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## A STUDY ON THE INTERNATIONAL COMPARISON OF THE PATTERN OF FOOD ENERGY INTAKES

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### INTRODUCTION

In discussing on foods, diets, nutritions and also their problems in the world, per caput consumptions or intakes of single food items and nutrients or major food groups among countries have tended to be examined individually for the purpose of clarifying nutritional conditions of respective countries<sup>1)</sup>. And besides the relationship between health status and diet in a country has often been explained by looking into the association of mortality, morbidity or incidence of disease with the quantity of individual food items, food groups or nutrients consumed<sup>2~3)</sup>.

However, when diet in a population group is observed, consumptions or intakes of individual food items are not determined independently of other foods with each other but synergistic or antagonistic relation is found between food items or food groups. Thus, such relation constructs what is generically called food consumption structure<sup>4~7)</sup>. This fact supports importance of understanding the health status of a population group not in relation to a single food item individually but by systemically considering the dietary patterns of the population group.

The authors now applied techniques of multivariate analysis which have often been used in various fields such as public health these days<sup>8~9)</sup>, to the most recent data of FAO: The purpose for this application may be possibly 1) to make clear the food consumption structure of the world, 2) to grasp the state of food intakes of countries as dietary patterns, 3) to classify the countries according to the similarity of said dietary patterns and 4) to quantitatively determine degree of the recent change in the dietary pattern of each country.

### MATERIALS AND METHOD

#### 1. Data

The data used in this study were obtained from the tables of food energy supplies in 163 countries in the world in 1961~65, 1972, 1973 and 1974 which were published by Food and Agriculture Organization of the United Nations<sup>10~13)</sup>. The figures of 1961~65 are mean values of energy supplies from 1961 to 1965. In the tables, per caput energy supplies per day (Cal) from 16 food groups are shown. The 16 food groups comprise cereals, roots and tubers (hereinafter referred to as tubers), sugar, pulses, tree-nuts, vegetables, fruit, meat and offals (hereinafter referred to as meat), eggs, fish, milk and products (hereinafter referred to as milk products), vegetable oils and fats (hereinafter referred to as vegetable oils), animal fats and oils (hereinafter referred to as animal fats), spices, stimulants and alcoholic beverages. The figures of the per caput energy supplies were obtained by subtracting amounts of export, increase in the stock and amount of non-human consumption from the total amount of national production and import and dividing thus obtained total supplies for human consumption by the number of population in a country. Therefore, the figures could be considered as average per caput food energy supplies for the people of the country at a kitchen level. Although the original table of FAO gives figures of 163 countries, those of Namibia were not used in this study, as they were partly missed. Thus, figures for 162 countries were submitted to the following analysis.

#### 2. Procedure of the analysis

(1) Correlation coefficients between 16 food groups in terms of the energy supply

Correlation coefficients between 16 food groups in terms of energy supplies were calculated, using the data of 162 countries of the year 1974 and those of the three periods (1961~65, 1972 and 1974) (the

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Tab. 1. Correlation coefficients between food groups in terms of the energy supply (1974)

	1)	2)	3)	4)	5)	6)	7)	8)	9)	10)	11)	12)	13)	14)	15)	16)
1) Cereals	1.000															
2) Roots and tubers	-0.590	1.000														
3) Sugar, Syrup	-0.228	-0.347	1.000													
4) Honey	-0.027	0.074	-0.191	1.000												
5) Pulses	-0.228	0.365	-0.302	-0.039	1.000											
6) Tree-nuts	-0.095	-0.137	0.310	-0.174	-0.075	1.000										
7) Vegetables	-0.473	0.310	0.018	0.208	0.078	0.114	1.000									
8) Fruit	-0.310	-0.140	0.627	-0.341	-0.204	0.390	-0.027	1.000								
9) Meat	-0.151	-0.236	0.670	-0.261	-0.204	0.491	-0.027	0.750	1.000							
10) Eggs	-0.195	0.041	0.171	-0.267	0.273	0.225	0.000	0.122	0.214	1.000						
11) Fish	-0.286	0.246	0.738	-0.278	-0.323	0.278	-0.032	0.795	0.718	0.085	1.000					
12) Milk	-0.168	-0.131	0.474	-0.242	-0.089	0.443	0.088	0.460	0.555	0.215	0.481	1.000				
13) Vegetable oils & fats	-0.250	-0.144	0.603	-0.267	-0.241	0.314	-0.068	0.760	0.682	0.036	0.703	0.266	1.000			
14) Animal oils & fats	0.243	-0.099	-0.036	-0.146	0.054	0.002	-0.061	-0.109	0.033	0.052	-0.107	-0.028	0.041	1.000		
15) Spices	-0.374	-0.132	-0.263	-0.263	-0.171	0.236	0.064	0.684	0.594	0.160	0.715	0.482	0.612	-0.046	1.000	
16) Stimulants	-0.255	-0.033	0.495	-0.164	-0.158	0.430	0.046	0.731	0.638	0.170	0.592	0.464	0.666	-0.044	0.557	1.000

