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STUDIES ON PULSES USED AS FOOD IN JAPAN

By

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The pulses are a very important source of protein for the Japanese who may require more of it. More than 30 uses of pulses can be listed at present in Japan. However, there are some difficulties in adjusting the taste or in utilizing the protein of pulses. Therefore, fundamental studies in the field of the protein utilization of pulses are required.

The present paper reports on two studies of pulses used as food in Japan: Part I treats of the statistical investigation of production and consumption of pulses in Japan, and part II the basic studies of the utilization of protein in Japan.

Part I Statistical studies on production and consumption of pulses in Japan

It is obvious that the deficiency of the protein intake of Japanese people is caused by their poor composition of diet. Table 1 shows the respective

Table 1. Supply of food by type.

(Per capita and per day)

Nutrition	1953	1954	1955	1956	1957	Average
Total	1050.4	1051.8	1100.2	1103.7	1097.6	1080.7
Cereals	478.3	474.6	479.6	474.3	458.2	473.0
Nuts	0.5	0.5	0.4	0.5	0.6	0.5
Potatoes	74.2	77.0	80.8	68.0	78.0	75.6
Sugars	14.8	15.6	15.8	15.6	10.3	14.4
Oils & Fats	4.2	4.6	4.4	5.1	4.8	4.6
Pulses	69.6	68.2	67.3	72.7	69.9	69.5
Animal foodstuffs	110.9	112.9	114.9	122.8	122.1	116.7
Vegetables & Fruits	200.9	203.8	234.8	236.5	228.3	220.9
Seaweeds	4.4	4.8	4.3	5.0	5.1	4.7
Industrial vegetables	50.4	49.5	55.7	59.1	55.9	54.1
Seasonings & Others	42.2	40.5	42.4	44.5	39.8	41.9

Source: Statistical Yearbook of Ministry of Welfare.

foodstuff intake, and Table 2 the nutrients intake of Japanese people from 1953 to 1957. As the table show, the amount of pulses is comparativly small, but we think that the utilization of pulses is one of the major problems in national nutrition. A comparison of presumptive turnouts of pulses from 1954 to 1958 in Japan is shown in Table 3.

Table 2. National average supply of nutrition.
(Per capita and per day)

		1953	1954	1955	1956	1957	Average
Proteins (g)	Animality	22.1	22.1	22.3	22.6	23.2	22.3
	Vegetal	46.6	46.8	47.4	46.5	46.5	46.8
	Total	68.7	68.9	69.7	69.1	69.6	69.2
Fats (g)		20.1	20.9	20.3	21.8	21.9	21.0
Carbohydrates (g)		403	403	411	405	404	405
Calories		2068	2074	2104	2092	2089	2085

Source : Statistical Yearbook of Ministry of Welfare.

Table 3. A comparison of presumptive turnouts of pulses in 1954—1958.
(Unit : tons)

Year	Soybeans		Peas		Broad beans	
	Green	Dried	Green	Dried	Green	Dried
1954	43,744	376,009	74,899	15,107	73,864	25,124
1955	44,123	507,086	79,065	27,891	72,930	24,734
1956	39,041	455,460	94,838	13,050	75,071	25,283
1957	40,314	458,480	98,190	16,637	66,109	20,505
1958	37,800	391,200	100,800	14,900	63,000	20,800
Average	41,004	437,647	89,558	17,517	70,195	23,389

Year	Kidney beans		Azuki beans*	Cow peas**	Mung beans***	Peanuts
	Green	Dried				
1954	36,334	73,089	81,677	11,779	195	39,311
1955	44,366	141,008	150,034	15,307	210	46,830
1956	48,529	77,448	107,568	16,321	195	49,552
1957	58,655	109,848	139,771	18,276	260	71,847
1958	58,100	148,900	141,500	16,700	230	83,300
Average	49,197	110,059	124,110	15,677	218	58,168

* Phaseolus angularis ** Vigna sinensis *** Phasealus mungs
Source : Statistical Yearbook of Ministry of Agriculture and Forestry.

Nowadays we have no objection in the theory that the nutritive value of protein depends upon the kind and amount of its amino acid composition. Table 4 shows the composition of pulses used as food in Japan, and Table 5 the amino acid composition of protein in cereals and pulses.

Table 4. Composition of pulses used as food in Japan.

Pulses	Cal	Water	Protein	Fat	Carbo-hydrate	Fibre	Ash	Vitamin				
								A	B_1	B_2	Niacin	C
	Cal	%	%	%	%	%	%	I.U.	mg	mg	mg	mg
Soybeans	396	9.85	31.98	18.00	26.66	7.12	4.64	10	0.50	0.15	3.0	0
Peas	317	13.40	21.70	1.00	55.20	6.00	2.22	50	0.50	0.20	4.5	0
Broad beans	316	13.30	26.00	1.15	50.30	5.80	2.77	100	0.50	0.20	2.5	2.0
Kidney beans	301	17.20	16.60	1.73	54.70	3.00	4.14	—	—	—	—	—
Azuki beans	307	14.91	20.94	0.70	54.13	5.00	3.64	10	0.50	0.15	2.5	0
Cow peas	29	88.71	3.28	0.25	3.34	2.09	0.72	—	—	—	—	—
Mung beans	321	13.61	22.98	1.66	53.41	3.95	2.96	100	0.50	0.25	3.0	0
Peanuts	588	3.70	27.57	46.20	15.50	0.80	2.00	0	0.70	0 06	15.6	0

Source : Standard tables of food composition in Japan.

