論　文

Breakfast cereal with balanced amounts of vitamins, minerals and dietary fiber improves skin conditions of young females

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ビタミン・ミネラルと食物繊維をバランスよく含むシリアルは若年女性の肌状態に好影響を及ぼす

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穀物を加工して栄養素を強化したシリアルには様々な種類があり，玄米シリアルのようにビタミン・ミネラルをバランスよく含むものや，小麦ふすまシリアルのように食物繊維が豊富なものなどがある。過去の研究で，全粒穀物シリアルを摂取することにより，肌状態，特に吹き出物や皮膚の赤みに良い影響を及ぼしたとするものがあるが，シリアルの成分の何が肌状態の改善に寄与しているかは，明らかになっていない。また，他の食品成分で肌状態が改善されたとする研究もあるが，タンパク質やカロテノイドに関するものなどであり，ビタミン・ミネラル全般や食物繊維に関する研究は少ない。今回は，シリアルの成分のうち，２大特長とも言える，①ビタミン・ミネラルのバランス，②食物繊維のどちらの要素がより皮膚の健康に寄与するかを検証するため，朝食欠食の習慣がある22～35歳の女性21名について，それぞれ上記２つの特徴を持つ全粒穀物シリアルの，皮膚に及ぼす影響について調べた。

21名を３群に分け，１群はコントロール群とし，その他は，ビタミン・ミネラルのバランスに優れた玄米シリアル群と，食物繊維を豊富に含む小麦ふすまシリアル群とに二分した。実験期間は全部で６週間とした。最初の２週間は，どの群も普段通りの食生活とし，食物繊維の効果を確認するため，発酵食品全般や，供試シリアル以外のシリアルは摂取しないように指導した。次の２週間は，コントロール群は普段通りの食事，それ以外の２群には，全粒穀物シリアル（玄米シリアル，もしくは小麦ふすまシリアル）40gを，朝１回と，昼か夜どちらかの１回，計１日に２食のシリアルを毎日摂取させ，それまで摂っていた炭水化物をシリアルに置き換えるよう指導した。最後の２週間は，３群とも，発酵食品や食物繊維の多い食品を摂らずに，普段通りの食生活とし，シリアルは摂取しないよう指導した。㈱エフシージー総合研究所において，２週間毎に測定した項目は次の通りである。体重，BMI，体脂肪率，皮膚水分量（電気伝導度型 SKICON-200），皮膚弾力（キュートメーター），皮脂量（透過光比率型セブメーター），皮膚拡大写真撮影（メディカルニッコール），皮膚キメ写真，排便回数，美容専門家による視診触診，皮膚状態・体調に関するアンケート。いずれの顔

面皮膚計測も，同研究室の23℃，50％ Room Humidity の恒温恒湿室にて15分間座位安静後実施した。また，計42日間の食事記録（シリアル摂取前14日，摂取中14日，摂取中止後14日）。食事記録は，栄養計算ソフト「Basic4」で解析し集計した。

なお，本試験は，ヘルシンキ宣言に基づきその原則を遵守し，被験者には試験目的を説明して同意が得られた上で実施した。

その結果，玄米シリアルグループ・小麦ふすまシリアルグループとも，全期間を通して，一日一回程度の定期的な排便回数を保った。この間の栄養素摂取状態は，小麦ふすまシリアルグループは，食物繊維とビタミンB_1，B_2と葉酸が非摂取期間に比べて有意に高い値を示した。玄米シリアルグループは，主にカルシウムと鉄，ビタミンA・B_1・B_2，C，ナイアシン，ビタミンE，食物繊維など，バランスよくビタミン・ミネラルと食物繊維の摂取量が有意に増加した。Fig.1と2は，それぞれ右目尻と右頬の水分量の変化を示しており，玄米シリアル群で，摂取期間の2－4週に，水分量が増えていることがわかる。また，Fig.3は，皮膚の弾力性の変化を示したもので，有意差はないものの，やはり玄米シリアル群で，摂取期間である2－4週に，皮膚の弾力性が増えていることがわかる。Fig.4a～dは玄米シリアルを摂取した30代女性の皮膚のキメ写真である（キメとは，皮膚の表面に広がる網目のような凹凸のこと。高い部分の“皮丘”，皮丘の間を溝のように走る“皮溝”，“毛孔”で形づくられる。均一に整った格子状の美しい起伏が続く状態が，キメの細かい皮膚と言うことができる）。Fig.4aはウォッシュアウト前，Fig.4bはシリアル摂取前，Fig.4cはシリアル2週間摂取後，Fig.4dはシリアル摂取中止後2週間で，摂取2週間後に皮膚のキメ，すなわち皮溝と皮丘の織り成す起伏が整ってきている。