Fig. 1 Configuration of 16 food groups by factor loadings (factors 1 and 2)

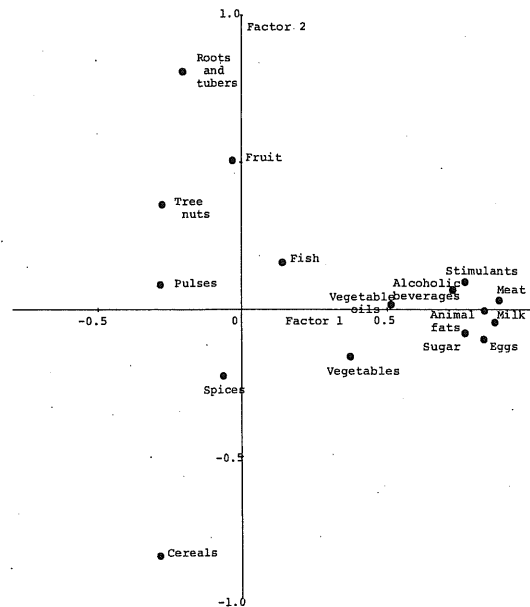
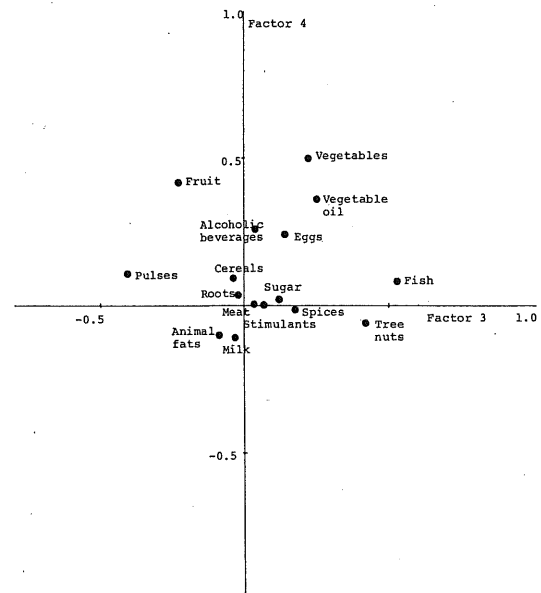


Fig. 2 Configuration of 16 food groups by factor loadings (factors 3 and 4)



number of the data amounts to 486 for each food group) respectively, thus producing two 16\*16 correlation matrices.

## (2) Factor analysis<sup>14)</sup>

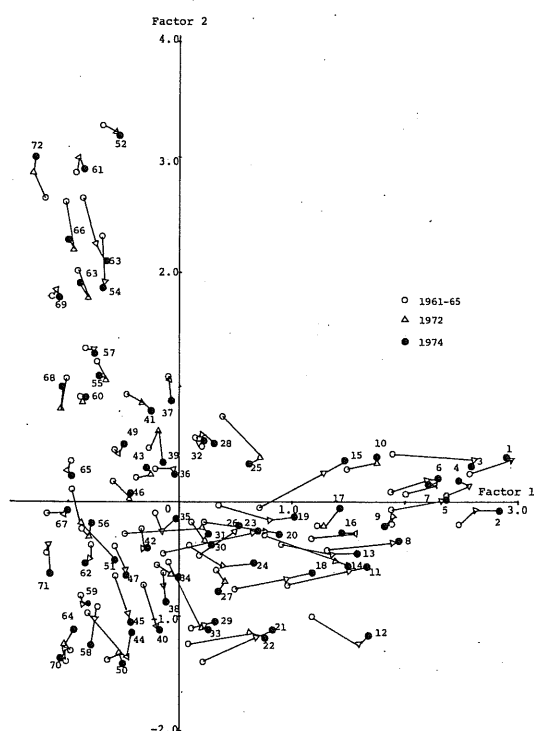
Factor analysis by means of the varimax method was applied to the 16\*16 correlation matrix of the three



