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Gross domestic product and dietary pattern among 49 western countries with a focus on polyamine intake

Phan Nguyen Thanh Binh[1,2], Kuniyasu Soda[3]*, Masanobu Kawakami[4]

[1]Department of Community Nutrition, HCMC Nutrition Center, Ho Chi Minh City, Vietnam;
[2]Department of Food and Nutrition, Japan Women's University, Tokyo, Japan;
[3]Department of Cardiovascular Research Institute, Saitama Medical Center, Jichi Medical University, Saitama, Japan;
*Corresponding Author: soda@jichi.ac.jp;
[4]Department of Internal Medicine, Saitama Medical Center, Jichi Medical University, Saitama, Japan.

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ABSTRACT

Socioeconomic status is known to affect dietary profile, and differences in food habits and choice may affect polyamine intake due to significant variations in the concentrations of the polyamines spermine, spermidine, and putrescine present in different foods. The relationship between gross domestic product (GDP) and dietary profile, with a focus on polyamine intake, was investigated for 49 different European and other Western countries. The data for food supply and GDP were collected from the database of the United Nations and the International Monetary Fund, respectively, and the amount of polyamine intake from food was estimated using polyamine concentrations listed in published sources. Countries were divided equally according to GDP values into two categories, higher and lower, and the amount and composition of food polyamines as well as dietary profile were compared. Higher GDP countries supply animal products and seafood in greater amounts than lower GDP countries; however, whole milk supply per calorie was higher in lower GDP than higher GDP countries. While crops supply was relatively higher in lower GDP countries, fruit supply was greater in higher GDP countries. Higher GDP was associated with increased amount of spermine and putrescine per total calorie, although spermidine amount per calorie was similar between higher and lower GDP countries. GDP, as an indicator of countries' socioeconomic status, is associated with the amount and the composition of polyamines as well as dietary pattern.

Keywords: GDP; Dietary Pattern; Polyamine Intake; Western Countries

1. INTRODUCTION

Socioeconomic status, defined by economic activities and social life, is closely associated with individual health as well as the public disease burden, which would include cardiovascular disease [1-3], type 2 diabetes [4-5] and some cancers [6-7]. At a national level, gross domestic product (GDP) per capita is considered to reflect the socioeconomic status of the country and is consistently related to health conditions, namely, wealthier countries generally have healthier populations [8-10]. Among the many factors that are involved in the association between socioeconomic status and health, dietary pattern is considered to be one of the most important. A number of studies have shown an association between socioeconomic status and dietary pattern as well as lifestyle [11, 12].

Among many nutrients and non-nutrients in foods, recent studies have brought light the importance of food polyamines, because recent studies have shown many biological activities of polyamine and beneficial effects for the health of mammals [13-15]. Polyamines, spermine, spermidine, and putrescine are polycations synthesized in almost all cells. Polyamines have been shown to be absorbed from the intestinal lumen and distributed to organs and tissues in the whole body [16-17]. Because foods are comprised of cellular components from various organisms, the majority of foods contain polyamines but their concentration is wide-ranging [18-20]. Since diets are built from a wide variety of foods and are also affected by different methods of processing and cooking, a community's diet is influenced and shaped by multidimensional factors, including socioeconomic status [21]. Therefore, the amount of polyamine intake must vary considerably between regions.

In the present study, in order to investigate the association between socioeconomic status and polyamine intake as well as dietary pattern, the amounts and compositions of three polyamines were estimated from several public database resources and previously published papers, and their relative amount of intake, *i.e.*, the amount relative to calorie intake, were compared among Western countries with relatively similar racial and ethnic composition and social and religious backgrounds.

2. METHODS AND MATERIALS

2.1. Database

Dietary data were gathered from the online database of the Statistics Division of the Food and Agriculture Organization of the United Nations (FAOSTAT). Levels of food supply in 2005 were used for estimation of national dietary pattern. The target populations included 49 countries in Europe, North America, and Oceania with similar racial and ethnic composition and social and religious backgrounds. As one of the representative indicators of socioeconomic status of the country, Gross Domestic Product (GDP) (PPPPC: purchasing power parity per capita) in 2005 was obtained from the International Monetary Fund (IMF).

