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Research Article

Health-compromising ingredients in fizzy drinks available in the markets of Dhaka city, Bangladesh

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Abstract

Fizzy drinks containing hazardous ingredients may pose public health risks to the consumers. This descriptive cross-sectional study was conducted to determine the level of health-compromising ingredients in fizzy drinks. Fifteen top-selling fizzy drinks [ten soft drinks (SfD) and five energy drinks (EgD)] available in the markets of Dhaka city, Bangladesh, were analyzed. pH was measured by pH meter. Quantitative estimation of TSS was done by a hand refractometer. Lane and Eynon's method was used to determine total and reducing sugar. The level of caffeine was estimated by high-performance liquid chromatography. Heavy metals were assessed using a graphite furnace atomic absorption spectrophotometer. The pH of SfD and EgD ranged from 2.5-3.4 and 2.9-3.4, respectively. The total sugar content in one serving (250 ml) was 20.8-28.8 gm for SfD and 22.6-37.0 gm for EgD, where six fizzy drinks exceeded the maximum daily allowable limit of sugar as recommended by the World Health Organization. Caffeine levels in the EgD were higher than those of SfD. The range of lead in SfD was 0.19-0.29 mg/L and in EgD was 0.19-0.22 mg/L. Levels of chromium were 0.08-0.26 mg/L and 0.07-0.30 mg/L for SfD and EgD, respectively.

Low pH, presence of excess sugar, caffeine, and heavy metals were the health-compromising ingredients found in this study. Awareness among the consumers and strict monitoring by the regulatory bodies of Bangladesh should be raised to reduce the negative impact of fizzy drinks on health.

Key words: Fizzy drinks; Non-communicable diseases; Heavy metals; Sugar; Health-compromising ingredient; pH; Caffeine

1. Introduction

Non-communicable diseases (NCDs) are the primary cause of deaths worldwide, and among the total NCD deaths, 85% of premature death occurs in low and middle-income countries [1]. In Bangladesh, NCDs were estimated to account for 67% of total deaths, of which cardiovascular diseases caused 30%, 12% by cancer and 3% by diabetes mellitus [2]. Along with the known risk factors mentioned elsewhere [1], fizzy drinks containing sugar, caffeine, heavy metals, etc., play a significant role in developing NCDs [3]. Sugar, the main contributor to weight gain, leads to the development of diabetes, cardiovascular disease, cancer, etc. [4-6]. Evidence shows that caffeine may lead to arrhythmia, hypertension, stroke, and sudden cardiac arrest [7]. Metallic impurities such as lead (Pb) and chromium (Cr) in the water used for manufacturing the fizzy drinks can cause damage to the brain and nervous system, as well as increase the risk of high blood pressure, uremia, and ultimately leading to death [8,9]. The acidic nature (pH <5.5) of the drinks may cause enamel erosion of teeth, dental decay and other dental diseases if consumed for a prolonged period [10-12]. Since the introduction of fizzy drinks in Bangladesh in the 1980s, it has become popular in both urban and rural areas [13], but there is minimal data regarding the amount of the hazardous ingredients present in fizzy drinks. Thus, this study was conducted to assess the health-compromising ingredients present in the top-selling fizzy drinks available in the markets of Dhaka city, Bangladesh.

2. Materials and Methods

2.1 Sampling and sample collection

This descriptive cross-sectional study was conducted to determine health-compromising ingredients, where fifteen popular brands [ten soft drinks (SfD) and five energy drinks (EgD)] among the top-selling fizzy drinks available in the markets of Dhaka, Bangladesh were sampled for this study. Two-stage stratified sampling was done for selecting the brands of fizzy drinks from the retail outlets. In the first stage, one City Corporation (CC) from Dhaka was randomly selected, and five markets from that CC were chosen following the randomization technique from the list of markets available on the CC website [14]. By employing a similar process, six retail outlets from each market were chosen, which yielded a total of thirty outlets. Retail outlet employees were then interviewed by using a semi-structured questionnaire to identify the most selling brands of fizzy drinks based on the maximum sell [15], where they were asked to rank three brands of SfD and EgD separately. The top three selling brands were ranked as I, II and III, where I was allocated for the highest selling one, II and III were given for second and third highest selling brands, respectively. This ranking revealed 21 brands of fizzy drinks (fifteen SfD and six EgD) commonly sold. A scoring system was then introduced, where a score of 3 was given for rank I, 2 for rank II and 1 for rank III. Summations of the scores were done to determine the top ten brands of

SfD and five brands of EgD. Sample of each brand in PET bottles was purchased and sent to the Institute of Food Science & Technology, Bangladesh Council of Scientific and Industrial Research, for determination of the health-compromising components. For anonymity, SfD samples were coded as SfD1 to SfD10 and EgD was coded as EgD1 to EgD5. Ethical permission for this study was received from the Institutional Review Board of Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh (Ref No. BSMMU/2017/7388). This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants. Written informed consent was obtained from all the respondents during the field survey.