Tab. 2 Factor loadings of 16 food groups

	Factor 1	Factor 2	Factor 3	Factor 4	communality
Cereals	-0.292	-0.839	-0.042	0.093	0.799
Roots and tubers	-0.214	0.781	-0.023	0.033	0.657
Sugar, syrups, honey	0.757	-0.089	0.115	0.018	0.595
Pulses	-0.292	0.084	-0.409	0.116	0.273
Tree-nut	-0.282	0.355	0.417	-0.059	0.383
Vegetables	0.376	-0.164	0.224	0.495	0.464
Fruit	-0.035	0.505	-0.233	0.413	0.481
Meat	0.881	0.033	0.032	0.003	0.778
Eggs	0.828	-0.104	0.141	0.238	0.772
Fish	0.139	0.156	0.530	0.083	0.332
Milk and products	0.867	-0.042	-0.035	-0.113	0.768
Vegetable oils and fats	0.502	0.013	0.251	0.364	0.447
Animal oils and fats	0.842	-0.004	-0.087	-0.098	0.727
Spices	-0.073	-0.229	0.174	-0.014	0.088
Stimulants	0.768	0.094	0.066	0.005	0.603
Alcoholic beverages	0.719	0.066	0.036	0.258	0.589

Fig. 3 Configuration of countries by factor scores (factors 1 and 2)—for the numbers refer to Tab. 3



periods combined. Furthermore, factor scores were calculated for the 486 data, using the factor loadings as weights.

### (3) Cluster analysis<sup>14)</sup>

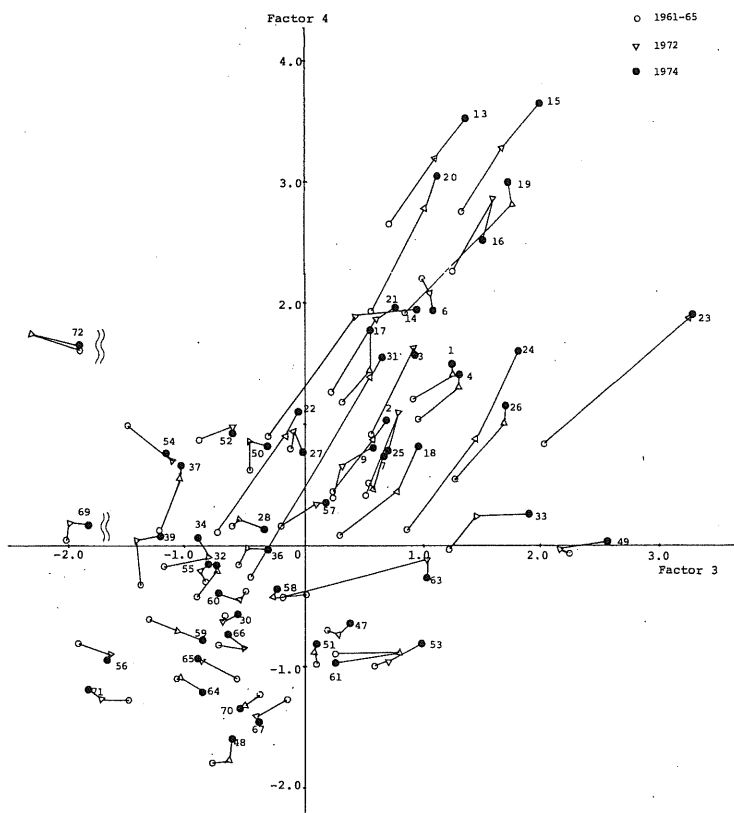
From the figures of the energy supplies in the 162 countries of the year 1974, a matrix of Euclidian dis-

Tab. 3 List of countries illustrated in Fig. 3 and 4

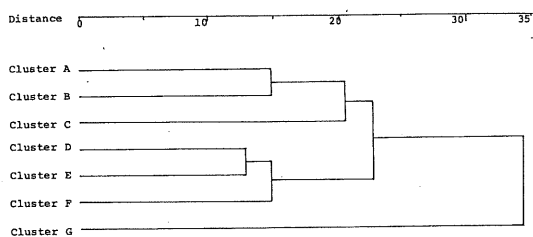
1	Switzerland	37	Paraguay
2	New Zealand	38	Mal W Malays.
3	Germany Fed.	39	Brazil
4	U.S.A.	40	Iraq
5	Austria	41	Fiji
6	France	42	El Salvador
7	Canada	43	Bolivia
8	Czechoslovak	44	Korea
9	Australia	45	Iran
10	Norway	46	Sudan
11	Poland	47	Philippines
12	Hungary	48	Somalia
13	Italy	49	Maldives
14	Malta	50	Egypt
15	Spain	51	Indonesia
16	Israel	52	Gabon
17	Argentina	53	Tonga
18	U.S.S.R.	54	Uganda
19	Portugal	55	Tanzania
20	Greece	56	Kenya
21	Bulgaria	57	Cameroon
22	Yugoslavia	58	Burma
23	Japan	59	India
24	Singapore	60	Nigeria
25	New Caledonia	61	Congo
26	Hong Kong	62	China
27	Chile	63	Ghana
28	Venezuela	64	Ethiopia
29	South Africa	65	Guinea
30	Cuba	66	Zaire
31	Libya	67	Chad
32	Colombia	68	Togo
33	Brunei	69	Burundi
34	Mexico	70	Bangladesh
35	Nicaragua	71	Upper Volta
36	Peru	72	Rwanda