To examine the relationship between socioeconomic status and dietary pattern, these countries were divided equally into two categories depending on their GDP values: higher GDP countries and lower GDP countries. Higher GDP countries where GDP was greater than 20,000 (current international dollars) were Australia, Austria, Belgium, Canada, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Malta, Netherlands, New Zealand, Norway, Slovenia, Spain, Sweden, Switzerland, United Kingdom, and United States of America. Lower GDP countries had GDP values less than 20,000 and included Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Estonia, Georgia, Hungary, Kazakhstan, Latvia, Lithuania, Poland, Portugal, Romania, Russian Federation, Slovakia, Tajikistan, The former Yugoslav Republic of Macedonia, Turkey, Turkmenistan, Ukraine, and Uzbekistan.

Concentrations of spermine, spermidine, and putrescine in foods were obtained from published reports of concentrations measured in European foods [19-20]. When these reports did not show polyamine concentrations for specific foods, or additional data were necessary to obtain an average concentration in a food, we used data from Nishibori *et al.* [18] (**Table 1**).

Because food supply data from WHO do not necessarily indicate the net food consumption, the relative amount of various foods and food elements was determined, e.g., food supply relative to total calorie. The

Table 1. Concentrations of three polyamines in foods (nmol/g or nmol/mL)[1].

Food items	Spermine	Spermidine	Putrescine
Apple[2]	0	14.73	14.27
Banana	1	44.9	317.3
Lemon & lime	0.9	18.4	53.8
Citrus (other)	0.9	18.4	53.8
Pineapple	10.9	27	7.6
Grape[3]	1.6	22.5	26.25
Orange & mandarin[4]	41.4	1143.35	-
Other fruits[5]	3.02	25.5	11.55
Pulses[6]	66.46	179.7	69.64
Treenuts[7]	46.93	186.97	56.9
Groundnut	34.6	388.7	61.4
Cereals[8]	17.94	57.55	27.29
Potato[9]	7.9	64.7	68.73
Maize[10]	8	144	576
Onion[11]	2.5	41.2	38.85
Tomato[12]	0	19.35	380.2
Vegetables[13]	6.69	124.13	52.98
Stimulants[14]	12.5	61.4	18.98
Oil crops	0	0	0
Sugar	0	0	3
Coffee	0	0	0
Alcoholic beverages[15]	1	0	-
Beer[16]	0	0.5	18.6
Wine[17]	0	2.17	26.8
Animal fats	0	0	0
Beef[18]	120.7	22.45	36
Butter & Ghee	0	0.5	0
Cephalopods[19]	86	13.5	82
Cheese[20]	21.581	145.337	589.71
Cream	0	0	0.3
Crustaceans[21]	0	1.98	4.48
Edible offals[22]	98.9	82.28	11.34
Eggs	0	0	20.5
Fish[23]	16.25	16.35	61.93
Honey	0	1	8
Meat[24]	110.53	29.68	32.78
Molluscs[25]	94.43	73.13	202.83
Mutton & Goat meat	131.3	39.7	8.2
Other Marine meat[26]	37.76	25.46	82.7
Pork	160.15	18.15	19.5
Poultry[27]	91.7	27.5	11.43
Whey[28]	1	1	0
Whole Milk	0	0	0.3

