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Article

Seasonal, spatial and socioeconomic variations in the dietary pattern of two cities of Bangladesh: a food frequency questionnaire survey

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Abstract: Two separate surveys were conducted in two cities of Bangladesh viz. Dhaka and Mymensingh to observe the seasonal as well as socio-economic variations in the dietary pattern. A total of 118 respondents were randomly selected and interviewed with a food frequency questionnaire (FFQ) to assess the dietary intake. Based on the respondents' household income they were categorized into low income level (LIL); medium income level (MIL) and high income level (HIL) groups. Among the two cities, carbohydrate consumption was higher in Mymensingh during both winter (407 $gp^{-1}d^{-1}$) and summer (442 $gp^{-1}d^{-1}$). On the other hand, animal protein consumption was higher in Dhaka (176 $gp^{-1}d^{-1}$in summer and 283$gp^{-1}d^{-1}$ in winter). Usually in winter, carbohydrate consumption was lower but protein consumption was higher. There was no significant seasonal and spatial variation of plant protein consumption. However, leafy vegetable consumption was higher in Mymensingh during summer season (87 $gp^{-1}d^{-1}$). Overall, non-leafy vegetables consumption increases during winter and found highest in Dhaka (655 $gp^{-1}d^{-1}$). In general, water consumption was higher during summer and found highest in Mymensingh (3.8$Lp^{-1}d^{-1}$). Concerning the income groups, in both locations and seasons, carbohydrate consumption was observed lowest among HILs, but animal protein consumption was found highest, especially, in Dhaka. Rice is consumed in greater proportion than wheat among LILs and MILs. Wheat consumption was higher among HILs. Of all the animal proteins, fish and chicken were occupies the major portion. But dry fish consumption was relatively greater among LILs. In Dhaka, plant protein consumption was higher by MILs but in Mymensingh it was found highest among HILs. Both leafy and non-leafy vegetables consumption was higher by HILs in Mymensingh but among MILs in Dhaka. In general fat consumption was higher among HIL group in both locations. The Principal component analysis (PCA) revealed a strong interaction between the respondent characteristics and consumption of different food items. The respondent income and education was positively correlated with the consumption of animal and plant proteins, oils and spices but negatively correlated with carbohydrate and dry fish consumption. The present study investigated the socioeconomic and seasonal influence on dietary pattern in two locations of Bangladesh which can be an effective tool in estimating the dietary exposure of chemical contaminants.

Keywords: dietary pattern; food frequency questionnaire (FFQ) survey; socioeconomic variation; Bangladesh

1. Introduction

Diets of populations around the world were primarily determined by the availability of local food and food practices. A balanced diet, adequate in all necessary nutrients; energy, protein, vitamins and minerals, can satisfy both perceptible and hidden hunger. Cereals, largely rice, are the main food in Bangladesh. Nearly two-

thirds of the daily diet consists of rice, some vegetables, a little amount of pulses and small quantities of fish if and when available (Jahan and Hossain, 1998). The typical diet in Bangladesh is, reportedly, not well balanced as well (Haque *et al.*, 2014).

Promoting healthy dietary patterns, in addition to targeted food-based dietary guidelines, might be a useful approach in order to improve diet and health in a population.

Dietary pattern analysis has become a popular method for studying overall diet and associations between diet and disease risk. Pre-specified indices are used to measure adherence to recommendations or diets with hypothesized health implications, whereas, data-driven methods, often factor or cluster analysis, are applied to identify underlying food patterns in a population empirically (Zukowska and Biziuk, 2008; Balder *et al.*, 2003; Hu, 2002). Participants' adherence to the dietary patterns can then serve as a holistic measure of their diet in assessment of diet–disease relationships. Such a holistic approach has several methodological advantages, as it includes unexplored dietary factors and nutrient interactions and increases the chance of detecting small but meaningful associations as they add up in the context of a whole diet, and at the same time not impeded by the disadvantages of correlated intakes (Hu, 2002; Jacques and Tucker, 2001).

The dietary intake pattern of different Asian countries is quite different in certain respects in spite of the close geographical proximity of these countries. A typical example is of very low milk intake in China, Philippines and Viet Nam. On the other hand, the daily intake of flesh foods by the Indian population is very small. The dietary intake of principal nutrients such as carbohydrates, fat, protein, energy, along with the data on the daily intakes of different food items and the elemental intake, is available from Bangladesh, China, India, Indonesia, Japan, Philippines, Pakistan and Viet Nam. Substantial dietary data are reported from China, Japan, India and Philippines. The limited data available from Pakistan, Indonesia and Viet Nam provide useful information on the possible variations in the dietary intakes of food items among the Asian population belonging to different countries (IAEA, 1998). However, similar studies have not done yet extensively for Bangladesh.

Dhaka and Mymensingh are the two major cities of Bangladesh. From demographic point of view, Dhaka is a cosmopolite city where people of different regions living together. Hence, the dietary habit should vary due to their differential cultural origin. On the other hand, Mymensingh being another populated city where the demography is more or less homogenous. But both the cities are in close proximity to various chemical contamination and prone to various chemical contaminants through dietary exposure. To estimate the level of exposure of different chemicals a detailed dietary pattern of different socio-economic groups is necessary. The present endeavor was undertaken to assess the dietary pattern of different socio-economic groups in the said two cities in order to determine the level of chemical contamination through diet.