**Fig. 4** Configuration of countries by factor scores (factors 3 and 4) —for the numbers used in this figure, refer to Tab. 3



**Fig. 5** Dendrogram of 7 clusters (162 countries in the world)



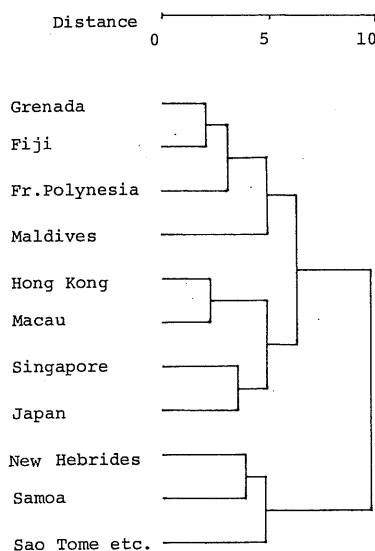
tance was obtained, and a cluster analysis called Ward's method was applied so as to yield clusters of the countries with maximum similarities measured in terms of the energy supply.

## RESULTS

### 1. Correlation coefficients with regard to the food groups

Correlation coefficients between food groups measured in terms of the energy supply of the year 1974

**Fig. 6** Dendrogram of 11 countries in cluster F



are shown in Tab. 1.

By convention of inferential statistics, correlation coefficients with the absolute value not less than



Tab. 4 Countries constituting each cluster

Cluster A (14 countries)	El Salvador, Honduras, Guatemala, Kenya, Botswana, Cape Verde, Haiti, Brazil, Nicaragua, Mexico, Upper Volta, Niger, Rwanda, Burundi
Cluster B (55 countries)	South Viet Nam, Viet Nam, Thailand, Philippines, Mal Sarawak, Bangladesh, Nepal, Bhutan, Cambodia, Lao, Burma, Yemen Ar., Lesotho, Afghanistan, Rhodesia, Mali, Zambia, Indonesia, Madagascar, China, Chad, Malawi, Korea Rep., Korea Dpr., Guinea, Guin. Bissau, Liberia, Sudan, Senegal, Gambia, Sierra Leone, Algeria, Iran, Jordan, India, Pakistan, Albania, Iraq, Somalia, Mauritania, Swaziland, Mal W. Malays., Mauritius, Morocco, Saudi Arabia, Yemen Dem., Egypt, Turkey, Syria, Tunisia, Libya, Mal Sabah, Brunei, Ethiopia, Sri Lanka
Cluster C (18 countries)	Nigeria, Angola, Mozambique, Togo, Benin, Tanzania, Cent. Afr. Emp., Solomon Is., Zaire, Congo, Tonga, Ghana, Cameroon, Ivory Coast, Ugondo, Comoro Is. Gabon, Papua N. Guin.
Cluster D (38 countries)	Colombia, Ecuador, Venezuela, Panama, St. Lucia, St. Vincent, Dominican Rp., Paraguay, Guadeloupe, Martinique, Peru, Dominica, Bolivia, Lebanon, New Caledonia, Guyana, Surinam, South Africa, Reunion, Cuba, Trinidad etc., Costa Rica, Jamaica, Belize, Chile, Romania, Yugoslavia, Bulgaria, Cyprus, USSR, Poland, Argentina, Barbados, Antigua, Neth. Antille, Bahamas, Uruguay, Mongolia
Cluster E (6 countries)	Spain, Italy, Portugal, Greece, Malta, Israel
Cluster F (11 countries)	Grenada, Fiji, Fr. Polynesia, Maldives, Hong Kong, Macau, Singapore, Japan, New Hebrides, Samoa, Sao Tome etc.
Cluster G (20 countries)	Germany Fed., Austria, France, Germany DR., Belgium-Lux, Canada, UK, U.S.A., Australia, Czechoslovak, Hungary, Denmark, Netherlands, Sweden, Norway, Finland, Ireland, New Zealand, Iceland, Switzerland

0.152 are presumed to have statistical significance at the 5% level.

As apparent in the Tab. 1, high correlations were observed between milk products and sugar, between meat and animal fats, between milk products and animal fats and between milk products and stimulants. On the other hand, cereals had strong negative correlation with tubers.