Table 5. Amino acid composition of protein in cereals and pulses.
(Values given as percentage of protein)

	Arg	His	Iso	Leu	Lys	Met	Phe	Thr	Try	Val	Cys	Tyr
Soybeans, meal	4.7	2.9	5.0	8.1	5.6	1.1	6.5	5.3	1.3	5.6	1.4	4.3
Kidney beans, meal	5.9	2.4	4.9	7.7	9.2	1.0	5.3	3.5	1.1	6.0	—	2.8
Peas, meal	7.6	2.4	6.4	6.5	7.7	1.8	4.3	3.9	0.8	4.2	0.7	3.9
Mung beans	6.2	2.1	3.2	5.4	3.3	0.5	3.1	—	1.2	4.1	0.4	2.4
Peanuts, meal	10.0	2.9	4.6	6.6	3.2	0.8	4.6	2.6	4.6	5.7	0.9	3.2
Rice, polished rice	8.3	2.2	4.5	7.8	3.7	2.3	4.5	3.4	—	6.2	—	—
Oat, meal	6.8	2.1	4.4	7.4	3.9	1.5	5.5	3.4	—	5.7	—	—
Wheat, whole wheat	4.2	2.1	2.9	6.6	2.7	1.4	4.9	2.9	—	4.3	—	—
Corn, meal	4.2	2.4	4.3	10.8	3.4	1.3	4.0	3.6	0.7	4.3	—	4.3

It is apparent that the nutritive value of soybean protein is slightly lower than that of animal food, but soybeans contain a large amount of protein and fat, and their amino acid composition is comparatively better. The amino acid composition of soybean protein is the best among the vegetable foods. Soybean and peanut are the twin stars of Japanese food firmament so far as the components are concerned. For Japanese people who live on poor protein food, soybeans are, next to fish, as a source of protein, and they should make full use of it.

The soybean production in Japan once exceeded 500 kilo tons, but later, siece Japan had close political relation with Manchuria, a large amount of soybeans was imported cheaply from that country. Therefore, the soybean yield in Japan decreased to 300 kilo tons or less. After the World War II, the transportation of soybeans from Manchuria ceased, thus Japan had to raise the yield to meet the shortage of soybeans, and at present more than 500 kilo tons of soybeans is being produced.

Table 6 shows the areas under cultivation of soybeans by places of production (Fig. 1). However, the present production is not sufficient to meet the demand of our country. To get more soybeans, 1000 kilo tons were imported mainly from the United States, and also recently from China. The amount of consumption of soybeans in our country is about 1500 kilo tons. In Table 7, the amount of consumption of soybeans by uses is shown.

Table 6. Planted area of soybeans in 1954—1958.

Region & Year		Hokkaido	North Eastern (7 Prefectures)	Central Japan (Tokyo and 21 Prefectures)	South Western (Shikoku and 5 Prefectures)	Kyushu	Total
		acres	acres	acres	acres	acres	acres
1954	Total	241,389.14	324,523.67	297,566.22	83,110.02	136,564.14	1,083,153.19
	Green	5,632.17	6,862.52	6,654.19	997.52	553.90	20,700.30
	Dried	235,756.97	317,661.15	290,912.03	82,112.50	136,010.24	1,062,452.89
1955	Total	172,722.28	316,795.98	280,331.49	73,713.27	124,596.40	968,159.42
	Green	2,357.77	6,862.52	6,024.31	715.66	188.72	16,147.98
	Dried	170,364.51	309,933.46	274,307.18	72,997.61	124,407.68	952,011.44
1956	Total	219,576.12	313,028.94	253,023.62	70,318.77	116,407.95	972,355.40
	Green	2,401.88	7,009.57	4,943.46	566.16	161.76	15,082.83
	Dried	217,174.24	306,019.37	248,080.16	69,752.61	116,246.19	957,272.57
1957	Total	181,371.50	298,328.45	245,967.42	71,063.84	116,604.02	913,335.22
	Green	1,708.28	6,872.32	5,198.36	499.98	132.35	14,411.79
	Dried	179,663.22	291,456.13	240,769.06	70,563.86	116,471.66	898,923.93
1958	Total	167,690.58	294,108.00	230,293.92	69,309.00	109,805.22	871,206.72
	Green	1,519.56	7,181.14	4,835.63	487.73	102.94	14,127.00
	Dried	166,171.02	286,926.86	225,458.29	68,821.27	109,702.28	857,079.72
Average	Total	196,549.92	309,357.00	261,436.51	73,502.98	120,795.54	977,708.01
	Green	2,723.93	6,957.61	5,531.18	653.41	213.93	16,080.06
	Dried	193,825.99	302,399.39	255,905 33	72,849.57	120,567.61	961,627.95

Source : Statistical Yearbook of Ministry of Agriculture and Forestry.

Table 7. The amount of consumption according to use of soybean.
(Unit : kilo tons)

Year	Miso	Shoyu	Tofu and other food	Chemical industry	Seed, bait, fertilizer and other	Total
1952	150	180	124	(54)* 66	76	596
1953	160	210	154	(86) 100	96	720
1954	161	225	178	(40) 57	106	727
1955	237	310	234	(77) 96	155	1032
1956	193	252	190	(84) 108	156	899
Average	180	235	176	(68) 85	118	794

* For monosodium glutamate. Source : Statistical Yearbook of Staple-food Management.