2. Materials and Methods

2.1. Subjects

This study was designed to include adult women members who are the cook or have clear idea about the total food consumption of the households and were randomly selected for interviews. A total of 118 households (66 households from Dhaka and 62 from Mymensingh) were randomly selected from various locations of the two cities. The interviews were conducted with the respondents individually in their respective houses or house premises.

2.2. Study locations and time

Separate surveys were conducted in two cities (viz. Dhaka and Mymensingh) during summer and winter seasons. These two cities were selected because Dhaka is a cosmopolitan city where people from all over the country live here. Hence, variation of food habit is expected to be found here. On the other hand, Mymensingh is comparatively a smaller locality and comprised of people of homogenous origin. Hence, food habits of the inhabitants are likely to be homogenous. In Dhaka, the surveys were conducted at Geneva Camp (Mohammodpur), Kamalapur slum, Mohammodpur, and Kalyanpur areas. Survey locations in Mymensingh included Morakhola slum, Sutiakhali, and Bangladesh Agricultural University residential area. In both cities, interviews were held during the peak time when the availability of seasonal vegetables were maximum in the market. The first interview took place between May 5 and June 20, 2013 in Dhaka and the second between August 1 and September 1, 2013 in Mymensingh for summer season. For winter season, interviews were held during the entire month of January, 2014 in Dhaka and during the whole of February, 2014 in Mymensingh.

2.3. Instrument for data collection

The Food Frequency Questionnaire (FFQ) was designed to assess the long-term daily diet of subjects in the study area. Before preparing the questionnaire, all the food items available in the market were first identified by

visiting the local markets of the study areas. Then, a preliminary version of the FFQ was developed extensively. The FFQ was finalized after pilot testing among 20 individuals who were not part of the study. Only common food items (110 to be exact) were included in the FFQ and food items with intake frequencies less than once per month during the past one year were deemed insignificant. About 10% of the food items were removed from the original food list because of infrequent consumptions. A structured questionnaire was used for collection of relevant data. Therefore, to simplify the FFQ, open-ended questions for the amount per meal, frequency per day or per month were used. Making all the necessary corrections, additions and modification, the questionnaire was then printed in final form. The interview survey of Total Diet Study (TDS), FFQ and time allocation study using compact spot-check method were carried out. Among the 122 subjects invited, of which 118 completed full interview, four were excluded because of incomplete FFQ.

2.4. Compilation of data and calculation of daily intake

Demographic parameters had been selected based on the research objectives as education of the respondents, family size and income of the family. The education was categorized by scoring. Education categories were illiterate, primary, secondary, higher secondary, graduate and postgraduates. The categories were scored as 1 to 6, respectively. Total number of family members of the subjects were considered as Family size. Based on the total monthly income, respondents were classified as low income level (LIL) (monthly income below 125 US$); medium income level (MIL) (monthly income between125 to 312.5 US$) and high income level (HIL) (monthly income more than 312.5US$). The average values for all respondent characters are presented in Table 1. All the data were put into the data sheet and per person daily intake for individual items were estimated using MS Excel data processing software. Principal component analysis (PCA) considering all subjects character and food consumption were done using MiniTab 17.

3. Results and Discussion

3.1. Seasonal and spatial variation of total dietary intake

The consumption of different food component varies in both seasons and locations. Although the total average food intake was greater in winter irrespective of locations, total consumption of different food items did not vary considerably in the two survey locations (Table 2 and Figure 1).

In general, overall carbohydrate consumption was greater in Mymensingh (34% during summer and 29% in winter) than in Dhaka (30%during summer and 22%in winter). In both locations, people consumed more carbohydrates during summer season. On the other hand, animal protein consumption was higher in Dhaka during both in summer and winter (15% and 16%) than Mymensingh (12% and 14%). However, there was no apparent seasonal and special variation in the uptake of plant protein and leafy vegetables. However, non leafy vegetables occupied a considerably greater portion of diet (46% in Dhaka and 42% in Mymensingh) during winter season. Spices consumption was a little bit higher in Dhaka (7 and 5% during summer and winter, respectively) than Mymensingh (6 and 4% during summer and winter, respectively). Oil consumption was greater in Dhaka (4%) than Mymensingh (3%) during summer but almost the same during winter.

3.2. Consumption of individual food categories

The survey outputs as daily intake of different food categories in the two cities are presented and discussed below:

3.2.1. Carbohydrate

In general, carbohydrate occupies lion share of Bangladeshi diet. The surveys in Dhaka and Mymensingh cities revealed that majority of the respondents consume rice and flour (as *ruti* or *paratha*) as their major source of energy, i.e. carbohydrate. The amount of intake of both of these two items varies in different income groups in different seasons (Table 3). In Dhaka, the amount of carbohydrate consumption during summer in LIL, MIL and HILwere369.75,385.34and 283.47 $gp^{-1}d^{-1}$, respectively and during winter, for the same, were345.25, 344.87and 249.49$gp^{-1}d^{-1}$, respectively. On the other hand, in Mymensingh during summer, the carbohydrate consumption among LIL, MIL and HIL were 426.78, 562.66and 335.43 $gp^{-1}d^{-1}$, respectively. Whereas, the LIL, MIL and HIL groups consume 439.84, 453.88, and 327.43 $gp^{-1}d^{-1}$carbohydrates during winter, respectively. Considering all respondents, the average carbohydrate consumption during summer and winter in Dhaka were346.19$gp^{-1}d^{-1}$and 313.20$gp^{-1}d^{-1}$, respectively, whereas, in Mymensingh these were 441.62$gp^{-1}d^{-1}$and 407.05$gp^{-1}d^{-1}$during summer and winter, respectively. From these data, it was obvious that irrespective of season and location, LIL and MIL groups consume significantly greater amount of carbohydrates than HIL group. It was also notable that

carbohydrate consumption was higher in Mymensingh by all income groups than Dhaka. In general, carbohydrate intake was higher in summer compared to winter season.