以下にシリアルによる今回の試験成績をまとめる。ビタミン・ミネラルと食物繊維のバランスに優れた玄米シリアルは，肌に問題のある若年女性の肌状態を改善させた。食物繊維の豊富な小麦ふすまシリアルは，肌状態の改善に寄与しなかった。シリアルは，若年女性の栄養素摂取状態を良くするのに寄与した。特にカルシウムや鉄，ビタミンA・B_1・B_2，C，ナイアシン，ビタミンE，食物繊維など，皮膚の健康にとって大切な栄養素の摂取増加に寄与した。

INTRODUCTION

Breakfast cereal is a generic term that means a processed cereal food fortified with multiple nutrients. There are many kinds of breakfast cereals, some containing well-balanced vitamins and minerals as in the case of brown rice cereal, and some being enriched with dietary fiber as in the case of wheat bran cereal (1) (2) (3) (4). A published paper reports that breakfast cereals can improve the skin health of young people, especially with respect to acne, pores, redness and general skin tone (5). The paper also suggests that breakfast cereals can contribute to overall nutrition of young people who usually skip breakfast, but it is not clear which specific nutrients in breakfast cereals contribute to their skin health. It is generally known that some food components do improve skin conditions, but the studies focus just on glucosaminoglucan, astaxanthin, tocotrienols, collagen peptides, etc. (6) (7); no detailed information is available on the effect of a mixture of multiple vitamins, minerals and dietary fiber.

The aim of this study is to clarify which class of breakfast cereal is more effective in improving the skin condition.

METHODS

Materials

Brown rice cereal made of brown rice as a major ingredient and wheat bran cereal made of wheat bran as a major ingredient were used, both of which are Kellogg products fortified with vitamins and minerals (Table 1, 4, 5), 'Genmai Flakes' and 'All-Bran®'. Nutrition values were calculated by KELLOGG (JAPAN) K.K.

Subjects

The present investigation was conducted in 2004. Human intervention trials were performed according to the Declaration of Helsinki. Subjects were recruited after being informed of the study protocol and methods, and consisted of 21 female volunteers who were troubled with their skin conditions. They were urban residents aged 22-35 years, with occupations such as office workers, housewives, etc.

Programs

The subjects were instructed to consume breakfast

Table 1 Nutritional qualities of the products*

Nutrient	Brown rice cereal**	Wheat bran cereal**
Energy (kcal)	150	133
Protein (g)	2.9	6.0
Fat (g)	1.0	1.7
Carbohydrate (g)	33.2	18
Potassium (mg)	91	560
Calcium (mg)	158	39
Magnesium (mg)	25	177
Phosphorus (mg)	340	363
Iron (mg)	6.0	5.0
Zinc (mg)	0.5	2.8
Copper (mg)	0.03	0.38
Manganese (mg)	0	0
Retinal equivalent (μg)	194	0
VitaminD (μg)	0.65	0
VitaminE (mg)	4.8	0
VitaminK (μg)	0	0
VitaminB_1 (mg)	0.42	0.70
VitaminB_2 (mg)	0.25	1.0
Niacin (mg)	7.4	6.0
VitaminB_6 (mg)	0	0
VitaminB_{12} (μg)	0	0
Folic Acid (μg)	0	88.0
Pantothenic acid (mg)	0	0
Vitamin C (mg)	48	0
Sodium chloride equivalent(g)	0.9	0.7
Dietary fiber (g)	1.9	12.9

* Labeled data of nutrient quantities in 40g/day

** Fortified with vitamins and minerals. For details see text

Calculated data of KELLOGG (JAPAN) K.K.

Table 3 Subjects belonging to the three diet groups and their biodata

Group	Gender	Age	BMI	n
Brown rice cereal diet group	Female	23－35 mean: 31.6	17.5－25.7 mean: 21.3	7
Wheat bran cereal diet group		27－35 mean: 30.7	17.5－29.2 mean: 22.0	7
Control diet group		22－35 mean: 31.1	19.6－22.6 mean: 21.7	7

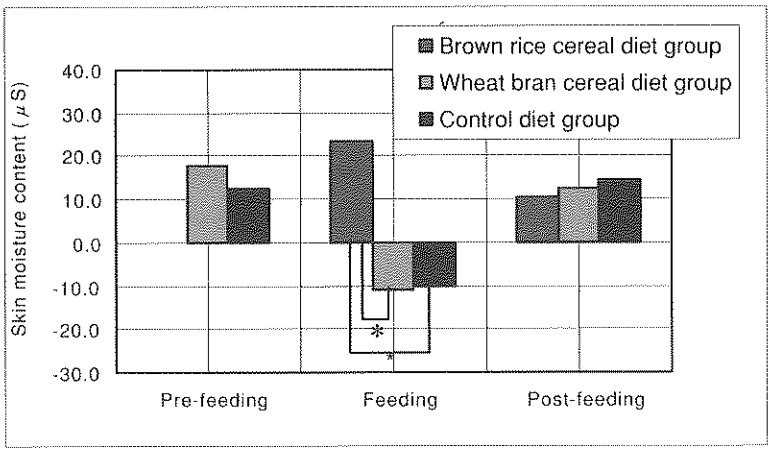
cereal according to the programs shown in Table 2. They were divided into the three groups: control diet group, brown rice cereal diet group and wheat bran cereal diet group (Table 3).