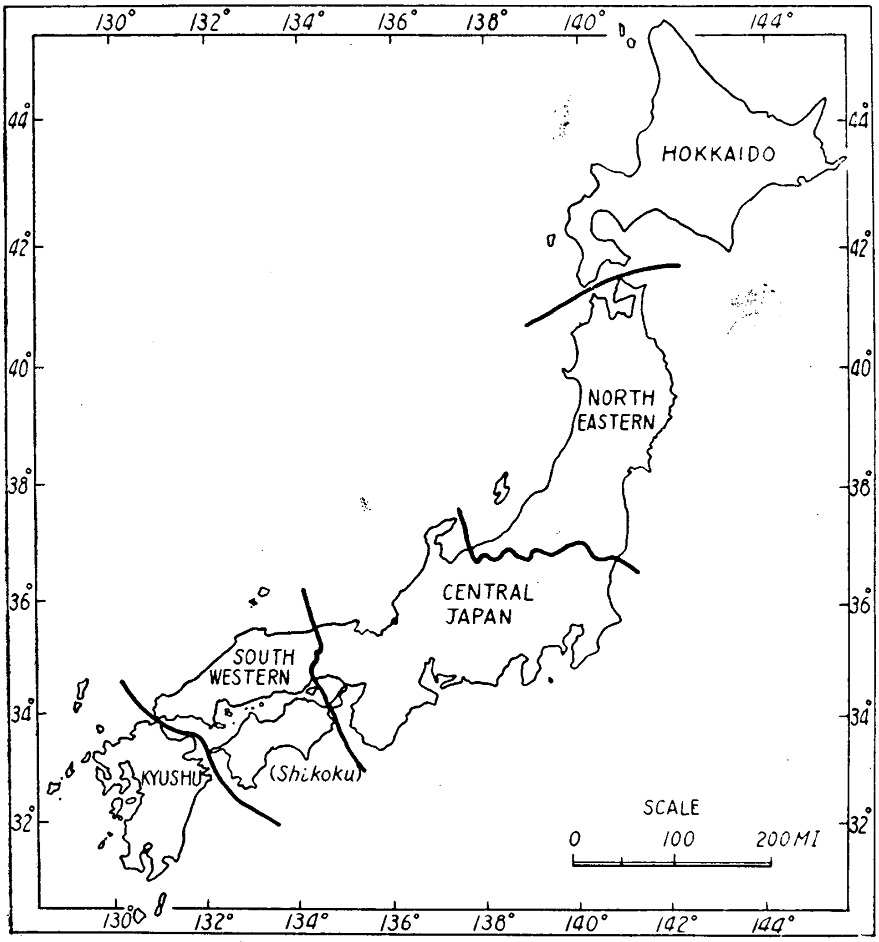

Fig. 1. Map of Japan.

The manners of cooking soybeans and the content of both protein and fat in soybean productions in Japan are noted in Table 8.

Table 8. The foods from soybean and the content of both protein and fat in soybean products in Japan.

Soybean products	Water	Protein	Fat
	%	%	%
Tonyu, soybean milk	90.8	3.6	2.0
Miso, soybean cheese, (sweet)	49.0	10.0	1.7
〃 〃 〃 (salty)	51.0	12.6	3.4
Shoyu, soybean sauce	72.2	6.9	0.6
Tofu, soybean curd	88.0	6.0	3.5
Yakidofu, roasted Tofu	83.0	8.8	5.1
Koridofu, congealed Tofu	10.3	53.5	26.4
Aburaage, fried slice Tofu	43.0	20.6	30.4
Namaage, fried Tofu	79.0	10.1	7.0
Ganmodoki, fried minced Tofu	64.0	15.4	14.0
Yuba, dried sheets of soybean protein	8.7	52.3	24.1
Natto, fermented soybean	58.5	16.5	10.1
Hama Natto, fermented soybean	38.1	25.9	12.4
Kinako, roasted soybean flour	7.8	21.9	19.2
Nimame, boiled soybean	—	19.6	6.1

Source : Standard tables of food composition in Japan.

Special processes are required for making soybean products, because the tissue of a soybean is very compact and much harder than that of cereal kernels, and also rich in cellulose. *Kinako* is made by grinding roasted soybeans to promote digestion. *Tonyu* (soybean milk) is a water soluble product, which results through the processes of water-soaking, and through cheesecloth-filtration with heating. Adding $CaCl_2$, $CaSO_4$ or $MgCl_2$ to *Tonyu*, we can get soybean curde which is called *Tofu*. A series of products, such as *Aburage* (fried slice Tofu), *Namaage* (fried Tofu), *Ganmodoki* (fried minced Tofu), *Yuba* (dried sheets of soybean protein), *Koridofu* (congealed Tofu) and *Yakidofu* (roasted Tofu), are made from *Tofu*. Fermentation on boiled soybeans makes other kinds of food. *Miso* (soybean cheese), *Shoyu* sauce and *Natto* (fermented soybean) are the products by fermentation. In general, these foods have their own fragrance.

Miso, *Shoyu* sauce and *Tofu* are the main foods among the soybean products mentioned above, and *Natto* and *Kinako* are also popular foods in Japan. The former three are essential for the nutrition of Japanese people. But among these foods, some soybean products have lost much of their nutrients because of being subjected to too many processes, and because of their poor taste. The formers are *Tofu* and *Shoyu* sauce and the latters are *Natto* and a kind of *Miso*. It is important to improve the production processes so that the nutritive value of soybean foods may not be lost, and that they may become more popular.

Part II Experiment— Basic studies on nutritive utilization of soybean protein (Studies on the heat processing of soybeans and the nutritive value of soybean protein)

It is the problem of digestibility that we must consider as an important condition in using soybean. Osborne and Mendel (1), as early as 1917, reported that the protein of raw food is different in nutritive value from that of heat treated food. They observed that rats grow better when fed on cooked soybeans as their sole source of protein, than on raw soybeans. The improvement in the nutritive value of soybean protein, affected by heat treatment in the presence of water, has been confirmed by other workers, but this phenomenon has not yet been satisfactorily explained.

It is known that three opinions exist concerning this probem as follow: First, trypsin inhibitor that was found in raw soybeans by Ham and Sandstedt (2) and by Bowman (3), and later crystallized by Kunitz (4) was considered to be largely responsible for the interference in the biological utilization of the protein, and that this inhibitor is destroyed or rendered inactive by heat has been demonstrated both *in vivo* (5, 6, 7) and *in vitro* (7, 8) experiments. Secondly, soyin, a toxic protein, recently isolated from raw soybean flour by

Liener and Pallansch (9) is said to have one cause of inhibition and this protein is inactivated by heat treatment of soybeans. Thirdly, Hayward's theory (10), that sulfur containing amino acid, a limiting factor soybean protein, was made biologically available by heat treatment.

