0.003^{c}	-0.008^{c}	-0.001^{b}
2wk	Intake	0.124^{a}	0.085^{d}	0.094^{c}	0.086^{bc}	0.095^{c}	0.073^{e}	0.069^{e}
	% absorp.	0.1^{a}	-2.4^{c}	-7.0^{c}	-0^{d}	-2.1^{b}	-0.1^{d}	-2.8^{c}
	Balance	0.006^{a}	0^{b}	-0.008^{d}	-0.001^{b}	-0.004^{c}	-0.010^{d}	-0.002^{c}
Cu 1wk	Intake	0.116^{a}	0.079^{c}	0.090^{b}	0.096^{b}	0.101^{a}	0.067^{d}	0.076^{c}
(ug/day)	% absorp.	6.0^{-a}	1.3^{b}	-6.7^{bc}	-0.1^{c}	-0.1^{c}	-1.5^{c}	-3.9^{c}
	Balance	0.009^{a}	-0.001^{b}	-0.006^{bc}	-0.010^{b}	-0.011^{c}	-0.01^{c}	-0.005^{d}
2wk	Intake	0.115^{a}	0.077^{c}	0.086^{bc}	0.090^{b}	0.094^{b}	0.068^{d}	0.064^{d}
	% absorp.	4.3^{a}	0^{bc}	-3.5^{b}	-5.5^{b}	-4.3^{b}	-1.5^{bc}	-0.1^{c}
	Balance	0.008^{a}	-0.001^{c}	-0.006^{d}	-0.006^{b}	-0.005^{b}	-0.001^{b}	-0.05^{d}
Zn 1wk	Intake	188.8^{d}	150.5^{c}	160.3^{d}	358.7^{a}	301.5^{b}	123.8^{c}	134.8^{c}
(ug/day)	% absorp.	7.1^{a}	-7.3^{c}	-8.5^{c}	-7.8^{c}	-3.3^{d}	-0.1^{c}	-2.2^{d}
	Balance	11.2^{a}	-1.3^{d}	-13.2^{f}	-2.6^{d}	-0.2^{c}	-3.9^{d}	-4.7^{c}
2wk	Intake	186.2^{dc}	146.2^{c}	153.8^{c}	566.2^{a}	439.5^{b}	123.0^{c}	116.6^{c}
	% absorp.	7.9^{a}	-3.3^{b}	-2.4^{c}	-1.6^{c}	-1.5^{c}	-4.0^{c}	-9.4^{d}
	Balance	15.6^{a}	-5.4^{b}	-4.1^{bc}	-10.2^{d}	-5.9^{d}	-4.4^{b}	-0.8^{b}
Mg 1wk	Intake	9.10^{d}	9.75^{c}	9.19^{d}	14.19^{a}	12.43^{b}	8.63^{c}	8.52^{e}
(mg/day)	% absorp.	2.0^{a}	-5.5^{d}	-1.6^{b}	-1.3^{b}	-4.8^{cd}	-8.1^{c}	-1.6^{bcdef}
	Balance	0.19^{a}	-0.52^{c}	-0.29^{cbc}	-0.17^{c}	-0.05^{c}	-0.05^{b}	-0.15^{d}
2wk	Intake	8.98^{d}	9.48^{c}	9.00^{d}	13.22^{a}	11.60^{b}	8.34^{d}	7.79^{e}
	% absorp.	0.1^{a}	-3.4^{c}	-1.1^{c}	-6.1^{c}	-5.2^{d}	-3.1^{d}	-2.3^{d}
	Balance	0.91^{a}	-0.32^{d}	-0.08^{d}	-0.09^{d}	-0.04^{d}	-0.24^{d}	-0.18^{d}

1) Values with the same superscripts in the row are not significantly different at 5% level
2) %absorption ; (intake mineral-fecal mineral/intake mineral)×100
3) balance : intake mineral-fecal mineral-urinary mineral

Table 6. ANOVA statistics for Na, K, Ca, Fe, Cu, Zn, ·Mg contents in intake and excretion

