Study on the nutritive values of vegetable milk

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Recently there are two kinds of vegetable milk powder produced by Taiwan Chlorella Manufacture Co. Ltd. Their commercial names are "Chlorella soya instant powder" (綠藻營養奶粉) and "milk-free chlorella and soya formula" (綠藻植物奶粉). Both of them are prepared from soy bean milk added with CGF and some other nutrient, but none of animal ingredient. Where CGF means chlorella growth factor discovered by Takechi et al (1). It is extracted from chlorella with hot water, and usually kept in 80% cane sugar solution. It has been found that chlorella contains much nutrients not only rich in essential amino acid (2) but also a growth stimulating factor (1, 3). These vegetable milk containing CGF are said very nutritive. The authors found that the addition of chlorella to soy bean milk could elevate the nutritive value of soy bean milk previously (4), and was also interested in the nutritive values of these new milk, therefore intended to compare the nutritive value of these vegetable milk with cow's milk in weaning rats. The results of growth, body length etc. are showing that the effects of "milk-free chlorella and soya formula" on young rats are very similar to cow's milk. However "chlorella soya instant powder" is not as nutritive as "milk-free chlorella and soya formula" yet, it is still better than whole original soy bean milk which does not contain the ingredient other than of soy bean.

Some effects of milk were observed in the adult rats. The plasma cholesterol content in adult rats are 156 and 136 mg/dl for the rats fed with cow's milk and vegetable milk respectively.

Experimental

Male weaning rats of the Long-Evans strain were used in this experiment. Selected 32 rats divided into 4 groups to be fed with 4 different milk for 30 days. They were housed 2 together in a cage equipped with bottle of water. The test diet and water were given ad libitum. The body weight of animals were weighed twice a week. A constant amount of diet was charged every day and food intake was measured twice a week. The test diets used in this experiment were 4 kind of milk, one of cow's milk and three of soy bean products. The cow's milk was distributed by Golden State Company Ltd.

The other three vegetable milk, were "soya bean milk powder", "chlorella soya instant" and "milk-free chlorella and soya formula". All of them were

supplied by Taiwan Chlorella Manufacture Co. Ltd. The composition of 4 milk is shown in Table 1.

Table 1. The composition of 4 kinds of milk

	Cow's milk	Soybean milk	Chlorella soya instant milk*	milk free chlorella and soya formula**
Fat %	28	20.02	13	20.0
Protein %	26.6	52.0	31	22
carbohydrate %	37.6	17.4	49.5	52
Ash %	5.8	5.0	3.5	4
Moisture %	2.0	5.6	3.0	2.0
C.G.F. unit/100g	—	—	2000	4200

*: Soybean milk added sucrose and lactose to dilute protein content and supplied C. G. F.
**: Soybean milk added sucrose and lactose to dilute protein content, and coconut oil added to elevate fat content, C. G. F. and vitamins also supplied.

Hemoglobin content was determined as acid hematin, using 0.02ml of blood collected from the tail of rat in the fourth week, after the animal were fed for 30 days they were killed by stunning transcetion of the great vessels of the necks. The blood for the blood assay was collected in a tube using ammonium oxalate as an anticoagulant. Plasma protein was determined by the modification of biuret yealtion, plasma cholesterol was determined by the modification of the method of Bloor at al. (5). The body length was measured when rat was laid on a table, apparent digestibility and biological value were determined according to the method of Mitchell (6).

The effect on the plasma cholesterol level of adult rat was also observed with Long Evans strain. 12 male rats about 18 months old and 300±10 g body weight were used. They were grown up under the same condition and took the same common diet. The rats were divided into 2 groups, one group was fed with cow's milk and another was fed with "milk-free chlorella and soya formula". Water and diet were given ad libitum. After they took the test diet for 6 weeks, they were killed by transection of vessels of the necks. The blood was collected to determine plasma cholesterol above method. Whole liver was weighed and about 2g of it was assayed for liver fat content.