Carbohydrate consumption in Bangladesh reported by few studies ranged between400-520$gp^{-1}d^{-1}$(IAEA, 1998; Greenfield and Southgate, 2003; HIES, 2010). HIES (2010) mentioned that the daily intake of carbohydrate was 402.9 $gp^{-1}d^{-1}$ in urban, 485.6 $gp^{-1}d^{-1}$ in rural and 463.9 $gp^{-1}d^{-1}$in national level. Carbohydrate consumption by low and medium income groups, especially, in the Mymensingh city was similar this report. However, it was found much lower among high income group's consumption level sat both cities. It was assumed that with the increase of income, carbohydrate in diet usually replaced by proteins and other high priced food items. In general, the average income of the respondents were higher in Dhaka compared to Mymensingh and accordingly the reduced carbohydrate consumption in Dhaka supporting the general assumption. During winter season, inclusion of many non-leafy vegetables coupled with lower energy demand might have contributed towards reduced carbohydrate consumption.

As mentioned earlier, in both cities carbohydrates include mostly rice and flour (or wheat). In Dhaka, the ratio of eating wheat and rice is almost same during summer among LIL, MIL and HIL groups (23:77, 21:79, and 21:79, respectively) (Table 4). However, in winter, MIL (35:65)and HIL (31:69) groups consume more wheat while among LIL it remained unchanged (Table 4). In Mymensingh, the proportion of eating wheat is the same in LIL and HIL (23%) during summer, while, MIL members consumes very small amount (1%) of wheat in summer. In winter, consumption of wheat in LIL decreases (12%) while increased in MIL and HIL (6% and 26%, respectively). In general, wheat consumption is higher in high income groups.

3.2.2. Animal Proteins

Proteins are of two types: animal and plant protein. In general, protein consumption was higher in Dhaka as the income level is higher there. Animal protein consumption, as presented in Table 3, in Dhaka among LIL, MIL and HIL groups during summer were 123.33, 176.40 and 227.76$gp^{-1}d^{-1}$and in winter were47.53, 276.45 and 346.80 $gp^{-1}d^{-1}$, respectively. On the other hand, in Mymensingh, during summer amount of animal protein consumption in LIL, MIL and HIL were71.63, 139.55 and 265.73 $gp^{-1}d^{-1}$, respectively. In winter, the consumption of animal protein in LIL, MIL and HIL were58.12, 200.08 and 328.21 $gp^{-1}d^{-1}$, respectively.

Animal protein consumption among HIL subjects was observed highest in both locations during summer (227.76 and 265.73 $gp^{-1}d^{-1}$, Dhaka and Mymensingh, respectively) and during winter (346.80 and 328.21 $gp^{-1}d^{-1}$in Dhaka and Mymensingh, respectively).Consumption of animal protein among LIL was the lowest in both seasons.

During the survey, the LIL subjects of Mymensingh informed that they rarely purchase any beef or mutton. They eat meat only during festive celebrations like *eid-ul-adha*. One of the major protein sources of LIL group of Mymensingh was dry fish, especially, *chyapashutki* (a kind of fermented dry fish). They eat *chyapashutki*3-4 days a week. On the other hand, respondents in Dhaka consume very little amount of dry fish (6%) in LIL (Table 4). However, they purchase beef, mutton, or liver at least a minimum amount in every week. Consumption of egg is also higher in Dhaka.

Among all the animal proteins, chicken and fish occupies the major portion of the protein diet in all income groups during both seasons and in both locations (Table 4). Both broiler chicken meat and farm grown fresh water fish (especially *pangus*, *koi*, *tilapia*, etc.) are available round the year and their prices are also within the range affordable to low-mid income people.

In Dhaka, the LIL consume small amount (13%) of mutton in summer while no mutton in winter. Chicken consumption reduces from 31% to 18%during winter while fish consumption increases a little from 40% to 42% in LIL. In case of MIL, chicken consumption reduces from 32% to 27% during winter while fish and egg consumption increases. HIL consume a small portion (2%) of mutton. During winter, beef and egg consumption reduces and chicken and fish consumption increases. There is almost no dry fish consumption in Dhaka.

In Mymensingh, during summer LIL consume highest amount of fish (58%) which reduces in winter (42%) while chicken, egg, dry fish and beef consumption increases (Table 4). On the other hand, in MIL, mutton consumption reduces while fish consumption increases during winter. In HIL mutton and egg consumption reduces while beef, chicken and fish consumption increases during winter.

Fish consumption is more in both locations because fish is a cheaper source of protein and could be purchased in a small quantity that is affordable by the LIL. In summer, fish intake ranges from 35% to 40% among all the proteins in Dhaka while HIL consume 35%, MIL consume 36% and LIL take 40% fish. In Mymensingh, fish consumption ranges from 32% to 58% and HIL consume 32%, MIL consume 32% and LIL take 58% fish. Between the two locations, the people of Mymensingh consume bigger amount of fish. Because, fish is locally grown here. Therefore, it is available and cheaper. Which makes it affordable to the natives.