[1]For the polyamine concentrations in each food, the mean concentrations in the following foods were used; [2]Jonagold, Golden, and Granny Smith; [3]Red grape and green grape; [4]Orange and orange (Bardocz); [5]Raisin, prune, pear, peach, apricot, kiwi, strawberry, and melon; [6]French bean, red bean, garden pea, soyabean (Bardocz), and red kidney bean (Bardocz); [7]Hazelnut, almond, and pistachio; [8]Rice, semolina, pasta, white bread, oat bread, rye bread, and whole wheat bread; [9]Potato, skinned; potato with skin; and potato (Bardocz); [10]Maize (Nishibori); [11]Onion and onion (Bardocz); [12]Tomato and tomato (Bardocz); [13]Salsify, celery, carrot, green cabbage, beet, beetroot, carrot, sorrel, radish, chicory, leek, escarole, red cabbage, green leek, Brussels sprout, lettuce, chervil, cabbage, parsley, mushroom, and button mushroom; [14]Garlic, yellow pepper, green pepper, and red pepper; [15]Whisky and Cognac; [16]Lager beer, and stout beer; [17]White (Burgundy), white (Loire), red (Bordeaux), red (Cotes-du-Rhone), red (Touraine), and red (Beaujolais) wines; [18]Veal and beef; [19]Squid and octopus (Nishibori); [20]Soft cheese, Swiss Emmental, French Emmental, goat cheese without rind, Brie pasteurized without rind, graded cheese, Camembert, Brie pasteurized with rind, goat cheese with rind, Roquefort, sweet Cantal with rind, Comte, Saint Nectaire without rind, Saint Nectaire with rind, aged cheddar (Bardocz), and fresh cheddar (Bardocz); [21]Scampi, shrimp, crayfish, and crab claw; [22]Ox tongue, liver mousse, chitterling, duck liver paste, and pork liver paste; [23]Hake, cod, whiting, smoked salmon, mullet, fresh salmon, cod (Bardocz), and trout (Bardocz); [24]Veal, pork, turkey, chicken leg, rabbit, lamb, chicken wing, and beef; [25]Oyster, white scallop, coral scallop, and clam (Nishibori); [26]Hake, cod, whiting, smoked salmon, mullet, fresh salmon, cod (Bardocz), trout (Bardocz), scampi, shrimp, crayfish, crab, squid, octopus (Nishibori), oyster, white scallop, coral scallop, and clam (Nishibori); [27]Turkey wing, chicken leg, and chicken wing; [28]No available data, therefore data of matured yogurt were used. Concentrations of polyamines in foods with no superscript indicate that they were from a single food. Polyamine concentrations were expressed as nmol/g or mL. [23]The amount in fish was a sum of the amounts in freshwater fish, and demersal, pelagic, and other marine fish, and [26]the amount in other marine meat was obtained by subtracting the sum of the amounts in fresh water fish, demersal and pelagic fish, other marine fish, crustaceans, mollusks, and cephalopods from the amount in fish & seafood in the FOSTAT database. Aquatic animals and other aquatic products were not consumed in surveyed countries. Polyamine concentrations in foods were taken from Cipolla B.G., *et al.* Polyamine contents in current foods: a basis for polyamine reduced diet and a study of its long term observance and tolerance in prostate carcinoma patients. Amino Acids 2007; 33: 203-12. Those marked as (Bardocz) were from Bardocz S., *et al.* Polyamines in food-implications for growth and health. J.Nutr.Biochem. 4: 66-71, 1993; and (Nishibori), from Nishibori N., *et al.* Amounts of polyamines in foods in Japan and intake by Japanese. Food Chem 2007; 100: 433-872.

relative amounts of foods as well as the amount of polyamines were compared between higher GDP and lower GDP countries.

2.2. Statistics

Food supply and polyamine amount in higher GDP and lower GDP countries were compared by Mann-Whitney test and p values less than 0.05 were considered significant. Analyses were done using StatView 5.0 (SAS Institute Inc.) run on an Apple computer, and regression coefficients greater than 0.4 and P values of less than 0.05 were considered significant.