Result and Discussion

The growth curves of the animals were shown in Fig. 1. It shows that the rate of growth of "milk-free chlorella and soya formula" was close by that of cow's milk. However "chlorella soya instant powder" is not so effective as "milk-free chlorella and soya formula" on the growth of young animal, it is still better than whole original soy bean milk. The food intake and body weight gain increased if the other vegetable substances such as carbohydrate and fat

were added to dilute soy bean milk protein. Especially, if enough vitamine and CGF were added with the diluents into the "milk free chlorella and soya formula", body weight gain would increased about thrice and FE twice as soy bean milk. Those results were almost as good as cow's milk (Table 2)

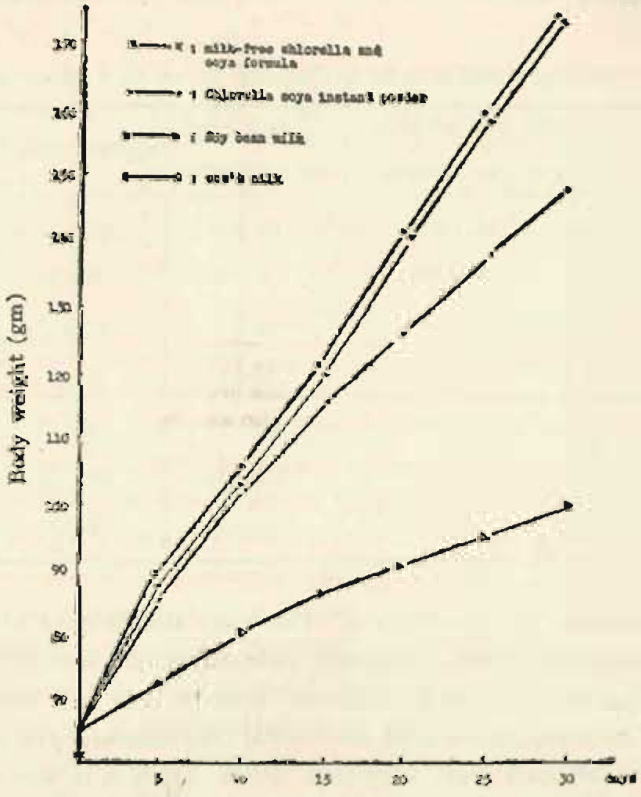

Fig. 1. Growth curve of rats fed with 4 kinds of milks

Table 2. Influence of 4 different kinds of milk on body weight gain and Feed intake

		milk-free chlorella and soya formula	chlorella-soya instant powder	soybean milk	Cow's milk
body weight (gm) for each rat	at the begining	63.8±3	63.3±5	63.1±4	63.2±5
	after 30 days	173.3±10	144.5±11	98.3±8	174.4±13
	weight gained	109.5±4.5	81.2±4.2	35.2±2.1	111.2±7.02
Feed intake for each rat in 30 days		290±19	240±16	175±22	65±30
F E		2.65±0.16	2.95±0.27	4.97±0.99	2.38±0.22

F E: Feed efficiency is the amount of the diet needed in gm to gain 1 gm body weight

The apparent digestibility and biological values were shown in Table 3. The biological value of original soy bean milk was 64%. It was elevated by addition of some other nutrients. Such as 71% for "milk-free chlorella and soya

formula". Inspite of the growth effect of "milk free and soya formula" was almost similar as cow's milk, the biological value of "milk free chlorella and soya formula" was still lower than that of 80% for cow's milk. It was observed that urinary nitrogen values of three vegetable milk were all higher than that of cow's milk.