The control group was fed on the usual diet of their own for 6 weeks. The other two diet groups were directed to eat their usual diet which, however, did not contain probiotics and other breakfast cereals. At the end of a two-week pre-feeding period, they were divided into 3 groups, the Brown rice cereal diet group, Wheat bran cereal diet group and control group. Age and body mass index of the volunteers were evenly distributed among the groups. For 2 weeks (from the 15th day to the 28th day), the Brown rice cereal diet group and Wheat bran cereal diet group ate 40 g of the respective breakfast cereals twice a day, at breakfast and at lunch or supper, instead of their carbohydrate foods (feeding period). They, then, consumed their usual diet for the subsequent

Table 2 Programs for feeding

Group	Sample	Serving	Schedule*		
			Pre-feeding (2 weeks)	Feeding (2 weeks)	Post-feeding (2 weeks)
Brown rice cereal diet group	Brown rice cereal (Kellogg's 'Genmai Flakes')	Twice a day (40g each)	Normal diet (without breakfast cereals and probiotics)	40g cereal for breakfast and 40g cereal for lunch or supper	Normal diet (without breakfast cereals and probiotics)
Wheat bran cereal diet group	Wheat bran cereal (Kellogg's 'All-Bran®')				
control diet group	None	None		Normal diet (without breakfast cereals and probiotics)	

*March 17 through April 26, 2004



*Significantly different between diet group ($p < 0.05$)

Fig.1 Differences in skin moisture contents at the corner of the right eye

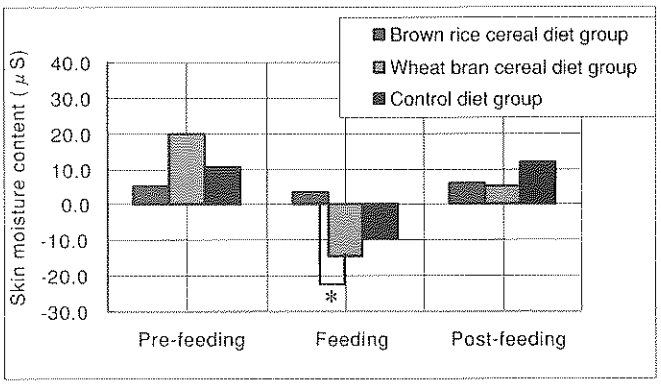
2 weeks (from the 29th day to the 42nd day of the post-feeding period). Nutrition profiles of the three diets taken during the 6-week periods are shown in Table 4-6, these being calculated by formula. Thus, the brown rice cereal contains balanced amounts of vitamins and minerals with a small amount of dietary fiber, and the wheat bran cereal is rich in dietary fiber and moderate amounts of vitamin B_1, B_2, niacin and iron, with no vitamin A, C, D, and E included. They were requested to replace their carbohydrate-rich foods with breakfast cereals, and were allowed to have other foods in addition to the cereal. Thereafter, they were given no dietary restrictions except being prohibited from eating any breakfast cereals for the following 2 weeks. All subjects were also asked not to change the cosmetics they were using. Also, during this 6-week period, they were prohibited from eating probiotic foods containing health-promoting bacteria such as yogurt and natto (fermented soybeans) which are important and well-known functional foods.

Evaluation of body conditions

Prior to the measurement of skin condition parameters, the subjects washed their faces and were relaxed for 15 minutes in a room at 23℃, 50 % room humidity (RH) for preconditioning. The following factors were then measured: height, body weight, body mass index (BMI), body fat (%), facial skin moisture content by skin surface hygrometer (SKICON-200, I.B.S co., Ltd.), facial skin elasticity by skin elasticity meter (CUTEMETER SEM575, Integral co.), facial skin oiliness (KAO SOFINA BEAUTY COMPUTER, Seb meter), and enlargement of skin surface (Medical-NIKKOR). All subjects were also examined by a skin specialist (FCG Research Institute, Inc.) who is a certified professional for skin analysis and cosmetic evaluation. Finally, subjects were asked to complete a questionnaire on facial skin and general health, e.g., frequency of bowel movements. These measurements were carried out at the start of the study, two weeks after (the final day of the pre-feeding period), four weeks after (the final day of the feeding period), and 6 weeks after (the final day of the post-feeding period). They also recorded their daily meals taken over for 42 days (i.e., 14 days before starting the test; pre-feeding, for the 14 days of monitoring; feeding, and for 14 days after monitoring; post-feeding). We analyzed all meals consumed using Basic-4 nutrition analysis software.