3. RESULTS

3.1. Amount and Proportion of Three Food Groups as Sources of Calories, Protein, and Fat

Table 2 shows the amount of calories, protein, and fat of total foods and of three food categories, and **Figure 1** shows the proportions of calories, protein, and fat for three food categories. Higher GDP countries tend to prefer animal products and seafood products more than lower GDP countries. Calories from animal and seafood products represented 29.03 ± 4.55% and 1.56 ± 1.04%, respectively, of total calorie in higher GDP countries and were significantly higher ($p < 0.001$) than those in lower GDP countries (21.61 ± 5.36% and 0.68 ± 0.14%, respectively). Conversely, the proportion of crops calories relative to total calories in lower GDP countries was greater than that in higher GDP countries (77.71 ± 5.66% vs. 69.41 ± 5.13%, $p < 0.001$). Similar to calories, protein from animal, seafood, and crops products accounted for 53.91 ± 4.51%, 7.02 ± 4.15%, and 39.08 ± 5.06%, respectively, in higher GDP countries and 41.67 ± 9.00%, 3.46 ± 3.38% and 54.87 ± 10.68%, respectively, in lower GDP countries (these differences were significant with p values of less than 0.001). The percentages of fat from animals and crops relative to total fat were similar (p = 0.358 and 0.230, respectively) for both higher (53.49 ± 9.92% and 50.31 ± 10.69%) and lower GDP countries (44.55 ± 11.08% and 48.86 ± 10.90%). However, the proportion of fat from seafood relative to total fat was higher ($p < 0.001$) in higher GDP countries (1.96 ± 2.14%) compared to lower GDP countries (0.83 ± 0.74%).

3.2. The Supply of Various Foods per Total Calorie (Table 3)

The majority of the amount of animal and seafood pro-

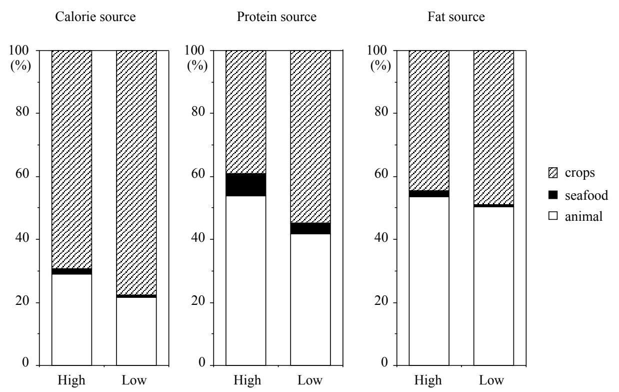

Figure 1. Percentage of calories, protein, and fat from crops, seafood, and animal products relative to total amounts. All data were obtained from the online database of the Statistics Division of the Food and Agriculture Organization of the United Nations (FAOSTAT). "High" indicates higher GDP countries where the GDP (PPPPC) in 2005 was more than 20,000 (current international dollars) and "Low" represents lower GDP countries where the GDP (PPPPC) in 2005 was less than 20,000 (current international dollars).

Table 2. Calorie, protein and fat supply.

	Higher GDP countries	Lower GDP countries	All countries
Calorie supply (*kcal/capita/day*)			
Animal calorie	996.22 ± 137.00	655.07 ± 210.23	829.13 ± 245.47
Seafood calorie	53.10 ± 33.88	21.88 ± 23.67	37.81 ± 33.03
Crops calorie	2397.57 ± 276.63	2310.54 ± 255.59	2354.94 ± 267.39
Total calorie	3446.89 ± 204.59	2987.49 ± 378.23	3221.88 ± 378.57
Protein supply (*g/capita/day*)			
Animal protein	57.93 ± 5.98	36.96 ± 11.45	47.66 ± 13.89
Seafood protein	7.68 ± 5.20	3.31 ± 3.78	5.54 ± 7.84
Crops protein	42.04 ± 6.65	47.16 ± 8.26	44.55 ± 7.84
Total protein	107.65 ± 9.13	87.42 ± 14.47	97.74 ± 15.70
Fat supply (*g/capita/day*)			
Animal fat	75.05 ± 12.63	47.36 ± 17.04	61.49 ± 20.36
Seafood fat	2.73 ± 2.93	0.84 ± 0.83	1.80 ± 2.36
Crops fat	63.77 ± 19.49	45.34 ± 13.96	54.74 ± 19.24
Total fat	141.55 ± 14.59	93.53 ± 25.17	118.03 ± 31.60

Data are expressed mean ± standard deviation (SD). Higher GDP countries indicate countries where GDP was greater than 20,000 (current international dollars). Lower GDP countries indicate countries where GDP values less than 20,000 (current international dollars).

ducts per total calorie was higher in higher GDP countries than in lower GDP countries. While supply of dairy products, especially cheese, was greater in higher GDP countries than lower GDP countries, whole milk supply per calorie was significantly higher in lower GDP countries than higher GDP countries. The majority of crops supply per calorie was higher in lower GDP countries, although fruit and tomato supply was greater in higher GDP countries compared to lower GDP countries. In addition, alcoholic drinks, especially wine and beer, were preferred in greater amounts in higher GDP countries relative to lower GDP countries.