Table 1. Location and season wise average respondent characters.

Location	Season	Income group*	Education**	Family members	Monthly income per family (US$)
Mymensingh	Winter	LIL	1.2	4.4	44
		MIL	2.2	5.9	215
		HIL	5.9	4.4	965
	Summer	LIL	1.2	4.6	52
		MIL	2.0	4.6	243
		HIL	5.1	4.6	591
Dhaka	Winter	LIL	1.3	3.6	65
		MIL	3.0	4.3	280
		HIL	4.1	3.8	813
	Summer	LIL	1.1	4.5	62
		MIL	3.3	4.3	267
		HIL	4.5	4.1	455

*Based on the total monthly income, respondents were classified as low income level (LIL) (monthly income < 125 US$); medium income level (MIL) (monthly income between 125 - 312.5 US $) and high income level (HIL) (monthly income > 312.5 US$).
** Education categories were illiterate, primary, secondary, higher secondary, graduate and postgraduates and were scored as 1 to 6, respectively.

Table 2. Season wise intake of different food categories by different income groups of Dhaka and Mymensingh.

Food category	Dhaka						Mymensingh					
	Summer			Winter			Summer			Winter		
	LIL	MIL	HIL	LIL	MIL	HIL	LIL	MIL	HIL	LIL	MIL	HIL
Carbohydrates	369.75±	385.34±	283.47±	345.25±	344.87±	249.49±	426.78±	562.66±	335.43±	439.84±	453.88±	327.43±
(g person^{-1} day^{-1})	143.66	97.99	59.40	130.70	206.76	61.18	165.19	187.00	136.75	176.97	194.94	61.65
Animal protein	123.33±	176.40±	227.76±	47.53±	276.45±	346.80±	71.63±	139.55±	265.73±	58.12±	200.08±	328.21±
(g person^{-1} day^{-1})	55.09	85.54	158.95	37.73	121.74	21.34	49.91	75.65	115.56	39.94	109.72	93.47
Plant protein	36.54±	40.01±	32.90±	27.46±	41.88±	37.19±	28.21±	28.56±	38.02±	22.79±	38.32±	50.81±
(g person^{-1} day^{-1})	17.24	22.02	16.23	14.63	15.82	21.01	21.25	16.75	12.69	15.28	18.81	17.18
Leafy vegetables	71.68±	59.57±	70.01±	57.93±	119.90±	42.18±	70.66±	78.90±	112.92±	70.83±	47.87±	82.53±
(g person^{-1} day^{-1})	60.43	44.01	43.44	46.12	100.92	48.11	67.53	63.13	59.07	61.87	37.43	35.01
Non-leafy vegetables	429.51±	368.17±	380.06±	476.25±	836.30±	654.45±	356.37±	454.03±	508.02±	461.18±	711.03±	600.19±
(g person^{-1} day^{-1})	237.18	203.69	228.68	205.53	204.20	316.94	199.69	209.69	340.73	251.56	504.54	266.62
Fats/oils	46.35±	53.44±	49.03±	24.79±	40.96±	66.43±	25.78±	31.09±	53.51±	20.09±	31.19±	82.94±
(g person^{-1} day^{-1})	18.04	24.58	18.33	12.57	17.52	15.84	17.78	13.13	17.24	12.95	14.76	66.60
Spices	82.00±	80.85±	72.86±	44.87±	94.18±	88.51±	49.85±	63.15±	112.48±	31.91±	65.11±	92.84±
(g person^{-1} day^{-1})	29.19	26.78	16.31	20.06	55.52	29.07	33.70	23.74	62.54	12.41	36.53	20.70
Salt	11.11±	13.25±	12.93±	8.04±	15.19±	14.39±	9.68±	16.20±	11.56±	12.94±	12.35±	13.03±
(g person^{-1} day^{-1})	5.09	5.16	5.52	4.65	2.53	3.47	4.22	5.36	5.93	5.83	4.84	6.17
Water	2793±	2611±	2132±	1892±	1714±	1926±	3138±	4608±	3689±	1893±	1868±	2531±
(ml person^{-1} day^{-1})	1382	855	453	533	780	479	1044	724	1172	369	718	566

Table 3. Season and location wise average intake of different food categories.

Food category	Dhaka		Mymensingh	
	Summer	Winter	Summer	Winter
Carbohydrates (g person^{-1} day^{-1})	346.19	313.20	441.62	407.05
Animal protein (g person^{-1} day^{-1})	175.83	223.59	158.97	195.47
Plant protein (g person^{-1} day^{-1})	36.48	35.51	31.60	37.31
Leafy vegetables (g person^{-1} day^{-1})	67.09	73.34	87.49	67.08
Non-leafy vegetables (g person^{-1} day^{-1})	392.58	655.67	439.47	590.80
Oils (g person^{-1} day^{-1})	49.61	44.06	36.79	44.74
Spices (g person^{-1} day^{-1})	78.57	75.85	75.16	63.29
Salt (g person^{-1} day^{-1})	12.43	12.54	12.48	12.77
Water (ml person^{-1} day^{-1})	2512	1844	3812	2097

Table 4. Distribution of the intake of carbohydrates, vegetables and animal proteins in Dhaka and Mymensingh during summer and winter.