RESULTS

Parameters for skin conditions are shown in Figures 1 and 2. On the final day of the feeding period, the subjects of the brown rice cereal diet group reported on improvements in their skin conditions. In particular, skin moisture content was significantly enhanced in this



*Significantly different between diet group ($p < 0.05$)

Fig.2 Differences in skin moisture contents at the corner of the right cheek

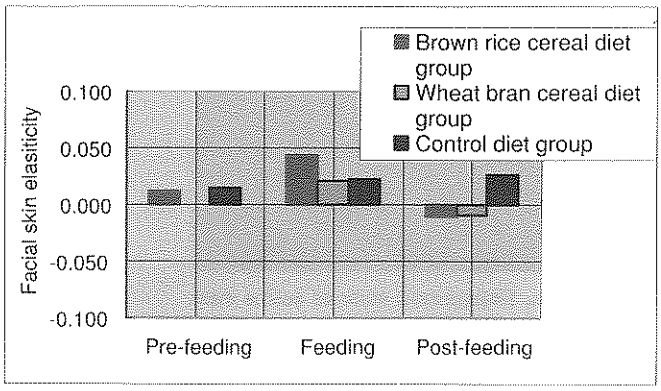
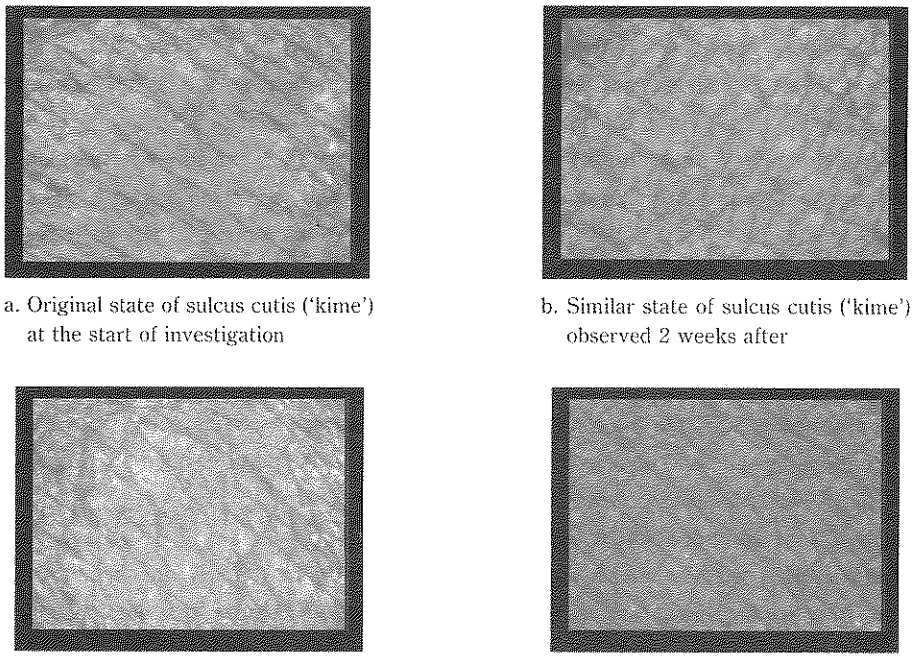


Fig.3 Differences in facial skin elasticity

group than in the control and the wheat bran cereal diet groups (t-test, $p<0.05$). The change in facial skin elasticity is not significantly different (Figure 3). This brown rice cereal is fortified with vitamin C, which should play an important role in collagen structure (8), this may also contribute to improving skin elasticity. At the final day of the feeding period, the subjects of the wheat bran diet cereal group had improved their skin conditions, especially in terms of facial skin elasticity, though the skin moisture content had decreased. No significant change was observed in skin condition for the control diet group.

In the subjects of the brown rice cereal diet group, cereal consumption for 2 weeks improved their skin conditions as seen from lattice structures of sulcus cutis (Figures 4a-4d). For the subjects of wheat bran cereal, there was only a slight change during the feeding period, with no significant improvement since no lattice structures were observed (Figures 5a-5d). In the control diet group, there was no significant change in sulcus cutis.

The test diets consisting of breakfast cereals affected the nutrient intakes. In the subjects of the brown rice cereal diet group, the intakes of the following nutrients were much higher than those of non-test diet group ($p<0.01$), where data on calcium, magnesium, phosphorus, iron, vitamin A, B_1, B_2, niacin, vitamin C and E levels are shown in Table 4. In terms of the intake of retinol, no significant difference was found. In the subjects of the wheat bran cereal diet group, the intakes of potassium, calcium, magnesium, phosphorus, zinc, copper, vitamin B_1, B_2, folic acid and dietary fiber were significantly higher than in those of the control diet group (Table 5). For control diet group, no significant difference was observed (Table 6). As shown in Table 4-6, the intakes of energy and carbohydrate in pre-feeding, feeding, and post-feeding stages, were not significantly different from each other. Concerning bowel frequency, the subjects of the brown rice cereal diet group showed no appreciable change during the feeding period (Figure 6).In the subjects of the wheat bran cereal diet group, the