3.3. Amount and Proportion of Three Polyamines

The average amounts of spermine, spermidine, and putrescine in foods were 38.48 (range 17.61-54.82), 89.05 (range 59.69-132.23), and 184.32 (range 71.82-419.17) µmol/day/capita, respectively, in all targeted countries; 46.23 ± 5.37, 90.87 ± 15.72, and 236.58 ± 69.47 µmol/day/capita, respectively, in higher GDP countries and 30.39 ± 8.09, 87.15 ± 16.28, and 129.89 ± 37.59 µmol/day/capita, respectively, in lower GDP countries.

When the proportions of each of the three polyamines accounting for total polyamines were compared (**Figure 2**), the percentage of spermine was similar (p = 0.810)

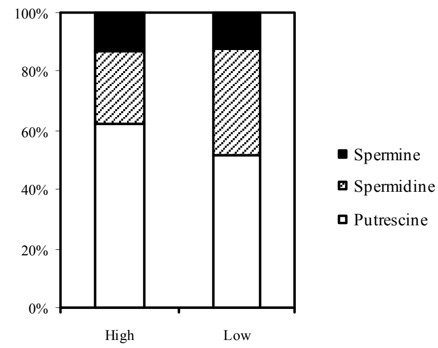

Figure 2. Percentage of spermine, spermidine, and putrescine relative to total polyamine intake in higher GDP countries (High, countries where GDP in 2005 was more than 20,000) and lower GDP countries (Low, countries where GDP in 2005 was less than 20,000). The polyamine amounts were calculated using values from public databases. Dietary data were gathered from FAOSTAT, and polyamine concentrations are indicated in **Table 1**.

between the two groups of countries (12.84 ± 2.68% in higher GDP countries, and 12.41 ± 2.45% in lower GDP countries), and the proportion of spermidine was significantly lower in higher GDP countries compared to lower GDP countries (24.75 ± 3.35% vs. 35.64 ± 4.24%, $p < 0.001$), while putrescine was significantly higher in higher GDP countries relative to lower GDP countries (62.41 ± 5.52% vs. 51.96 ± 4.37%, $p < 0.001$).

Table 3. Calorie, protein and fat supply.

	Higher GDP countries	Lower GDP countries	*p*-value
A. Animal meat (*g*) *per total calorie* (1000*kcal*)			
Bovine	17.09 ± 6.95	11.15 ± 5.40	0.004
Pork	28.56 ± 11.48	15.40 ± 12.20	< 0.001
Mutton&Goat	4.13 ± 5.76	2.75 ± 3.99	0.39
Poultry	21.08 ± 10.46	11.98 ± 6.10	< 0.001
Offals	3.05 ± 2.20	3.26 ± 1.52	0.459
Other meats	1.73 ± 1.70	0.66 ± 1.03	0.001
Dairy products	199.17 ± 49.43	164.73 ± 45.12	0.012
Cheese	12.49 ± 4.94	4.58 ± 3.08	< 0.001
Whole milk	65.98 ± 30.02	110.40 ± 52.25	< 0.001
Butter & Ghee	2.76 ± 1.62	1.61 ± 1.19	0.009
Honey	0.59 ± 0.30	0.52 ± 0.39	0.327
Egg	8.70 ± 2.49	8.66 ± 3.09	0.81
B. Seafoods (*g*) *per total calorie* (1000*kcal*)			
Demersal fish	6.57 ± 5.03	2.50 ± 5.03	< 0.001
Pelagic fish	6.38 ± 7.47	3.92 ± 4.31	0.02
Fresh water fish	2.86 ± 2.17	1.13 ± 0.87	< 0.001
Other marine fish	0.79 ± 0.76	0.60 ± 0.73	0.418
All fish	16.60 ± 10.69	8.15 ± 8.23	< 0.001
Molluscs	1.61 ± 1.56	0.24 ± 0.53	< 0.001
Cephalopods	0.82 ± 1.30	0.25 ± 0.66	0.017
Crustaceans	2.64 ± 3.00	0.55 ± 1.47	< 0.001
Seafood total	21.73 ± 13.61	9.22 ± 9.66	< 0.001
C. Crops (*g*) *per total calorie* (1000*kcal*)			
Cereals	93.06 ± 16.67	147.14 ± 42.34	< 0.001
Fruits	97.27 ± 22.47	61.25 ± 23.73	< 0.001
Vegetables	94.21 ± 36.04	127.12 ± 51.14	0.083
(Fruits&Vegetables)	191.47 ± 49.29	188.37 ± 65.83	0.447
Pulses	2.42 ± 1.60	2.04 ± 2.47	0.139
Potato (All)	55.57 ± 14.46	75.16 ± 34.67	0.052
Tomato	16.87 ± 9.85	8.28 ± 9.61	< 0.001
Beer	61.03 ± 29.36	38.31 ± 25.40	0.008
Wine	16.87 ± 9.85	8.28 ± 9.61	< 0.001