Location	Season	Income Group	Rice	Wheat	Total carbohydrate p^{-1}d^{-1}	Leafy	Non-leafy	Total Vegetable gp^{-1}d^{-1}	Beef	Mutton	Chicken	Fish	Dry fish	Egg	Liver	Total animal protein gp^{-1}d^{-1}
Dhaka	Summer	LIL	283.0 (77%)	86.7 (23%)	369.8	71.7 (14%)	429.5 (86%)	501.2	5.9 (5%)	15.5 (13%)	38.3 (31)	49.3 (40%)	0.30 (0%)	13.9 (11%)	0.17 (0%)	123.3
		MIL	303.0 (79%)	82.4 (21%)	385.3	59.6 (14%)	368.2 (86%)	427.7	26.0 (15%)	10.9 (6%)	56.1 (32%)	63.3 (36%)	0.82 (0%)	19.4 (11%)	0.00 (0%)	176.4
		HIL	223.7 (79%)	59.7 (21%)	283.5	70.0 (16%)	380.1 (84%)	450.1	45.4 (20%)	5.2 (2%)	66.8 (29%)	79.3 (35%)	1.20 (1%)	27.8 (12%)	2.08 (1%)	227.8
	Winter	LIL	266.3 (77%)	78.9 (23%)	345.3	57.9 (20%)	476.3 (80%)	534.2	3.0 (6%)	0.0 (0%)	8.4 (18%)	19.9 (42%)	0.28 (1%)	13.1 (27%)	2.91 (6%)	47.5
		MIL	222.5 (65%)	122.4 (35%)	344.9	119.9 (18%)	836.3 (82%)	956.2	43.1 (16%)	3.2 (1%)	73.9 (27%)	112.2 (41%)	1.06 (0%)	39.4 (14%)	3.74 (1%)	276.5
		HIL	171.5 (69%)	78.0 (31%)	249.5	42.2 (6%)	654.5 (94%)	696.6	45.7 (13%)	6.0 (2%)	126.8 (37%)	129.6 (37%)	0.61 (0%)	36.8 (11%)	1.36 (0%)	346.8
Mymensingh	Summer	LIL	327.9 (77%)	98.9 (23%)	426.8	70.7 (17%)	356.4 (83%)	427.0	4.3 (6%)	0.0 (0%)	15.2 (21%)	41.5 (58%)	3.32 (5%)	7.0 (10%)	0.32 (0%)	71.6
		MIL	557.7 (99%)	5.0 (1%)	562.7	78.9 (15%)	454.0 (85%)	532.9	15.4 (11%)	12.0 (9%)	51.0 (36%)	44.6 (32%)	2.17 (2%)	12.6 (9%)	1.85 (1%)	139.6
		HIL	256.9 (77%)	78.6 (23%)	335.4	112.9 (18%)	508.0 (82%)	620.9	36.3 (14%)	15.9 (6%)	87.7 (33%)	83.8 (32%)	2.19 (1%)	35.8 (13%)	4.00 (1%)	265.7
	Winter	LIL	386.4 (88%)	53.4 (12%)	439.8	70.8 (13%)	461.2 (87%)	532.0	4.1 (7%)	0.2 (0%)	13.6 (24%)	24.6 (42%)	3.45 (6%)	12.1 (21%)	0.00 (0%)	58.1
		MIL	427.8 (94%)	26.1 (6%)	453.9	47.9 (6%)	711.0 (94%)	758.9	23.0 (11%)	3.8 (2%)	70.9 (35%)	75.8 (38%)	1.38 (1%)	25.2 (13%)	0.00 (0%)	200.1
		HIL	243.3 (74%)	84.1 (26%)	327.4	82.5 (12%)	600.2 (88%)	682.7	58.7 (18%)	6.0 (2%)	118.8 (36%)	114.0 (35%)	0.64 (0%)	24.2 (7%)	5.80 (2%)	328.2