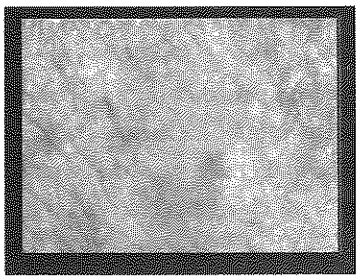
a. Original state of sulcus cutis ('kime') at the start of investigation

b. Similar state of sulcus cutis ('kime') observed 2 weeks after

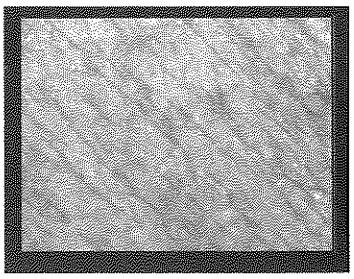
c. Improved state of sulcus cutis ('kime') observed 4 weeks after

d. Improved state of sulcus cutis ('kime') at the end of the 6-week-long

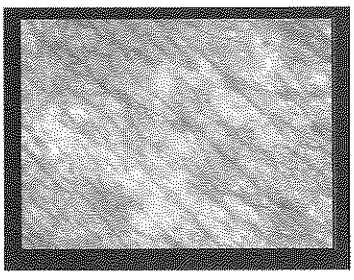
Fig.4 Differences in the state of sulcus cutis for an averaged 35-year-old female in the brown rice cereal diet group



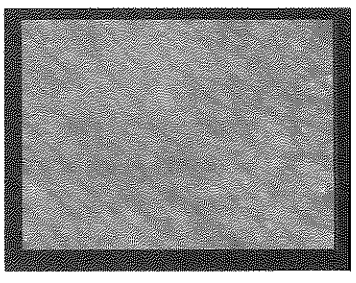
a. Original state of sulcus cutis ('kime') at the start of investigation



b. Unimproved state of sulcus cutis ('kime') observed 2 weeks after



c. Unimproved state of sulcus cutis ('kime') observed 4 weeks after



d. Unimproved state of sulcus cutis ('kime') at the end of the 6-week-long

Fig.5 Differences in the state of sulcus cutis for an averaged 29-year-old female in the wheat bran cereal diet group

bowel movements increased, though not significantly, during the feeding period, while bowel movements decreased in the control diet group.

DISCUSSION

The advantage of breakfast cereals compared to other foods like white rice or bread is found in containing much more vitamins, minerals and dietary fiber. It is important to make clear the balance among these three nutrients for the particular purpose of improving skin conditions by taking breakfast cereals.

Wheat bran cereal is rich in dietary fiber but the balance of vitamins and minerals is not sufficient. In this study, the wheat bran cereal diet group did not significantly improve skin conditions, especially in terms of skin moisture content (Figures 1, 2). On the other hand, brown rice cereal contains less dietary fiber than wheat bran cereal, but it has a better balance of vitamins and minerals and actually improved skin elasticity (Figures 1, 2). We thus consider that well-balanced vitamins, minerals and dietary fiber are important for skin health.

Regular defecation frequency is important for keeping skin health, but all the subjects in all the groups of this study had a regular, daily bowel movement, and therefore we were unable to find its correlation with skin health. The use of constipated subjects would give clearer results.

We will also undertake investigations on the effect of breakfast cereal consumption to intestinal microflora in special relation to skin health.

CONCLUSION

The consumption of a breakfast cereal made of brown rice with well-balanced amounts of vitamins, minerals and dietary fiber can improve the skin health for young females who are troubled with their skin, whereas a breakfast cereal made of wheat bran did not contribute to improving skin condition probably because two servings of this cereal contain excessive dietary fiber. It may be of critical importance to take sufficient amounts of calcium, iron, vitamins A, B_1, B_2, niacin, and vitamins C and E, as well as dietary fiber from a breakfast cereal for the particular purpose of improving skin health.

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Table 4 Energy and nutrient intakes in the brown rice cereal diet group