## 2. Factor analysis

Applying the technique of factor analysis to the 16\*16 correlation matrix of the three periods, we extracted four factors. The contribution ratios of the first, second, third and fourth factors were 33.2%, 11.5%, 5.4% and 4.6%, respectively.

The factor loadings of 16 food groups are shown in Tab. 2, and the graph of the first and second factors and that of the third and fourth factors are displayed in Figs. 1 and 2, respectively.

Of the scores of the four factors with respect to the 162 countries, those for about 70 countries are plotted

and linked in sequence of the three periods, i.e. 1961~65, 1972 and 1974 in Fig. 3 (for the factors 1 and 2) and in Fig. 4 (for the factors 3 and 4).

As seen in Figs. 1 and 2 showing the configuration of the 16 food groups, eggs, milk products, sugar, meat, animal fats, stimulants and alcoholic beverages were located near with each other and vegetables were in the vicinity of vegetable oils. Both facts indicate that consumptions of meat, eggs, milk products, sugar, animal fats, stimulants and alcoholic beverages were closely related with each other and consumption of vegetables was related with that of vegetable oils as well.

Now, we shall inspect what the four factors display in view of Tab. 2 and Figs. 1 to 4.

The first factor: High factor loadings were found in cases of meat, milk products, animal fats, eggs, stimulants, sugar and alcoholic beverages, resulting in such a high contribution ratio as 33.2%. Countries with high scores of the first factor were those devel-



**Tab. 5** Mean values and standard deviations of energy supplies from 16 food groups in clusters A to G (per caput kilocalories per day)

Cluster	Cereals	Roots & tubers	Sugar	Pulses	Tree-nuts	Vegetables	Fruit	Meat
A	1069(281)	181(261)	227(160)	183(82)	23(18)	14( 6)	120(151)	74(51)
B	1473(254)	82(107)	162(106)	48(33)	53(54)	29(23)	61( 55)	75(41)
C	615(115)	832(127)	77( 20)	56(20)	123(33)	22( 8)	167( 66)	71(21)
D	1037( 94)	151( 32)	367( 35)	51(11)	30(10)	33( 6)	119( 24)	257(50)
E	1134(133)	132( 66)	366( 59)	59(14)	59(23)	90(11)	135( 25)	319(40)
F	882(166)	191( 97)	266( 56)	47(17)	187(83)	41(13)	75( 36)	199(75)
G	758( 69)	161( 23)	473( 30)	17( 4)	23( 7)	45( 7)	89( 9)	557(45)

	Eggs	Fish	Milk & products	Vegetable oils	Animal fats	Spices	Stimulants	Alcoholic beverages
A	10(10)	7( 6)	67(41)	77(54)	40(35)	1(1)	3( 3)	49(35)
B	7( 7)	24(25)	63(58)	127(96)	28(25)	7(9)	2( 3)	24(32)
C	3( 1)	32(11)	21( 9)	110(19)	14( 6)	4(3)	2( 1)	47(24)
D	18( 3)	31( 7)	172(26)	178(25)	90(20)	3(1)	13( 3)	91(19)
E	48(17)	47(20)	224(41)	433(59)	67(32)	2(1)	17(12)	171(89)
F	22(12)	111(31)	66(25)	165(36)	56(19)	3(2)	9( 3)	56(28)
G	51( 4)	40(11)	388(49)	265(50)	295(50)	4(3)	32( 8)	197(26)

**Tab. 6.** Size of change of the pattern of energy intake expressed by the Euclidian distances based on the four factors between 1961-65 and 1974

Order	Name of country	Euclidian distance
1	Libya	2.312
2	Japan	1.932
3	Singapore	1.851
4	Malta	1.812
5	Portugal	1.610
6	Korea Rep.	1.481
7	Yugoslavia	1.447
8	Greece	1.433
9	Spain	1.417
10	Hungary	1.392

oped industrially in Europe, North America and Oceania. The increase of scores was observed as the year proceeded on in the countries possessing relatively high scores of this factor. As for Japan, the score increased remarkably from the first (1961~65) to the second period (1972).

The second factor: Tubers, fruit and tree-nuts had highly positive factor loadings and cereals had a highly negative factor loading. Countries with high factor scores were located in Africa and in the South Pacific Ocean, while countries with low scores were scattered

in Asia and in Africa.

The third factor: Fish and tree-nuts had highly positive factor loadings, while pulses and fruit had negative factor loadings. Japan had a prominently high score of this factor reflecting that she was one of the distinguishing fish-eating countries in the world. On the other hand, very low factor scores were found in Rwanda and Brundi where much pulses were consumed.

The fourth factor: Vegetables, fruit and vegetable oils had high loadings and Mediterranean countries such as Spain, Italy, Israel, Portugal etc. had high scores of this factor. Vegetables and vegetable oils had relatively high loadings on this factor as well as on the third factor, and therefore, they could not be explained simply in terms of the fourth factor.