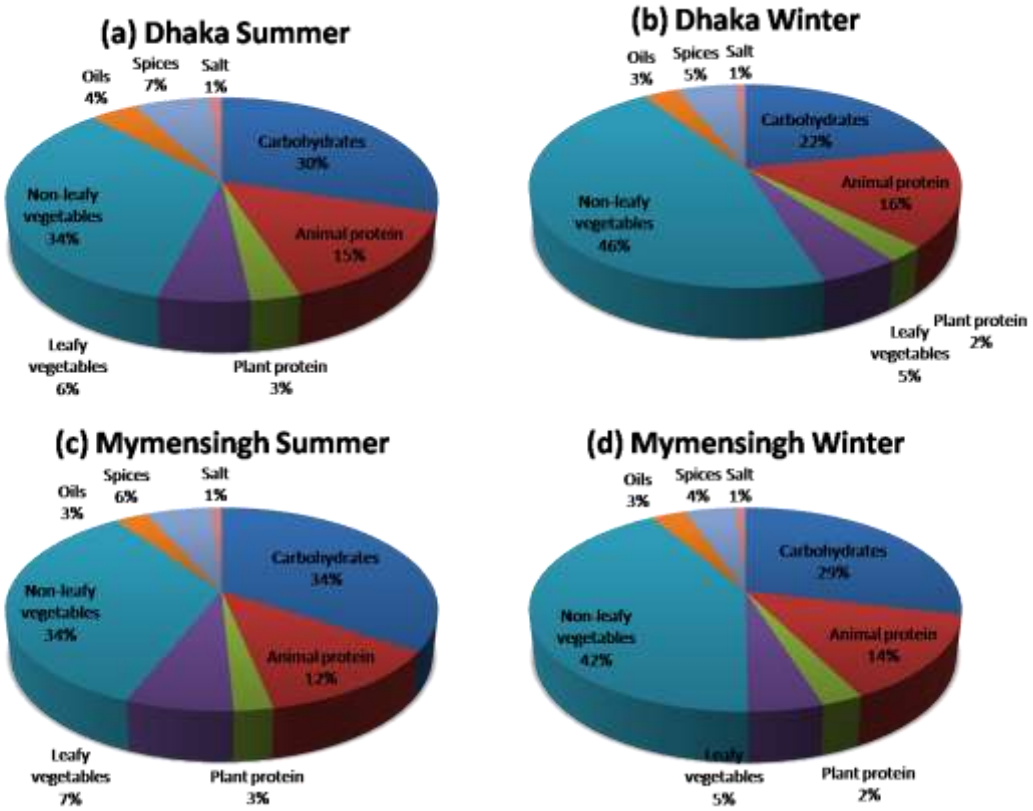

Figure 1. Distribution of consumption of different food categories in Dhaka (a and b) and Mymensingh (c and d) during summer and winter.

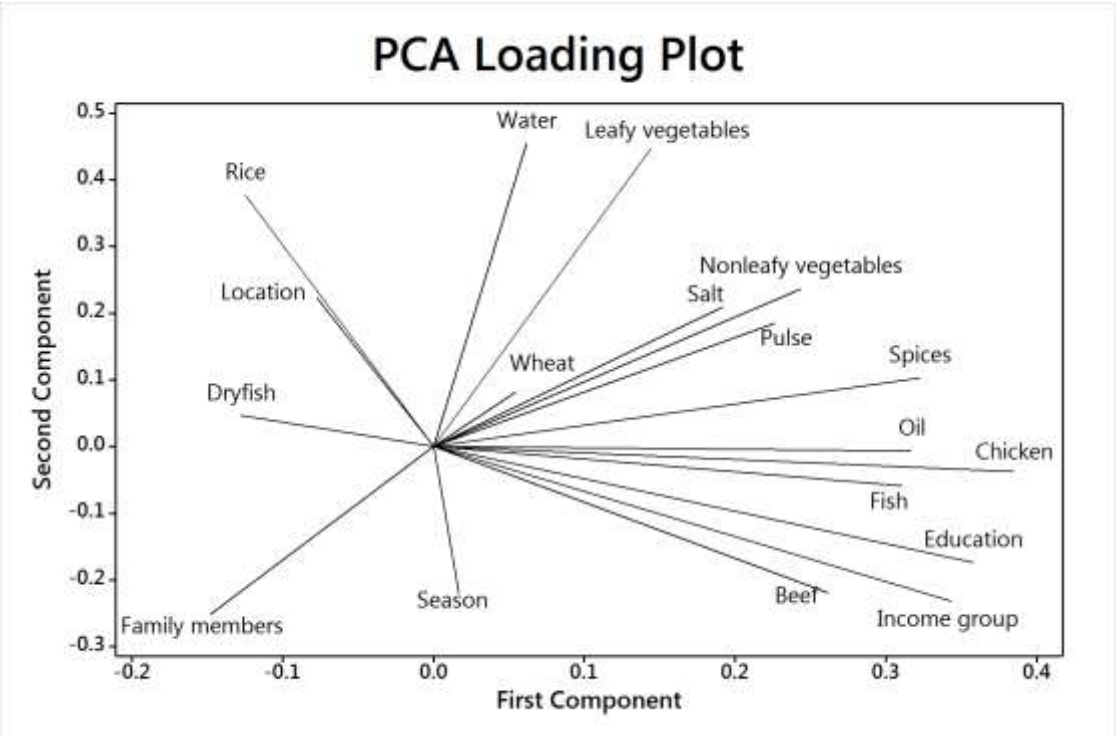

Figure 2. Biplot representation of the Principle Component Analysis (PCA) results for all parameters (food items and subjects characters). The length of each eigenvector is proportional to the variance in the data for each parameter. The angle between eigenvectors represents correlations among different parameters.

HIES (2010) found that average animal protein consumption in Bangladesh is 42.2$gp^{-1}d^{-1}$ in urban, 20.5$gp^{-1}d^{-1}$ in rural and 26.2 $gp^{-1}d^{-1}$ in national level. But it was 30.7 $gp^{-1}d^{-1}$ in urban, 17.6 $gp^{-1}d^{-1}$ in rural and 20.8 $gp^{-1}d^{-1}$ in national level in 2005. In 1998, IAEA found that average animal protein content was 54$gp^{-1}d^{-1}$. In our survey, it is much higher than the previous results. So, it can be concluded that the protein consumption is increasing day by day.