Melnich *et al.* (11) demonstrated that the increase in nutritive value of the soybean protein resulting from heat treatment was accompanied by an increase in the susceptibility of the protein to pancreatic digestion *in vitro*. These workers indicated that methionine is liberated at a slower rate than the leucine or lysine in soybean protein and that heat processing increases the rate of liberation of methionine to a greater extent. In support of their observation, Evans (12), Jones (13) and Riesen *et al.* (14) observed that a marked increase *in vitro* digestability occurred when soybeans were boiled or autoclaved in water. On the other hand, a deficiency of cystine in the protein of raw soybeans was noted by Mitchell and Smuts (15). Later, Hayward *et al.* (10) found that the addition of cystine or casein improved the growth of rats fed on raw soybeans, but not of those fed on cooked beans, and expressed the belief that cystine in the raw protein may exist in a form unavailable to the animal, but available by heating. These workers (16) found that methionine, another sulfur containing amino acid, has been found to be even more effective than cystine in supplementing the protein of raw soybeans. It is evident, therefore, that heated soybeans are slightly deficient in methionine, while raw soybean protein is definitely deficient in this amino acid.

Now, evidently drastic heating decreases the availability to the animal organism of certain amino acids, since the nutritive value of overheated soybean is improved by the addition of lysine (17), and restored by the addition of methionine and lysine (18), or methionine, cystine and lysine (19).

In part II, we report that in experiment 1, the relation between the heat condition and the digestibility of soybean protein was studied by measuring the effect of various heat treatments on digestibility of raw soybeans and the degree of liberation of nutritive limiting factor, methionine, cystine and lysine, by *in vitro* pancreatic digestion; in experiment 2, the differences of nutritive value were compared by measuring the growth, serum protein, liver -fat, -phospholipid and -glycogen in rats fed on a diet containing the soybean and its products *i.e. Kinako*, *Tofu* and *Natto* as their sole source of protein *in vivo*.

Materials and Methods

Sample and heat treatment. The soybean flours employed in this study were all prepared from the same kind of *Ōu* No. 13 which has been harvested from the experimental farm of the Faculty of Agriculture, Tohoku University.

The samples were ground through a sieve of 30 mesh/inch, defatted with ether. This flour was used for the control. The composition of soybean is; moisture 13.2 %, protein 40.5 %, fat 18.2 %, sugar substance 19.4 %, fiber 4.0 %, ash 4.6 %. The heat treatments consisted of: (1) boiled, (2) autoclaved at 110°C, (3) autoclaved at 130°C, (4) dry heated at 105°C, and (5) drastic dry heated at 150°C. The heating time is 30 minutes.

In vitro digestibility. The digestibility of the protein *in vitro* enzymic digestion was determined according to the procedure of Melnick and his associates (11).

Estimation of methionine. Methionine was estimated according to the procedure of Bolling's modification of the Sullivan-McCathy method (20).

Estimation of cystine. Estimation of cystine was done by the method of Folin (21).

Estimation of lysine. Lysine was estimated manometricaly using L-lysine decarboxylase. Enzyme preparation was made by the procedure of Kondo's modification (22) of the Gale method.

Experimental animal. Weanling male albino rats of the Wistar strain, weighing approximately 50 g were used in these experiments. The animals were divided, with respect to weight, into similar groups of five and were housed in individual cages with raised screen bottoms.

Diet and feeding technique. Composition of the rations fed to the various groups of rats are shown in Table 9. All of the diets shown in the table contained 10 per cent of protein and starch for the balance to give a total

Table 9. Composition of experimental diets.

Component	Group No.				
	I	II	III	IV	V
	g	g	g	g	g
Soybean,(1) boiled, 30 min.	26.3				
Soybean, autoclaved, 30 min.		30.9			
Kinako(2)			30.8		
Tofu, congealed Tofu(1)				15.8	
Natto(1)					26.4
Starch	63.7	59.1	59.2	74.2	63.6
Soybean oil	5.0	5.0	5.0	5.0	5.0
McCollum salts No. 115	4.0	4.0	4.0	4.0	4.0
Vitamin mixture(3)	1.0	1.0	1.0	1.0	1.0
Level of protein (%)	10.0	10.0	10.0	10.0	10.0

(1) Commercial good
(2) Dry heated soybean flour, 140°C, 6 min.
(3) Milligrams per 100 gm diet: thiamine chloride 1.0, riboflavin 1.0, pyridoxine 2.0, niacin 2.5, calcium pantothenate 3.0, folic acid 0.2, choline chloride 100.0, inositol 10.0, biotin 0.04

of 100 per cent. Protein level was determined for the sample of soybean and its products used in the these studies with the semi-micro Kjeldahl technique. Throughout the experiment, each animal was supplemented orally with two drops of liver oil per week by dropper. Food and water were given *ad libitum* and animal body weights were recorded at regular intervals. After a 24 day experimental period, rats of groups I, III, and IV, were supplemented with 0.3 per cent of DL-methionie, and for the group V, one-fifth of the total soybeans was replaced by autoclaved soybeans. After the animals had maintained on their respective rations for 40 days, they were sacrificed for determination.

Estimation of serum protein. Total protein levels of serum were estimated by the refractometer.