Parameter	Intake	% of Absorption	Balance
Na	A B AB AC ABC	A	–
K	A C AB AC ABC	–	A B C AB AC BC ABC
Ca	A B AB AC BC ABC	–	–
Fe	–	A AB	A
Cu	A B C AB AC BC ABC	A B C AB AC BC ABC	A B C AB AC BC ABC
Zn	A B C AB AC BC ABC	A B C AB AC BC ABC	A B C AB AC BC ABC
Mg	A B AB ABC	A AB ABC	A AC ABC

Values with different alphabet within the column were significantry different at 5% level
Significant factor
A ; Significantly different among different kind of dietary goups at 5% level
B ; Significantly different among different dietary levels at 5% level
C ; Significantly different among different feeding periods at 5% level
AB ; There were interactions between the vegetable kinds and the levels of dietary at 5% level
AC ; There were interactions between the vegetable kinds and periods of dietary at 5% level
BC ; There were interactions between the vegetable and levels periods of dietary at 5% level
ABc ; There were interactions between a kind, level and period of dietary at 5% level

Na intake was the least in high-squash diet group for 1 week and low-squash diet group for 2 weeks. The interactions between the kind of vegetables, feeding level and feeding period were observed. The percent Na absorption was positive in control group and negative in vegetable fed groups($P<0.05$). Low-carrot diet group showed decreased Na absorption most significantly compared to control group. Na balance was negative in groups receiving vegetables. Among them. low-peahull diet group showed the lowest($P<0.05$) Na balance. However, interacting effect of all experimental factors did not affect the % absorption and balance of Na.

K intake was higher in high-carrot diet fed group than in control diet group($P<0.05$). The kind of vegetables, feeding level and feeding period affected K balance. The % absorption of K was negative in all experimental groups. Although high-carrot diet group increased the K intake, the % absorption of K was lowered, and the extension of feeding period decreased the % absorption of K. Therefore, feeding the vegetables resulted in negative K balance.

The intake of Ca was decreased in vegetable fed annimals compared with the control group. Especially high-squash diet group for 1 week feeding and low-squash diet group for 2 weeks feeding showed that feed intake was decreased compared with control diet group. It was observed that Ca intake was affected by the kind of vegetables, feeding level and feeding period. The % absorption and Ca balance were negative in all experimental groups. The effects of vegetables, feeding level and feeding period on Ca balance·were not observed.

Fe intake was significantly decreased in vegetable fed animals and particulary in squash fed animals. There were no interaction between other experimental factors on Fe intake. In vegetable fed groups, the % absorption and balance of Fe were negative but standard diet fed groups showed positive Fe balance. It was observed that the lowest % of Fe absorption was in high-squash diet group and vegetables have an effect on % absorption and Fe balance.

Feeding the vegetables decreased Cu intake, and when the squash is fed, the Cu intake was the lowest. Interactions between the kind of vegetables, feeding level and feeding period affected Cu intake. The % absorption and balance of Cu were negative in experimental groups, however, it was positive in the control group. The interacting effect of experimental factors on Cu metabolism was observed.

Zn intake was significantly higher compared to the standard diet group in high-peahull diet group while low in the squash fed group. It was observed the Zn intake was affected by the kind of vegetables, feeding level and feeding period. The % absorption and balance of Zn were positive in control group, while negative in all other experimental groups, and were affected by the kind of vegetable, feeding level, and feeding period.

In the high-peahull diet group, Mg intake was increased compared to the control group. The kind of vegetables and feeding level of diet affected Mg intake. The % absorption and balance of Mg were negative and affected by the kind of diet.

Discussion

Recently, much of the experimental works indicating dietary fibers bind various minerals. Dietary fiber could theoretically influence not only minerals but also vitamin bioavailability via several mechanisms[20-26)45)]. The present study measures the effects of altering level of different vegetables in experimental diets on mineral balance of mice. Na, Ca, Fe and Cu intakes of experimental animals fed on high-squash diet were much lower that of the control but K intake was higher in carrot fed animals. Zn and Mg intakes were higher in peahull fed animals than of the control but Fe intake was exceptionally low. Mineral absorption rate and balance of the control resulted in positive balance while experimental group showed negative balance overall. The data of several studies are suggestive of a trend toward negative mineral balance with the higher fiber diets. However, the cellulose-induced negative Mg balance was not significantly different from the control, the negative balance found after 4-weeks of fruit, vegetable, and spinach consumption was not apparent after 6 weeks on the diet, and although the wheat bran diet reduced the percentage of Mg absorbed, overall Mg balance was no different from the control.