3.2.3. Plant Proteins

Amount of plant protein was higher in Dhaka in both seasons. In Dhaka, consumption of plant protein in LIL, MIL and HIL were36.54, 40.01 and 32.90 $gp^{-1}d^{-1}$, respectively during summer while it was27.46, 41.88 and 37.19 $gp^{-1}d^{-1}$,respectively during winter. In Mymensingh during summer LIL, MIL and HIL consumed28.21, 28.56, and 38.02 $gp^{-1}d^{-1}$ of plant protein, respectively. During winter, same income groups consumed22.79, 38.32 and 50.81$gp^{-1}d^{-1}$ of plant protein, respectively (Table 3). In general, plant protein consumption was higher among the MIL in Dhaka but among the HIL in Mymensingh. Moreover, pulse consumption was slightly greater during the winter season. Because, during summer only lentil is usually available, but during winter season, apart from lentil, mung bean and black gram are also available for consumption.

Average plant protein (in the form of pulses) consumption in Bangladesh was 17.2$gp^{-1}d^{-1}$ in urban population, 13.2$gp^{-1}d^{-1}$ in rural and 14.3 $gp^{-1}d^{-1}$ in national level (HIES 2010). But it was 18.6$gp^{-1}d^{-1}$ in urban, 12.7 $gp^{-1}d^{-1}$ in rural and 14.2$gp^{-1}d^{-1}$ in national level in 2005. IAEA reported in 1998 that daily pulse intake was 120 $gp^{-1}d^{-1}$. However, in the present survey, the pulse consumption was greater than the previous reports. It is noticeable that the reports cited here are five years apart and the present study (conducted after another five year) showed the gradual increase of plant protein inclusion in Bangladeshi diet.

3.2.4. Vegetables

People consume vegetables as leafy and non-leafy form. In Dhaka, the leafy vegetable consumption in LIL, MIL, and HIL was71.68, 59.57 and 70.01 $gp^{-1}d^{-1}$, respectively during summer whereas, 57.93, 119.90and 42.18 $gp^{-1}d^{-1}$, respectively during winter. The amount of consumption of non-leafy vegetables was higher in both locations. During summer in Dhaka the LIL, MIL and HIL consume 429.51, 368.17 and 380.06 $gp^{-1}d^{-1}$ non-leafy vegetables, respectively, whereas, 476.25, 836.30 and 654.45$gp^{-1}d^{-1}$ non-leafy vegetables respectively during winter (Table 3).

In Mymensingh, during summer the LIL, MIL and HIL consumed70.66, 78.90 and 112.92$gp^{-1}d^{-1}$ of leafy vegetables, respectively and during the winter 70.83,47.87 and 82.53$gp^{-1}d^{-1}$, respectively. The MIL and LIL took 532.93$gp^{-1}d^{-1}$ and 427.03 $gp^{-1}d^{-1}$, respectively. In case of non-leafy vegetables, LIL, MIL and HIL consume 356.37, 454.03 and 508.02$gp^{-1}d^{-1}$, respectively during summer and 461.18, 711.03 and 600.19 $gp^{-1}d^{-1}$, respectively during winter (Table 3).

The ratio of consumption of leafy and non-leafy vegetables as in Dhaka was almost same during summer (Table 4). Whereas in winter, LIL group consumed higher portion of leafy vegetables. In case of MIL group, consumption of non-leafy vegetables increased a little (18%). But, consumption of non-leafy vegetables decreased (6%) in HIL. In Mymensingh, during summer the proportion of consumption of non-leafy vegetables was almost same like Dhaka. But it rose between LIL and MIL during winter. In case of HIL, proportion of consumption of leafy vegetables decreased (6%) during winter.

The amount of total vegetable consumption was higher during winter in both locations. The availability of leafy and non-leafy vegetables increased in both summer and winter, which was reflected by increased consumption in both locations. The HIES (2010) report reveals that the vegetable consumption including potatoes during 2005 were 377.3, 374.9, and 384.9$gp^{-1}d^{-1}$in national, rural and urban population, respectively. But it rose up during 2010. The consumption was 402.4, 411.5, and 376.6 $gp^{-1}d^{-1}$ in national, rural and urban population respectively. IAEA (1998) shows that the vegetable consumption is 150$gp^{-1}d^{-1}$. Our findings are higher than the previous studies. Therefore, we can conclude that the vegetable consumption is increasing day by day.

3.2.5. Oil

The consumption of edible oil in Dhaka during summer among LIL, MIL and HIL were 46.35, 53.44 and 49.03 $gp^{-1}d^{-1}$, respectively. During winter, oil consumption among LIL, MIL and HIL were 24.79, 40.96 and 66.43 $gp^{-1}d^{-1}$, respectively.

The consumption of oil in Mymensingh during summer among LIL, MIL and HIL were 25.78, 31.09 and 53.51$gp^{-1}d^{-1}$ respectively. During winter, oil consumption among LIL, MIL and HIL were 20.09, 31.19 and 82.94 $gp^{-1}d^{-1}$, respectively.

The HIL consume highest and LIL consume lowest amount of oil in both locations. The reason behind this was the food habit. Cooking of proteins (included in greater amount among HIL diet) usually requires more spices and oils. Again, the food consumed by HIL group is usually cooked using more oils and were of better quality compared to the other two groups.

In Mymensingh, a LIL family of 11 members uses 1litre oil for a month. According to IAEA 1998, the intake of edible oil was 6$gp^{-1}d^{-1}$.According to HIES (2005), average per capita per day oil intake (in grams) by Bangladeshi resident were16.5, 14.3 and 22.9 in national, rural and urban level accordingly. HIES 2010 report showed the result was 20.5, 18.3 and 26.6 $gp^{-1}d^{-1}$ in national, rural and in urban level.