The scores of the third and fourth factors were generally increasing in the countries with high scores of these factors as the year proceeded on, as apparent in Fig. 4.

### 3. Cluster analysis

By applying cluster analysis to the motrix of Euclidian distances calculated between countries based on the data of energy supplies of 16 food groups in 1974, the 162 countries of the world were first divided into two clusters of countries, one of which consisted of



20 industrially developed countries in Europe, North America and Oceania and the remaining countries were divided into clusters successively according to the distances between countries. According to the criteria of Euclidian distances 12.8 specified a priori, the 162 countries could be divided into seven clusters ultimately. Fig. 5 illustrates the dendrogram of the seven clusters labelled by A, B, C, D, E, F and G. Cluster G was the most distinguishing since it consisted of above-mentioned 20 developed countries.

Now, we describe what each cluster reveals.

Cluster A consisted of some countries in Latin America and Africa and is characterized by relatively high consumption of both cereals and pulses.

Cluster B consisted of most of Asian countries, some countries in Africa and Albania and high importance attached to cereals in the diet distinguishes this cluster from others.

Cluster C consisted of some countries in Africa and the South Pacific Ocean and characteristic of the diet of this cluster is the large consumption of tubers, treenuts and fruit.

Cluster D consisted of mainly Latin American and East European countries and is remarkable in that none of the energy supplies from 16 food groups surpassed those of the other clusters from the corresponding food groups.

Cluster E consisted of six countries located around the Mediterranean Sea and was distinguished by the greatest dependence on vegetables and vegetable oils in the world. Furthermore, energy supplies from the food groups other than tubers, sugar, treenuts, animal fats and spices ranked second in the world.

Cluster F consisted of several Asian countries and countries in the Pacific Ocean and high consumption of fish or tree-nuts is the characteristic found in this cluster.

Cluster G consisted of the so-called industrially developed countries in Europe, North America and Oceania and large consumptions of sugar, meat, eggs, milk products, animal fats, stimulants and alcoholic beverages mark this cluster.

Japan belonged to cluster F and the dendrogram of 11 countries constituting the cluster F is shown in Fig. 6. It is seen in the figure that Japan was situated nearest to Singapore. Countries constituting the seven clusters are given in Tab. 4 and mean values of energy

supplies of 16 food groups in each cluster are shown in Tab. 5.

## DISCUSSION

### 1. Materials

Data used in this study are those collected and published recently by FAO on the basis of the official informations or reliable unofficial informations of the countries. It is believed that they are one of the most comprehensive and reliable data available on food supplies or food consumption of the countries in the world.

So far, various studies have been made to compare the food supply patterns of countries using the data of food weight. It should be noted, however, that our study is distinct from those studies, since we used data on food energy supplies instead of food weights. As foodstuffs classified into the same food group on an international scale are much diversified, use of data of energy supplies will be justified in the sense that the influence of water content of foodstuffs may be eliminated.

### 2. Correlation coefficients between food groups

As already mentioned, sugar, meat, eggs, milk products, animal fats, stimulants and alcoholic beverages possessed high correlation coefficients with each other indicating that large amounts of these foodstuffs were consumed in the lump to constitute a specific diet. In other words, sugar, eggs, milk products, animal fats, stimulants and alcoholic beverages were also essential energy sources in countries where meat was important. On the other hand, cereals had a relatively high negative correlation coefficient with tubers and no positive correlations were observed in any other food groups except for vegetables and spices. Thus, it is suggested that tubers were not generally important and that excessive importance was often attached to only cereals, in countries where cereals were taken as staple foods. Tubers also had no significant positive correlation with other food groups except for tree-nuts and fruit and this fact also reveals the nutrition problems encountered in roots- and tubers-eating countries.

Correlation coefficients calculated in our study were considerably different from those obtained by Yoshikawa et al.<sup>15)</sup> who used international consumption data of 11 food groups expressed by weight.



The differences stated above might be attributable not only to the difference in the way how the food-stuffs were classified and in the year of the data used but also to the fact that data analyzed by Yoshikawa et al. were of 37 countries including only a few developing countries.

Furthermore, the correlation coefficients between food groups obtained in our study were generally much higher than those calculated by Toyokawa et al.<sup>7)</sup> who used the domestic food consumption data from the Japanese Nutrition Survey conducted in 1971. From the statistical point of view, absolute values of correlation coefficients obtained from international data will be usually larger as compared with those obtained from the data within a country, since the data obtained from the homogeneous sample may sometimes yield low correlation coefficients due to small variation of data.