	Stage											
	Pre-feeding (n = 7)				Feeding (n = 7)				Post-feeding (n = 6)			
Nutrient	Mean	±	S.D.	vs	Mean	±	S.D.	vs	Mean	±	S.D.	
Protein (%)	13.6	±	1.1		13.5	±	1.2		12.9	±	1.5	
Fat (%)	28.8	±	4.6		27.8	±	3.3		28.2	±	4.7	
Carbohydrate (%)	57.6	±	5.3		58.5	±	4.3		58.9	±	5.9	
Energy (kcal)	1659.7	±	330.8		1825.0	±	237.7		1532.8	±	251.6	
Water (g)	1037.9	±	277.4		1340.7	±	234.1		1044.4	±	129.2	
Protein (g)	51.6	±	20.1		61.6	±	10.8		49.7	±	13.0	
Fat (g)	54.9	±	16.7		58.3	±	13.1		49.7	±	15.1	
Carbohydrate (g)	215.1	±	35.1		237.1	±	30.9		193.5	±	24.6	
Saturated fatty acids (g)	16.7	±	6.7		18.5	±	5.8		14.9	±	5.6	
Monounsaturated fatty acids (g)	20.5	±	6.1		18.8	±	4.2		17.3	±	5.1	
Polyunsaturated fatty acids (g)	10.2	±	2.3		10.8	±	2.5		9.7	±	2.1	
Dietary Fiber (mg)	9.5	±	1.8		11.9	±	2.6	*	8.1	±	1.6	
Cholesterol (mg)	297.3	±	115.8		288.3	±	70.9		255.3	±	106.1	
Ash (g)	12.4	±	2.9		16.4	±	2.9		12.4	±	2.7	
Sodium (mg)	2857.6	±	815.1		3390.7	±	831.9		3041.8	±	783.9	
Potassium (mg)	1678.9	±	411.4		2238.7	±	498.7		1576.5	±	327.9	
Calcium (mg)	339.9	±	167.4	**	892.4	±	178.3	**	333.2	±	165.0	
Magnesium (mg)	177.4	±	35.2	**	253.0	±	45.2	**	164.0	±	28.4	
Phosphorus (mg)	803.7	±	234.0	**	1558.3	±	200.8	**	730.7	±	219.1	
Iron (mg)	5.8	±	1.6	**	16.3	±	1.4	**	5.1	±	1.6	
Zinc (mg)	6.8	±	1.5		7.3	±	1.4		6.0	±	1.2	
Copper (mg)	1.0	±	0.2		0.9	±	0.2		0.8	±	0.2	
Manganese (mg)	2.5	±	0.9		2.3	±	0.5		2.1	±	0.5	
Retinal (μg)	329.9	±	286.8	*	604.1	±	97.7	**	209.0	±	121.3	
Caroten (μg)	1722.0	±	332.3		1544.4	±	446.7		1558.2	±	530.0	
Retinal equivalent (μg)	609.7	±	322.7		867.9	±	117.1	**	469.5	±	162.4	
Vitamin D (μg)	5.1	±	2.3		5.0	±	1.8		4.2	±	2.2	
Vitamin E (mg)	7.0	±	2.0	**	15.6	±	1.6	**	6.3	±	2.0	
Vitamin K (μg)	128.9	±	32.6		134.9	±	43.5		100.8	±	17.4	
Vitamin B_1 (mg)	0.7	±	0.2	**	1.5	±	0.1	**	0.7	±	0.2	
Vitamin B_2 (mg)	0.9	±	0.3	**	1.7	±	0.4	**	0.9	±	0.3	
Niacin (mg)	13.9	±	3.0	**	26.3	±	2.9	**	13.3	±	3.2	
Vitamin B_6 (mg)	0.9	±	0.2		0.9	±	0.2		0.9	±	0.3	
Vitamin B_{12} (μg)	5.7	±	1.7		5.1	±	1.2		4.3	±	1.8	
Folic Acid (μg)	218.0	±	41.7		207.3	±	50.4		181.7	±	72.7	
Pantothenic acid (mg)	4.5	±	1.4		5.0	±	1.4		3.9	±	1.2	
Vitamin C (mg)	53.7	±	16.4	**	145.1	±	28.3	**	48.5	±	12.6	
Salt equivalent (g)	7.4	±	1.8		8.2	±	1.8		7.6	±	2.0	

** $p < 0.01$, * $p < 0.05$

The brown rice cereal used is fortified with vitamin A, B_1, B_2, C, D, E, niacin, iron and calcium.