Estimation of liver fat and phospholipid. Liver fat contents were determined as ether-soluble matter and liver phospholipid was estimated according

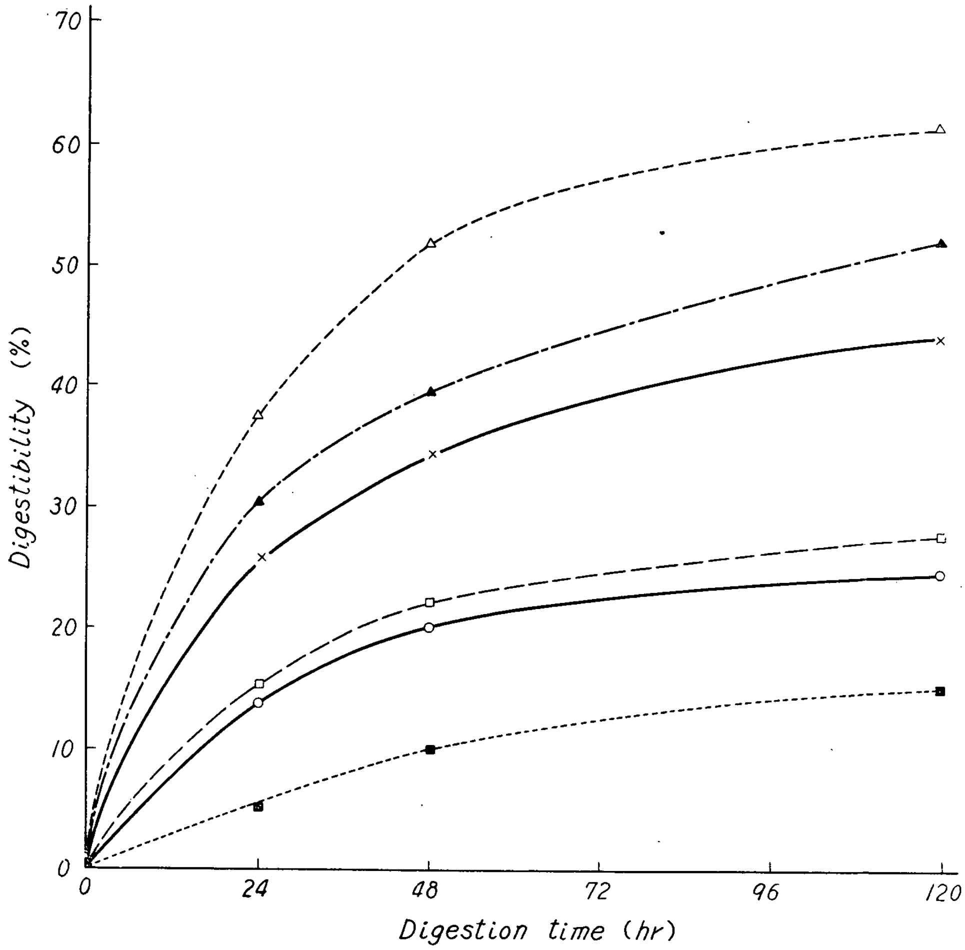

Fig. 2. The influence of the heat treatment of soybean protein on the digestibility.

○— None (Control) ×— Boiled
△— Autoclaved, 110°C ▲— Autoclaved, 130°C
□— Dry heated, 105°C ■— Dry heated, 150°C

to the procedure of Best *et al.* (23).

Estimation of liver glycogen. Liver glycogen was determined according to the procedure of Seifter *et al.* (24) by the use of anthrone reagent.

Results and Discussion

Experiment 1. Effect of heat on the digestibility of soybean protein.

Condition of heat treatment and the digestibility

The influence of the heat treatment of soybean protein on the digestibility is shown in Fig. 2. The results showed that the digestibility of soybean