### 3. Factor analysis

As seen from Tab. 2 and Figs. 3 and 4, sugar, eggs, milk products, animal fats, stimulants and alcoholic beverages were situated near with each other. Thus, we may safely say that these foods were consumed in a closely related manner so as to constitute a specific dietary pattern. The countries characterized by the dietary pattern were the so-called developed countries in Europe, North America and Oceania consuming much meat. So let us name these foods "meat-related foods."

The first factor might be interpreted as a factor which determined the degree of relative importance of the meat-related foods in the diet. Nakayama et al.<sup>16)</sup> showed by a cross-sectional study in 1963 that consumption of starchy foods increased with the increase of income in developing countries, while consumption of starchy foods was negatively correlated with income in developed countries. He also described that Japan, Portugal etc. were situated at the boundary point between the developing countries and the developed countries and that consumption of animal foods increased as income increased except for high income countries in which increase of the consumption of animal foods was inconspicuous. As seen in Tab. 3, the factor scores of the first factor increased remarkably as the year proceeded on in countries with medium factor scores. The fact indicates that consumption of the meat-related foods substantially increased during

the years from 1961~65 and 1974 in these countries, while there was little increase in the consumption of meat-related foods in countries with low scores. These results seem to support Nakayama's opinion in a sense and thus the first factor may be supposed to be associated with the economical standard of life in the country. However, consequence of history or convention of the country<sup>17)</sup> should never be disregarded.

The second factor is supposed to be a factor influencing degree of importance of either cereals or tubers in the diet. Thus, among countries with low scores of the first factor, countries with tubers-based diet and those with cereals-based diet were distinguished by the scores of the second factor. It is noteworthy that very few countries possessed high factor scores of both of the first and second factors. This fact indicates that the diet taken by the tubers-eating countries does not contain much animal foods. Autret et al.<sup>18)</sup> has mentioned that diets based on roots and tubers often cause serious protein deficiency due to low protein content as well as low protein scores of these foods, and that it is preferable to substitute cereals for roots and tubers in the diet gradually in order to improve such nutritional situation in roots and tubers-eating countries rather than to supplement these foods with animal foods. As seen in Fig. 3, the factor scores of the second factor of some countries with high scores decreased as the year proceeded on. This fact suggests that consumption of roots and tubers decreased and consumption of cereals increased. This fact may well conform to the recommendation made by Autret et al.<sup>18)</sup>

In order to measure the size of change in the pattern of energy supplies of each country from the first period (1961~65) to the third period (1974), we calculated Euclidian distances based on the scores of the four factors. Ten countries having the highest distances are shown in Tab. 6. Regardless of the direction of the change, it may be said that change in the dietary pattern of Japan was the largest next to Libya. It should be noted that gross domestic product (GDP) of most of these countries shown in Tab. 6 had undergone great changes during the period from 1960 to 1973. This fact suggests close connection between change of the dietary pattern and economical status on the national level, as has been pointed out by J. Perrie et al.<sup>19)</sup>, who has mentioned that gradual



restructuring of the diet as a function of income is a general phenomenon and that each country moves from features basic to it and reflecting its dietary heritage at the speed corresponding to the rate of increase of per caput income.

It is worthy of attention how will the food consumption pattern of Japan change in future, from the view point of possibility of change which will be recognized in the national health status as well as from the standpoint of agricultural policy.

#### 4. Cluster analysis

At the first glance, the structure of the clusters obtained by cluster analysis seems somewhat different from the visually seized results of factor analysis as shown in Figs. 3 and 4, and distinctness of Japan, Rwanda or Brundi seems to have been weakened. However, it is duly understood that the results of cluster analysis and those of factor analysis are consistent, when we recollect that the contribution ratio of the first factor excelled those of the remaining factors to a great extent.

It is interesting to note that Japan constituted a cluster with such countries as shown in Fig. 6 and that Singapore whose GDP was the highest next to Japan in Asia was situated at the nearest position to Japan. With regard to only the energy intake from fish, the figure of Japan (183 Cal) is nearer to that of Maldives (202 Cal) or that of New Hebrides (154 Cal) rather than that of Singapore (119 Cal). The similar situation applies to figures of other food groups, too. Thus, the fact that Singapore is situated at the nearest position to Japan implies the best resemblance of the pattern of food energy intake of Japan to that of Singapore as a whole.

Tamura et al.<sup>20)</sup> had divided 96 countries in the world into six clusters by applying cluster analysis (the nearest neighbor method) to the similarity matrix of food consumption pattern calculated by using data of food supplies expressed by food weight in 1960~63. Although the results of our study agree with those of Tamura et al. in that both Japan and Singapore belonged to the same cluster, the great difference observed between the both studies in constitution of other clusters may be attributable to the difference in the classification of foods as well as to the difference in the method and in the year of data used.