Table 3. The digestibility and biological value of 4 kinds of milk

	milk free chlorella and soya formula	chlorella soya instant powder	soybean milk	cow's milk
N. intake (mg)	441±27	421±35	417±27	470±36
Fecal N. (mg)	92±20	43±11	82±16	90±28
absorbed N. (mg)	349±23	338±21	335±57	380±65
apparent digestibility (%)	79±5	80±4	80±5	81±6
Urinary N. (mg)	102±20	118±16	120±28	80±16
absorbed N. retained (mg)	247±47	220±58	215±64	300±68
apparent biological value (%)	71±7	66±13	64±9	80±10

N.: nitrogen

After the rats were fed for 30 days. The body weight gain and body length were measured, then blood was collected from the great vessel of the neck for assay. The results were shown in Table 4. Body weight and body length were almost the same between cow's milk and "milk free chlorella and soya formula". But those of soy bean milk were very low. From Table 4, it was observed that, no matter the body size was large or small, the data of blood assay were very similar in all 4 test groups, except the plasma cholesterol content. Plasma cholesterol of cow's milk was higher than those of vegetable milk, such as 143 mg/dl for former and 118-130 mg/dl for the latter (Table 4).

Table 4. Body size and the results of blood assay

	milk free chlorella and soya formula	chlorella soya instant powder	soybean milk	cow's milk
body weight at final (g)	173.3±10	144.5±11	98.3±8	174.4±13
body size (cm)	18.4±0.3	17.3±1.3	15.5±1.0	18.5±0.4
Hematocrit (%)	4.4±0.1	4.4±0.2	4.3±0.1	4.5±0.1
Hemoglobin content (g/dl blood)	15.9±0.8	15.7±1.3	15.7±1.0	15.4±0.8
plasma protein (g/dl plasma)	6.9±0.4	6.8±0.2	6.8±0.3	6.8±0.3
Cholesterol (mg/dl plasma)	130±25	118±19	128±19	143±24

Table 5 shows a comparision of the effect of the animal milk and vegetable milk on rat liver fat and plasma cholesterol. Plasma cholesterol and liver fat of cow's milk were 15% and 5.4% higher than those of "milk free chlorella and soya formula" respectively.

Table 5. A comparision of liver fat and cholesterol of rats affected by cow's milk and milk free chlorella soya bean milk

	liver weight / body weight	liver fat content %	cholesterol mg/dl plasma
cow's milk	2.8±0.1	6.2±0.8	156±0
milk free chlorella soya bean milk	3.0±0.2	5.9±1.0	137±9

Summary

In the comparision of the nutritive value of three vegetable milk "soy bean milk", "chlorella soya instant powder" and "milk free chlorella and soya formula" with cow's milk in weaning rats, the growth effects of "milk free chlorella and soya formula" and cow's milk were almost the same, but the biological value of this vegetable milk was still lower than that of cow's milk. The other two vegetable milk were not so effective as "milk free chlorella and soya formula" Especially, the effect of soy bean milk on growth is very low. Otherwise soy. bean milk, which does not contain the ingredient other than of soy bean and has too high protein and low carbohydrate levels, is supplied with carbohydrate and other ingredients, it is not as nutritive as cow's milk.

Plasma cholesterol of the rat fed with cow's milk was higher than that of the rat fed with vegetable milk.

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綠藻植物奶粉的營養價值之研究

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最近臺灣綠藻公司出品兩種植物奶粉—綠藻營養奶粉和綠藻植物奶粉，這些是用豆漿加上從綠藻抽出的綠藻精（CGF）、豬乳和椰子油等植物成分及 vitamins 等製成的不含動物成分的奶粉。據說營養價很高，著者等曾經發現若加綠藻於豆漿粉中，可以提高豆漿粉的營養價值，因此對這些植物奶粉的營養價值同感興趣。就用4組 Long-Evans 的幼鼠，各以植物奶粉和牛奶粉來飼養做比較。

所得到的結果：餵以綠藻植物奶粉的和餵以牛奶粉的對生長如體重身長等方面的影響無大差異。但餵以綠藻營養奶粉的差一些，餵以純豆粉的相差最大，吃量最少體重較輕身長也最小。這些事實表示，純豆粉若不加糖類時因其蛋白質含量過高，醣類過低養份配得不平衡，所以不適合於動物的生長。至於蛋白質的生物價 (biological value)，還是牛奶粉的高於所有植物奶粉的。

植物奶粉和牛奶粉對 plasma cholesterol 的影響，飼養成鼠的結果，吃牛奶粉之成鼠其 plasma cholesterol 比吃植物奶粉的高15%。