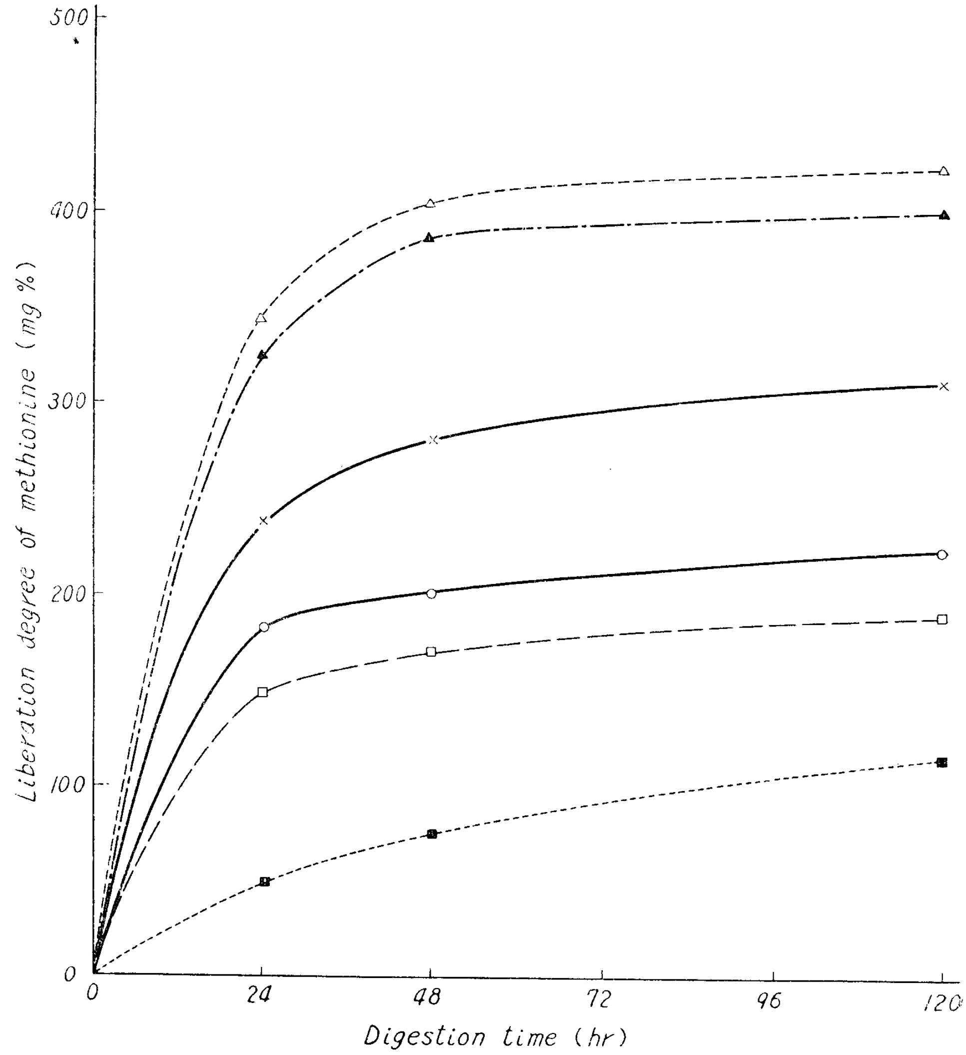

Fig. 3. Condition of heat treatment and liberation of methionine.

○— None (Control) ×— Boiled
△— Autoclaved, 110°C ▲— Autoclaved, 130°C
□— Dry heated, 105°C ■— Dry heated, 150°C

protein was increased as the digestion period was prolonged and the autoclaving at 110°C as the heat condition, in all cases showed the highest digestibility and was followed by the autoclaving at 130°C and boiling. The dry heating, on the other hand, decreases the digestibility as compared with the control (raw) and the dry heating at 150°C showed the lowest digestibility. It seemed possible that when soybeans, were heated with water, soybean protein was denatured, and became to be readily attacked by enzyme, while heat treatment with water destroyed some amino acids in the protein molecular. These results showed that heat treatment sometimes has a beneficial, sometimes a harmful effect on the nutritive value of protein.

Condition of heat treatment and liberation of limiting amino acid.

The liberation degree of methionine, cystine and lysine by pancreatin digestion is shown in Figs. 3, 4 and 5. The degree of methionine liberation

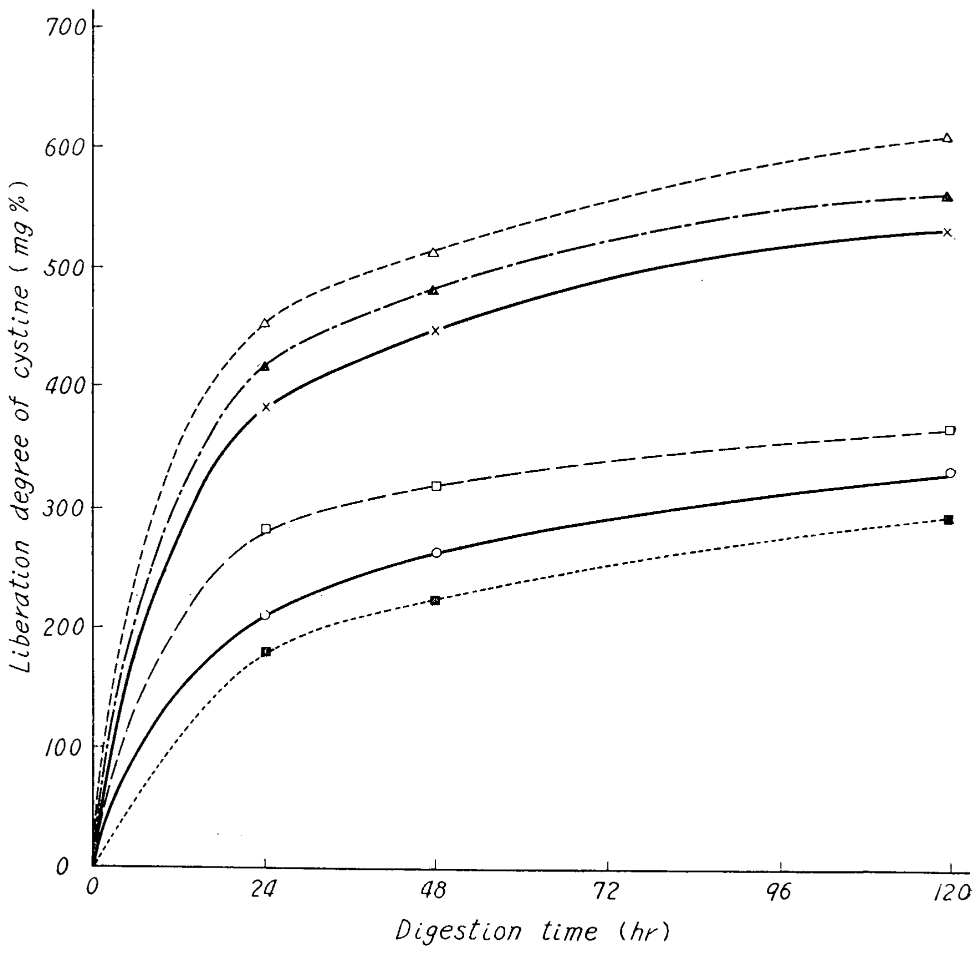

Fig. 4. Condition of heat treatment and liberation of cystine.