The present results do not support the opinion of

Yoshikawa et al.<sup>15)</sup> who applied principal component analysis to the international food consumption data of 1964 that dietary pattern of Japan bore the best resemblance to that of Spain, Italy etc. The difference between the results of Yoshikawa et al. and those of our study might be attributable to the fact that data of almost all the countries in the world, i.e. 162 countries were submitted to analysis in our study, while those of only 37 countries were used by Yoshikawa et al.

Finally we should mention some points on the methodology of the analysis used in our study. We applied factor analysis and cluster analysis to the data, so that we may be able to find some clusters with respects to foods and countries. From the methodological point of view, we could obtain these clusters simply by factor analysis, taking the location of countries as shown in Figs. 3 and 4 into consideration. It should be noted, however, that Burbank<sup>9)</sup> used cluster analysis in order to find some clusters with regard to the geographical distribution and emphasized that cluster analysis prevails over factor analysis in the sense that application of cluster analysis would provide the successive hierarchical structure of many sites of cancer. We don't agree with this assertion, since some difficulties may arise also in cluster analysis such that results of cluster analysis do not provide enough information as to how the extracted clusters relate to each other, although the factors extracted by any method of factor analysis are independent to each other. In view of this, we think that application of factor analysis and cluster analysis to a set of data both simultaneously would never fail to yield meaningful results for developing some hypothesis on food problems.

#### SUMMARY

1. Factor analysis (the varimax method) was applied to the data of food energy supplies in 162 countries in 1961~65, 1972 and 1974 published by Food and Agriculture Organization of United Nations. We used 16 food groups as variables and obtained the following results.

(1) We extracted four factors which determined the pattern of food energy intakes of the countries. The contribution ratios of the first, second, third and fourth factors were 33.2%, 11.5%, 5.4% and 4.6%, respectively.



(2) The first factor might be regarded as the factor determining the degree of dependence of the diet on meat, eggs, milk and products, animal fats, sugar and alcoholic beverages (hereinafter referred to as meat-related foods).

(3) The second factor might be considered as the determinant of the degree of dependence of the diet either on roots and tubers or cereals.

(4) The third factor might be considered to determine the importance of fish, tree-nuts or pulses in the diet.

(5) The fourth factor might be regarded as the factor giving an influence on the intakes of vegetables and vegetable oils.

(6) The general trend of the change of the food energy intake pattern during the period from 1961~65 to 1974 seems to be in the direction of decrease of roots and tubers consumption and increase of cereal consumption in roots- and tubers-eating countries and of increase of the consumption of meat-related foods and decrease of the cereal consumption in the diet in countries which were situated in between cereal-eating countries and countries consuming a large quantities of meat-related foods.

2. Cluster analysis was applied to a matrix of Euclidian distances obtained from the data of food energy supplies of 162 countries in 1974 and as the result, the countries in the world were classified into seven clusters having respective characteristic patterns of food energy intakes. It was made clear that Japan was at the shortest distance from Singapore, i.e. that the pattern of food energy intake of Japan bore the best resemblance to that of Singapore.

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## 食糧エネルギー摂取パターンの 国際比較に関する研究

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1. 国連食糧農業機関が発表した1961~65年(平均), 1972年および1974年の世界162か国の食品群別のエネルギー供給量のデータに因子分析(バリマックス法)を適用した。その結果, 4つの因子が抽出された。第1から第4因子までの各因子の寄与率は, それぞれ33.2%, 11.5%, 5.4%, および4.6%であった。

第1因子は肉, 卵, 乳・乳製品, 動物性脂肪, 砂糖およびアルコール飲料(以下, 肉関連食品と称する), 第2因子は根茎または穀類, 第3因子は主として魚, 樹果または豆類, そして第4因子は野菜および植物油の食事における多寡を決定する因子と考えられる。

このような意味を有する各因子の因子得点にもとづいて, 国ぐにをそれぞれのエネルギー摂取パターンの特徴によって分類することができた。

また, 1961~65年から1974年までの期間のエネルギー供給パターンの変化の一般的傾向として, 根茎多食国における根茎の消費の減少と穀類消費の増加がうかがわれ, また穀類多食国と肉関連食品を多食する国の中間に位置する国ぐににおける肉関連食品の消費の増大が見られた。

2. 1974年の162か国の16食品群別のエネルギー供給量から算出したユークリッド距離行列にクラスター分析を適用した結果, これらの国ぐにを, それぞれ特徴あるエネルギー供給パターンを有する7つのクラスターに分類することができた。また, 日本はシンガポールと最も近距離にあり, 日本のエネルギー摂取パターンがシンガポールのそれに最も近似していることが判明した。