In spite of the higher intake of K, Zn and Mg in experimental groups, the absorption rate showed negative balance in this study. Each experimental factors such as kind of vegetables, feeding level, and feeding period affected absorption rates of Cu and Zn. It also affected the balance of K, Cu and Zn to be negative. The results of several studies examining the influence of various dietary fibers on Ca balance show different effects[48)].

Insoluble dietary fiber sources, such as wheat bran have significant negative effect, while fruit and vegetable had a positive effect. present study also showed that Ca absorption rate and balance were negative in all experimental groups. In spite of the higher intake of K, Zn and Mg in experimental group, the absorption rate showed negative balance.

Body-weight gain was increased in high-peahull diet group compared with the control. However, there were no significant differences in feed efficiency ratio beteween experimental groups. Urine and feces volumes were increased in vegetable fed experimental groups.

Taken together, the results of the present study and others suggest that mineral balance may be affected by altering level of different vegetables. However, this study could not determine which factors in the vegetable diets affected mineral balance of mice.

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무기질 출납에 있어서의 섬유질 및 Vitamin 급원 식품의 영향

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종류가 다른 채소 3종을 임의로 선정하여 마우스의 Na, K, Ca, Fe, Cu, Zn, Mg 밸런스에 어떠한 영향을 미치며, 또한 채소의 종류나 양, 사육기간이 영향을 미칠 수 있는 요인인지 조사하였다.

실험동물은 8주된 SPF계 마우스 130마리를 사용했으며 평균 체중은 29-38g 이었다. 마우스 10마리를 대조군으로, 나머지 120마리를 3군으로 나누어 이를 다시 두군으로 나누어 한마리씩 분리 사육시켰다. 대조군은 물(2차 증류수)과 식이를 제한없이 주고 다른군은 물 대신 임의로 선정한 채소 3종(당근, 껍질콩, 호박)으로 대체하고 각군 20마리 중 10마리는 1주(단기간) 10마리는 2주(장기간) 사육시켜 실험 완료일 까지의 실험식이 섭취량이 대조군과 유의적인 차가 없는 마우스만을 실험대상으로 하였다. 또한 이들 채소의 양에 따라서 당근대량군(12 마리), 당근소량군(10마리), 껍질콩대량군(11마리), 껍질콩소량군(9마리), 호박대량군(10 마리), 호박소량군(14마리)으로 분류하였다.

체중증가는 대조군에 비하여 껍질콩대량군이 높게 나타났으며, 식이 효율은 대조군에 대한 차이가 없었다. 분변과 요량은 채소 급여에 의하여 증가하였다. 체중증가와 식이효율, 분변과 요량에는 채소의 종류나 양, 사육기간등이 작용인자로는 확인되지 않았다.

무기질 섭취량은 대조군에 비하여 Na, Ca, Fe, Cu가 호박대량군에서 가장 낮게 나타났고, K는 당근대량군이 가장 높게 나타났으며 Zn, Mg는 껍질콩대량군에서 가장 높게 나타났다. Na, K, Ca, Fe, Cu, Zn, Mg의 흡수율과 밸런스는 대조군이 플러스의 균형을 나타내는데 반하여 채소 급여군은 모두 마이너스의 균형을 나타내었다.

채소의 종류, 양, 사육기간이 Na, K, Ca, Cu, Zn의 섭취량에, Cu, Zn의 흡수율에, K, Cu, Zn 평형에 각각 영향을 미치는 요인인 것으로 확인되었다.

K, Zn, Mg는 대조군에 비하여 실험군의 섭취량이 증대 했음에도 불구하고 흡수율은 마이너스이였다.