Data are expressed mean ± standard deviation (SD). Higher GDP countries indicate countries where GDP was greater than 20,000 (current international dollars). Lower GDP countries indicate countries where GDP values less than 20,000 (current international dollars).

Foods in higher GDP countries seemed to contain spermine and putrescine in greater amounts than those in lower GDP countries (**Table 4**). Conversely, foods in lower GDP countries tended to contain spermidine in much greater amounts compared to higher GDP countries. Simple regression analyses revealed that GDP has positive correlations with total polyamine per total calorie (r = 0.503, $p < 0.01$), total spermine per total calorie (r = 0.677, $p < 0.01$), and total putrescine per total calorie (r = 0.608, $p < 0.01$). However, there was a negative

Table 4. Comparison of polyamine amount (μmol) per total calorie (1000 kcal/day).

	Higher GDP countries	Lower GDP countries	*p*-value
Spermine	13.43 ± 1.54	10.07 ± 1.76	< 0.001
Spermidine	26.30 ± 3.77	29.35 ± 5.45	0.018
Putrescine	68.43 ± 18.38	43.26 ± 9.91	< 0.001
SPM + SPD	39.73 ± 4.25	39.42 ± 5.39	0.719
Total polyamine	108.16 ± 21.11	82.69 ± 13.63	< 0.001

Data are expressed mean ± standard deviation (SD). Higher GDP countries indicate countries where GDP was greater than 20,000 (current international dollars). Lower GDP countries indicate countries where GDP values less than 20,000 (current international dollars). SPM: spermine; SPD: spermidine.

correlation between GDP and total spermidine per total calorie (r = –0.498, $p < 0.01$). Individuals in higher GDP countries preferred foods rich in polyamine, especially spermine and putrescine, while individuals in lower GDP countries preferred foods rich in spermidine.

3.4. Proportion of Three Food Groups as Sources of Three Polyamines (Figure 3)

The high percentage (73.26 ± 4.57%) of food-based spermine originated in animal products in higher GDP countries, and its proportion was significantly higher ($p < 0.001$) than that for lower GDP countries (55.40 ± 13.72%). Spermine from crops represented 23.05 ± 4.20% and 43.24 ± 14.35% of total spermine in higher and lower GDP countries, respectively ($p < 0.001$). The majority of spermidine and putrescine originated in crops; 83.85 ± 3.61% of spermidine and 83.74 ± 5.57% of putrescine in higher GDP countries, and 92.59 ± 3.49% of spermidine and 89.86 ± 5.39% of putrescine in lower GDP countries. The proportion of crops spermidine and putrescine relative to total amounts was higher ($p < 0.001$ for both) in lower GDP countries compared to higher GDP countries. Spermidine from animal products accounted for 14.57 ± 3.28% and 6.94 ± 3.16% of total spermidine, while the percentage of putrescine from animal products was 14.10 ± 5.53% and 9.12 ± 5.01% of total putrescine in high and lower GDP countries, respectively ($p < 0.001$ for spermidine and $p = 0.003$ for putrescine). The amounts of spermine, sper midine, and putrescine from seafood in each total amount were small: 3.70 ± 2.03%, 1.59 ± 0.94%, and 2.16 ± 1.12%, respectively, for higher GDP countries, and were only 1.36 ± 1.99%, 0.47 ± 0.75%, and 1.02 ± 1.26%, respectively, for lower GDP countries. The percentages for higher GDP countries were greater than those for lower GDP countries ($p < 0.001$). Individuals in higher GDP countries took these three polyamines from animal and seafood products much more than did those in lower GDP countries, while lower GDP countries obtained polyamines from crops.