Table 5 Energy and nutrient intakes in the wheat bran cereal diet group

Nutrient	Stage											
	Pre-feeding (n = 7)				Feeding (n = 7)				Post-feeding (n = 7)			
	Mean	±	S.D.	vs	Mean	±	S.D.	vs	Mean	±	S.D.	
Protein (%)	13.9	±	2.2		15.7	±	1.8		14.1	±	1.9	
Fat (%)	32.9	±	3.2		31.9	±	3.0		32.0	±	3.5	
Carbohydrate (%)	53.2	±	4.7		52.4	±	4.0		53.2	±	5.1	
Energy (kcal)	1705.7	±	223.5		1733.9	±	307.8		1686.3	±	389.2	
Water (g)	1286.8	±	527.8		1512.9	±	402.8		1336.6	±	425.5	
Protein (g)	55.3	±	9.4		65.6	±	10.1		56.8	±	14.2	
Fat (g)	59.6	±	9.7		61.3	±	17.0		57.0	±	15.0	
Carbohydrate (g)	211.5	±	41.7		218.8	±	40.4		216.4	±	61.2	
Saturated fatty acids (g)	18.3	±	4.1		21.6	±	6.8		17.4	±	5.3	
Monounsaturated fatty acids(g)	20.7	±	3.5		18.7	±	5.5		20.0	±	5.2	
Polyunsaturated fatty acids (g)	11.3	±	2.1		9.3	±	2.2		11.1	±	2.5	
Dietary Fiber (mg)	8.8	±	2.0	**	39.1	±	2.4	**	8.8	±	2.7	
Cholesterol (mg)	321.0	±	99.8		266.1	±	78.8		308.9	±	68.4	
Ash (g)	13.8	±	3.2	**	19.7	±	3.1	*	14.5	±	4.1	
Sodium (mg)	3259.0	±	903.7		3386.6	±	823.3		3537.9	±	1110.0	
Pottasium (mg)	1758.0	±	291.5	**	3210.6	±	416.5	**	1927.3	±	774.4	
Calcium (mg)	375.4	±	128.6	**	737.1	±	142.6	**	375.4	±	157.9	
Magnesium (mg)	181.0	±	28.1	**	538.6	±	46.6	**	214.9	±	110.2	
Phosphorus (mg)	820.3	±	132.1	**	1672.3	±	154.2	**	828.0	±	197.3	
Iron (mg)	5.6	±	0.7	**	9.9	±	1.2	**	5.8	±	1.4	
Zinc (mg)	6.3	±	1.1	**	11.7	±	1.4	**	6.7	±	2.1	
Copper (mg)	0.8	±	0.1	**	1.5	±	0.2	**	0.8	±	0.2	
Manganese (mg)	2.6	±	1.2		2.2	±	1.1		2.8	±	1.0	
Retinal (μg)	203.9	±	54.7		319.0	±	150.9		259.9	±	244.7	
Caroten (μg)	1392.6	±	517.3		1355.9	±	673.2		1649.6	±	632.8	
Retinal equivalent (μg)	438.0	±	115.0		549.9	±	145.0		537.0	±	283.4	
Vitamin D (μg)	4.3	±	1.0		4.7	±	2.6		4.1	±	1.7	
Vitamin E (mg)	7.1	±	0.8		7.3	±	5.0		6.7	±	1.5	
Vitamin K (μg)	119.7	±	31.9		125.0	±	62.3		141.7	±	86.6	
Vitamin B_1 (mg)	0.8	±	0.2	**	1.2	±	0.2	**	0.8	±	0.2	
Vitamin B_2 (mg)	1.1	±	0.2	**	2.1	±	0.3	**	1.1	±	0.3	
Niacin (mg)	14.8	±	3.3		16.8	±	2.9		14.4	±	4.6	
Vitamin B_6 (mg)	0.9	±	0.2		0.9	±	0.2		0.9	±	0.3	
Vitamin B_{12} (μg)	4.8	±	2.2		5.3	±	1.8		5.3	±	2.1	
Folic Acid (μg)	205.9	±	40.5	**	377.3	±	77.3	**	214.1	±	93.9	
Pantothenic acid (mg)	4.4	±	0.5		5.3	±	1.0		4.5	±	1.0	
Vitamin C (mg)	62.4	±	15.3		67.0	±	21.7		62.7	±	18.9	
Salt equivalent (g)	8.2	±	2.4		8.1	±	2.8		9.9	±	3.3	

** $p < 0.01$, * $p < 0.05$

The wheat bran cereal used is fortified with vitamin B_1, B_2, niacin, and iron.