3.2.6. Spices

Consumption of spices in Dhaka during summer was 82.00, 80.85 and 72.86 $gp^{-1}d^{-1}$, respectively among LIL, MIL and HIL whereas 44.87, 94.18 and 88.51 $gp^{-1}d^{-1}$, respectively for the same during winter (Table 3).

In Mymensingh, during summer the consumption of spices was 49.85, 63.15 and 112.48 $gp^{-1}d^{-1}$, respectively among LIL, MIL and HIL whereas, 31.91, 65.11 and 92.84 $gp^{-1}d^{-1}$, respectively for the same during winter (Table 3).

In Dhaka the consumption of spices in LIL was the highest during summer while lowest in HIL. The use of spices in Geneva camp and Kamalapur slum was very high. On the other hand, MIL consumes the highest amount of spices during winter. In Mymensingh during the both seasons LIL consumed the lowest and HIL consume the highest amount of spices. In general, the consumption of spices was higher in Dhaka in both seasons. Higher amount of animal protein consumption in Dhaka may contribute to this fact as animal protein requires more spices during cooking.

The spices were onion, garlic, ginger, turmeric, red chili, cumin and coriander. Among the spices, consumption of onion was the highest in both locations and both seasons. However, subjects of Mymensingh consumed a very little amount of ginger as they eat very little amount of meat. According to the HIES (2010) survey, the spice consumption in Bangladesh increased over the years. In 2005, the national, urban and rural daily spice consumption was 53.4, 63.1 and 50.2 $gp^{-1}d^{-1}$, respectively; while in 2010, it was 66.0, 69.3 and 64.8 $gp^{-1}d^{-1}$, respectively. The average spices consumption in Dhaka (78.57and 75.85 during summer and winter, respectively) and Mymensingh (75.16 and 63.29 summer and winter, respectively) (Table 2) observed in the present survey was higher than the HIES (2010) report which indicated that the spice consumption is following an increasing trend in Bangladesh.

Due to the increase of proteins and vegetables in the diet, as discussed above, over the years, the consumption of spices probably increased.

3.2.7. Salt

Consumption of salt in Dhaka during summer among LIL, MIL and HIL were11.11, 13.25 and 12.93$gp^{-1}d^{-1}$, respectively and 8.04, 15.19 and 14.39$gp^{-1}d^{-1}$, respectively for the same in winter(Table 3).In Mymensingh, the salt consumption during summer among LIL, MIL and HIL were 9.68, 16.20 and 11.56 $gp^{-1}d^{-1}$, respectively. Whereas in winter, 12.94, 12.35 and 13.03$gp^{-1}d^{-1}$, respectively for the same.

There was no big difference in salt consumption between two locations in both the seasons in case of individual income groups. However, average salt consumption was higher in Mymensingh both the seasons (Table 2). The consumption of salt was the highest in MIL except for winter in Mymensingh and lowest in LIL except for winter in the same location.

3.2.8. Water

In Dhaka consumption of water during summer among LIL, MIL and HIL were 2793, 2611 and 2132 $mLp^{-1}d^{-1}$, respectively. Whereas 1892, 1714 and1926 $mLp^{-1}d^{-1}$, respectively in winter for the same. In Mymensingh, consumption of water during summer among LIL, MIL and HIL were 3138, 4608 and 3689 $mLp^{-1}d^{-1}$, respectively and during winter 1893, 1868 and 2531 $mLp^{-1}d^{-1}$, respectively in winter for the same (Table 3).

Average water consumption was higher in Mymensingh compared to Dhaka. Again, water consumption was higher during summer than in winter in both locations.

3.3. Principal Component Analysis (PCA)

Principal component analysis (PCA), a data reduction method, has been used with data from different countries and cultures to identify dietary patterns in specific populations (Ax *et al.*, 2016). In Figure 2, the biplot graph of PCA showing the inter relationship between respondent characters and daily food intake of different categories where length of each eigenvector is proportional to the variance of each variable and the angle between each

eigenvector represents the correlation among different variables. It was evident from the graph, that the consumption of animal proteins (viz, chicken, beef, fish, etc.), edible oils and spices are positively correlated with the income and education of the respondent from both locations. Non-leafy vegetables, pulses and wheat are also positively correlated with the income and education but to a lesser extent. Similar results were also reported by HIES (2010), Islam (2013) and Shaheen *et al.* (2015).

On the other hand, the consumption of rice and dry fish are negatively correlated with the income and education but positive with location. In other words, rice intake among low-income group respondents is comparatively higher, especially in Mymensingh. Such correlation was apparently inconclusive for leafy vegetables and water. According to PCA, seasonal variation and family size play little effect on the intake of different food categories except for leafy vegetables and water. Leafy vegetables and water intake was higher in summer but lower in winter.

4. Conclusions

In conclusion, it was obvious that there exists a seasonal as well as spatial variation in the consumption of different food categories among various income groups. Most prominent variations were observed in case of carbohydrates, protein and non-leafy vegetables. Again, family income also influenced choice of particular animal proteins or carbohydrates. From the survey outcome, it was also showed that habitat has a strong influence on food habit of people. Apart from these findings, there are some encouraging results as well. The results showed that average protein and vegetable intake over the years increased and dependency on carbohydrate decreased. Lastly, the outcome of the study can be an effective tool in estimating the dietary exposure of chemical contaminants.

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Conflict of interest

None to declare.

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