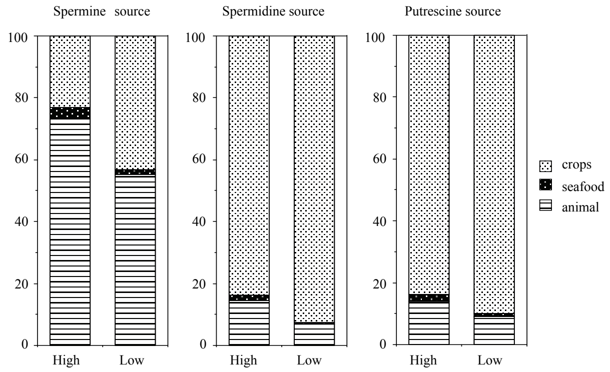

Figure 3. Percentage of crops, seafood, and animal products relative to total amounts of spermine, spermidine, and putrescine in higher GDP countries (High) and lower GDP countries (Low).

4. DISCUSSION

Differences in socioeconomic status are known to affect the dietary pattern of individuals [22-25]. In this ecological study, we illustrate the relationship between GDP and dietary pattern on the basis of country. The results of the study where data were obtained from open databases have several similarities to those of previous epidemiological studies using personal and collective databases. Namely, higher socioeconomic status is associated with increased intake of fruits, seafood, and cheese.

In the present study, despite the higher supply of crops products in lower GDP countries compared to higher GDP countries, fruits are preferred in higher GDP countries. It is widely accepted that higher socioeconomic status is associated with increased intake of fruits and vegetables [11,23,26-31]. Similarly, as observed in the present study, many studies have shown a positive association between socioeconomic status and seafood intake [28-29,32]. Although the association between dairy products and socioeconomic status is not so apparent, some epidemiological studies have shown that skimmed milk is mainly consumed by the higher socioeconomic groups whereas the lower groups consume full-fat milk [11,31]. While we had insufficient information about the fat content of dairy products, our findings that individuals in higher GDP countries consumed more cheese than whole milk are consistent with previous studies [22,30].

This study delineates the relationship between food polyamines and socioeconomic status of countries. The absolute amounts of three polyamines in all targeted countries obtained from database information are also similar to those of the previous studies in which about 35 μmol spermine, 55 μmol spermidine, and 160 μmol putrescine were estimated to be consumed [33], and those in higher GDP countries were also similar to those of previous reports for higher GDP countries, Britain, Italy, Spain, Sweden, and Netherlands in which 350 to 500 μmol polyamines were estimated to be consumed [34].

The present study shows that individuals in higher GDP countries prefer foods rich in polyamine, especially spermine and putrescine, much more than those in lower GDP countries. Increased spermine supply in higher GDP countries seems due mainly to the increased supply of animal meat, in which spermine is abundant. Increased putrescine supply in higher GDP countries seems to be due to the increased supply of vegetables and fruit, where the putrescine concentration is high.

This ecological study showed that socioeconomic status is associated not only with dietary pattern but also with the amount and proportion of polyamines. The difference in food choice is considered to have some role in the prevalence of several diseases [35-47], and our previous studies showed that increased polyamine intake contributes to decreases in age-associated pathological changes in mice [13]. Therefore, increased polyamine intake may have some role on the difference in the prevalence of diseases associated with socioeconomic disparity. However, this is an ecological study and data do not necessarily indicate the personal food consumption, so, there may be confounding factor(s) between polyamine amount and socioeconomic status. Further analyses using personal database are desired.

5. ACKNOWLEDGEMENTS

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