○— None (Control) ×— Boiled
△— Autoclaved, 110°C ▲— Autoclaved, 130°C
□— Dry heated, 105°C ■— Dry heated, 150°C

showed the same tendency of digestibility, *i. e.*, autoclaving at 110°C was the highest, twice as high as the control and was followed by the autoclaving at 130°C and boiling. Dry heating lowered the liberation degree and dry heating at 150°C showed the lowest value. The degree of the liberation of

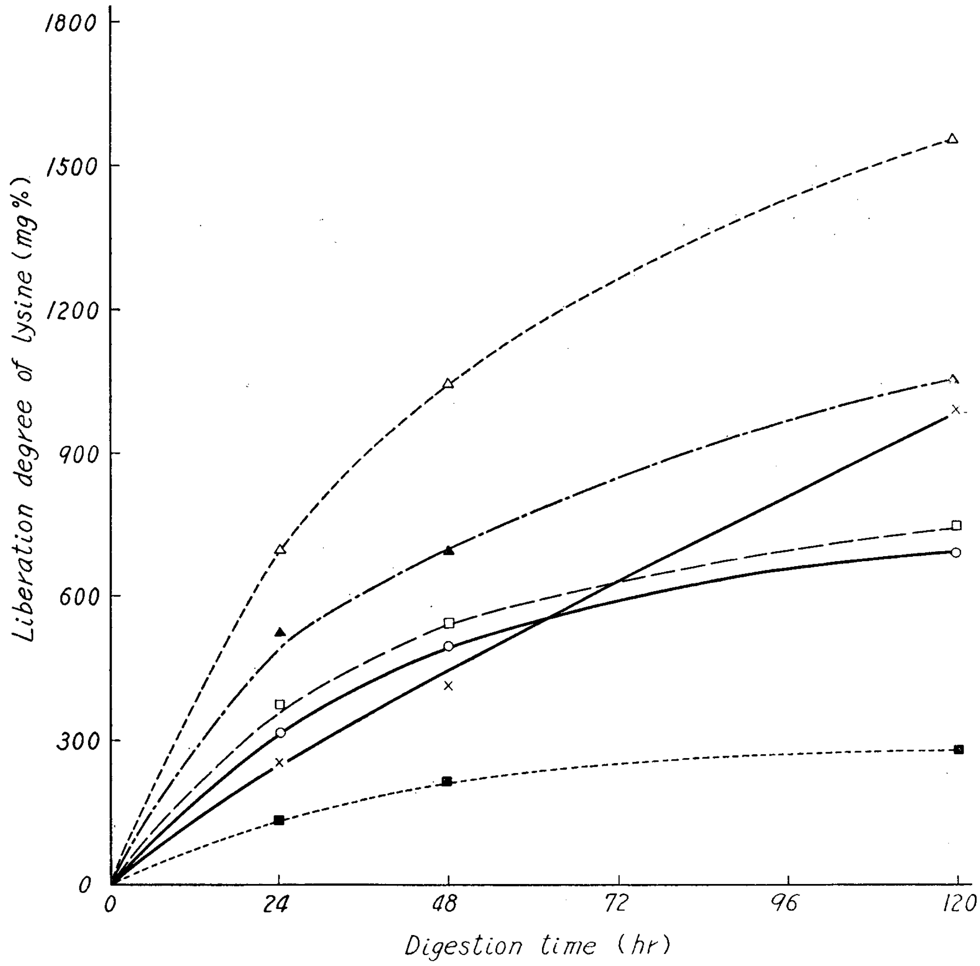

Fig. 5. Condition of heat treatment and liberation of lysine.

○— None (Control)	×— Boiled
△— Autoclaved, 110°C	▲— Autoclaved, 130°C
□— Dry heated, 105°C	■— Dry heated, 150°C

cystine and lysine were almost the same in tendency as that of metionine.

Deficiency of cystine in the protein of raw soybeans was noted by Mitchll and Smuts (15). Later, Hayward and Hafner (16) found that the addition of cystine or methionine improved the growth of rats fed on raw soybeans, but not that of those fed on cooked beans, and expressed the belief that cystine in the raw protein may exist in a form unavailable to the animals, but available on heating.

Experiment 2. Nutritional experiment of weanling rats fed with various types of soybeans and its products.

Growth of rats.

The change of body weight of rats fed on a diet containing the soybeans and their products is shown in Table 10 and Fig. 6. As is seen from the