Table 6 Energy and nutrient intakes in the control diet group

Nutrient	Stage								
	Pre-feeding (n = 7)			Feeding (n = 7)			Post-feeding (n = 7)		
	Mean	±	S.D.	Mean	±	S.D.	Mean	±	S.D.
Protein (%)	14.7	±	1.7	14.1	±	1.4	14.2	±	2.0
Fat (%)	29.4	±	3.6	29.2	±	4.1	29.0	±	3.9
Carbohydrate (%)	55.9	±	4.7	56.8	±	4.9	56.8	±	5.0
Energy (kcal)	1784.6	±	198.5	1619.0	±	301.1	1602.3	±	338.5
Water (g)	1371.0	±	389.4	1288.8	±	302.7	1234.5	±	217.6
Protein (g)	64.5	±	8.6	56.5	±	10.7	55.3	±	9.4
Fat (g)	58.1	±	6.6	52.6	±	10.1	51.9	±	12.2
Carbohydrate (g)	222.6	±	51.7	207.7	±	55.9	204.0	±	62.4
Saturated fatty acids (g)	17.0	±	2.5	14.3	±	3.4	14.6	±	3.6
Monounsaturated fatty acids(g)	20.0	±	2.9	18.6	±	3.5	17.4	±	4.5
Polyunsaturated fatty acids (g)	12.4	±	2.1	12.2	±	2.4	11.3	±	2.4
Dietary Fiber (mg)	11.3	±	3.0	10.5	±	2.7	9.8	±	3.1
Cholesterol (mg)	347.4	±	79.9	256.7	±	82.0	261.1	±	91.8
Ash (g)	14.9	±	2.1	14.5	±	3.3	13.9	±	2.8
Sodium (mg)	3383.7	±	419.6	3442.9	±	855.8	3407.6	±	619.8
Pottasium (mg)	2100.4	±	377.4	1954.6	±	413.0	1814.3	±	453.7
Calcium (mg)	408.9	±	129.7	396.9	±	126.8	354.0	±	67.5
Magnesium (mg)	225.3	±	49.8	207.9	±	50.4	192.6	±	48.5
Phosphorus (mg)	971.3	±	145.1	840.4	±	153.4	829.4	±	161.3
Iron (mg)	6.5	±	1.2	5.9	±	1.5	5.9	±	1.5
Zinc (mg)	7.4	±	1.0	6.5	±	1.0	6.4	±	1.5
Copper (mg)	1.0	±	0.2	1.0	±	0.3	0.9	±	0.3
Manganese (mg)	2.6	±	1.0	2.7	±	0.8	2.4	±	0.8
Retinal (μg)	268.7	±	211.3	160.4	±	81.4	209.6	±	144.5
Caroten (μg)	1956.3	±	762.4	2087.3	±	1024.1	2033.6	±	1017.6
Retinal equivalent (μg)	597.1	±	269.6	535.6	±	176.9	551.3	±	236.5
Vitamin D (μg)	5.7	±	3.4	5.6	±	3.6	5.0	±	1.8
Vitamin E (mg)	8.4	±	1.3	7.8	±	1.8	7.1	±	1.8
Vitamin K (μg)	129.1	±	28.5	137.6	±	32.7	123.6	±	28.6
Vitamin B_1 (mg)	0.9	±	0.1	0.8	±	0.1	0.8	±	0.2
Vitamin B_2 (mg)	1.0	±	0.2	0.9	±	0.2	0.8	±	0.2
Niacin (mg)	18.7	±	5.0	15.6	±	3.3	15.2	±	3.2
Vitamin B_6 (mg)	1.2	±	0.2	1.1	±	0.2	1.0	±	0.2
Vitamin B_{12} (μg)	6.4	±	3.3	4.9	±	2.7	5.7	±	3.4
Folic Acid (μg)	268.9	±	61.9	240.1	±	55.0	228.1	±	54.8
Pantothenic acid (mg)	5.5	±	0.8	4.7	±	0.7	4.6	±	0.9
Vitamin C (mg)	76.1	±	18.4	75.9	±	20.3	70.1	±	19.7
Salt equivalent (g)	8.6	±	1.1	8.8	±	2.2	8.7	±	1.5

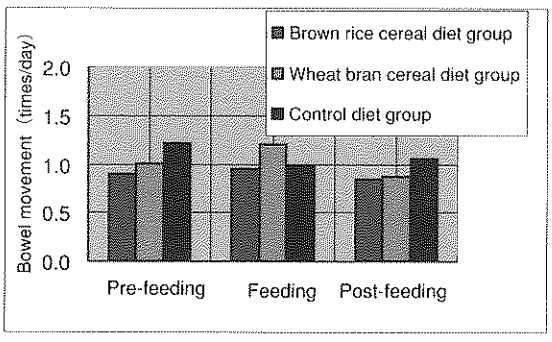

Fig.6 Differences in bowel movement frequency

REFERENCES

1) Yasue Nakagawa, Emiko Harashima, Asako Miura, Gumpei Urata, Shihoko Suzuki and Keisuke Tsuji: Journal of Home Economics of Japan, 54, 2, (2003)

2) Tsuneyuki Oku, Sadako Nakamura: J. Japanese Association for Dietary Fiber Research, 5 (1), 11-22, (2001)

3) Toshihisa Morimoto, Teruko Ito, Yoko Nakashima, Miwako Tanaka, Sumiko Nagayama: J. Japanese Association for Dietary Fiber Research, 1 (2), 15-22, (1998)

4) Yoko Nagashima, Toshie Tsuda, Sumiko Nagayama, Sachie Ikegami : J. Japanese Association for Dietary Fiber Research, 5 (2), 11-20, (2001)

5) Rumi Ide, Toshiharu Gomyo, Masayo Miura, Tomoko Furukawa, Souichi Murozono, Katsuji Matsunaga, Tomoko Fujimura-Ito: J. Integr. Stud. Diet. Habits, 15 (2), 102-110, (2004)

6) Takayuki Yasunishi, Hiroyuki Kojima, Yukinobu Nishibe, Tsuneo Bando, Munekazu Iinuma : Fragrance Journal, 9, 79-86, (1996)

7) Kohsuke Hayamizu, Takako Terayama, Nobuko Kajiwara : J. New Rem. & Clin., 49, 9, 31-37, (2000)

8) Senturk N, Keles GC, Kaymaz FF, Yildiz L, Acikgoz G, Turanli AY: Clin Exp Dermatol., 29, 2, 168-175, (2004)