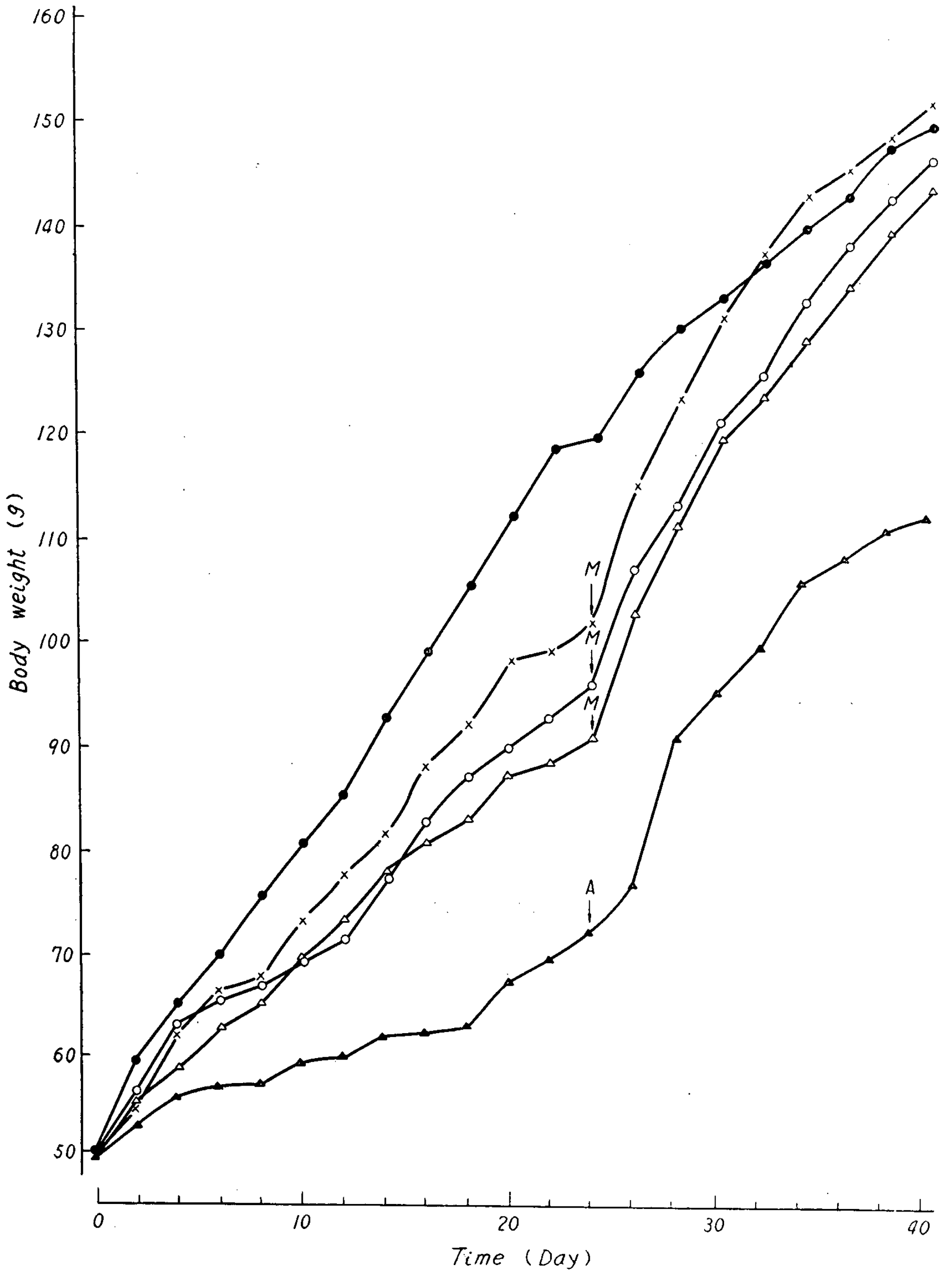

Fig. 6. Effects of various types of heat processing on the nutritive value of soy bean protein.

○— Soybean, boiled ●— Soybean, autoclaved at 110°C
×— Kinako △— Tofu
▲— Natto
↓M : +0.3% methionine ↓A : +Autoclaved soybean

results, autoclaved soybean meal (group II) produced the best growth of 20.3 g per week, and the order of growth is as follows: *Kinako* meal (group III) 15.2 g, boiled soybean meal (group I) 13.2 g, *Tofu* meal (group IV) 12.1 g and

Table 10. Growth and liver weight of rats fed on experimental diets.

Group No.	Diet	No. of animals	Average body wt. and gain			Liver weight	Liver/body wt.
			Initial	24th day*	Final (40th day)		
			g	g	g	g	%
I	Soybean, boiled	5	49.6	95.0 (+45.4)	146.6 (+97.0)	5.9	4.1
II	Soybean, autoclaved	5	49.8	119.5 (+69.7)	150.2 (+100.4)	6.3	4.2
III	Kinako	5	49.1	101.5 (+52.4)	152.7 (+103.6)	6.8	4.5
IV	Tofu	5	50.0	91.5 (+41.5)	144.0 (+94.0)	6.0	4.2
V	Natto	5	49.6	72.5 (+22.9)	113.0 (+63.4)	5.1	4.3

* After 24 day, rats of groups I, III and IV, were supplemented 0.3% of DL-methionine, and for the group V, one-fifth of the total soybeans was replaced by autoclaved soybeans.

Natto meal (group V) 6.6 per week. In the groups I, III and IV, however, the addition of methionine to the diet resulted in some growth improvement (22.3–22.7 g per week) and also the addition of autoclaved soybean diet to group V showed food effect (17.6 g per week).

Serum protein, liver -fat, -phospholipid and -glycogen.

The levels of serum protein and the contents of liver -fat, -phospholipid and -glycogen are presented in Table 11. No remarkable difference was observed in each group.

Table 11. Serum protein, liver-fat, -phospholipid and -glycogen of rats fed on soybean and its products.

Group No.	Diet	No. of animals	Serum protein	Liver fat		Liver phospho-lipid	Liver glycogen
				Dry wt.	Wet wt.		
			%	%	%	%	%
I	Soybean, boiled	5	5.4±0.1*	22.0±0.7	6.6±0.2	3.2±0.1	2.0±0.2
II	Soybean, autoclaved	5	5.1±0.1	22.7±0.8	6.0±0.3	3.1±0.2	2.3±0.1
III	Kinako	5	5.3±0.2	22.6±1.7	5.8±0.5	3.0±0.1	2.3±0.1
IV	Tofu	5	5.1±0.1	22.8±0.2	6.1±0.4	3.2±0.1	2.2±0.2
V	Natto	5	4.9±0.1	23.8±0.4	6.8±0.1	3.0±0.1	1.8±0.1

* Standard error of the mean.

Summary

Statistical data on production and consumption of pulses in Japan are shown. Japanese people taking poor protein food must utilize soybeans next

to fish and it is one of the focal problems from the view point of national nutrition.

The influence of heat treatment on the nutritive value of soybean protein was experimentally studied by measuring the effect of heat on the digestibility of soybean protein and the degree of liberation of nutritive limiting factors, methionine, cystine and lysine, by *in vitro* pancreatic digestion. The digestibility of soybean protein was increased as the digestion period was prolonged, and the autoclaving at 110°C showed the highest digestibility, and the autoclaving at 130°C and boiling followed next. The dry heating rather decreased the digestibility as compared with the control (raw) and the dry heating at 150°C showed the lowest digestibility. The degree of amino acids liberation showed the same tendancy as digestibility.

Nutritional experiments are presented in comparison with the rate of gain, serum protein, liver -fat, -phospholipid and -glycogen of weanling rats fed with various types of soybeans and their products. Autoclaving of soybean meal produced the best growth and next *Kinako* meal, boiling meal, *Tofu* meal and *Natto* meal. The levels of serum protein, liver -fat, -phospholipid and -glycogen of animals show no remarkable difference in each group.

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