2.2 Determination of pH

The pH of the selected samples was determined by using a pH meter (H1 98106 by HANNA, Italy) following the conventional procedure [16].

2.3 Determination of total soluble solids (TSS)

TSS of all the fizzy drinks were measured by using a hand refractometer (ATAGO 9099, Japan), according to the standard procedure [17]. It is expressed as (%) sucrose or °Brix at 20°C [18].

2.4 Determination of total and reducing sugar

Lane and Eynon's method was adopted from Shamanna Ranganna for the determination of total sugar and reducing sugar [19].

2.5 Determination of caffeine

High-performance liquid chromatography (HPLC) (JASCO MX-2080, Japan) technique was used for the detection and quantification of caffeine. Fizzy drink samples were degassed by ultra-sonication. By using a micropipette, 1 mL of each sample was taken, and to each, 1 mL of HPLC grade methanol was added. Each mixed sample was vortex and syringe filtered, later injected to the HPLC. The matrix-free standard was prepared, and a calibration curve was made by using standard caffeine concentration (Blank, 25 mg/L, 50 mg/L, 100 mg/L, 150 mg/L, 200 mg/L). Caffeine was determined by measuring absorbance at 272 nm. It is to be noted that the analytical technique was unable to detect the caffeine levels accurately when below 25 ppm.

2.6 Determination of heavy metals

Fizzy drinks samples were acid digested to determine the heavy metals (Pb, Cr) using Graphite Furnace Atomic Absorption Spectrophotometry (SHIMADZU AA-6300, Japan). The method was described elsewhere [20].

2.7 Statistical analysis

Continuous data were presented using the median and range. Statistical analysis was done using Microsoft Excel 2010.

3. Results and Discussion

The analyzed lab results of the health-compromising ingredients in the fizzy drinks are demonstrated in Table 1.

3.1 pH

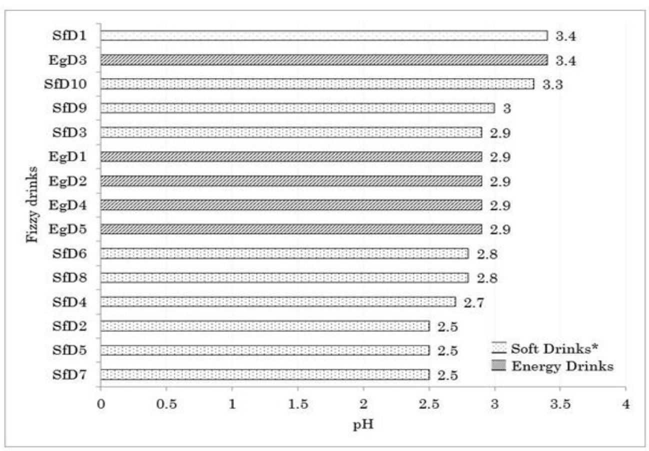
The median (range) of pH for SfD and EgD were 2.8 (2.5-3.4) and 2.9 (2.9-3.4), respectively (Table 1). pH lower than 3.0 is known to be extremely erosive to dental health [21]; therefore, seven SfD and four EgD (Figure 1) from this present study pose a threat to developing dental decay, and consumption of these over prolonged periods should be avoided.

Components	Soft drinks (n=10)		Energy drinks (n=5)	
	Median	Range	Median	Range
pH	2.8	2.5-3.4	2.9	2.9-3.4
Total soluble solids (°Brix)	11.0	10.0-12.0	15.0	9.5-16.0
Total sugar (gm/100 ml)	9.9	8.3-11.5	13.4	9.0-14.8
Reducing sugar (gm/250 ml)	19.8	5.5-23.5	23.6	19.3-35.8
Caffeine (ppm)	18.1	0.0-145.0	111.8	91.3-321.7
Lead (Pb) (mg/L)	0.21	0.19-0.29	0.19	0.19-0.22
Chromium (Cr) (mg/L)	0.13	0.08-0.26	0.13	0.07-0.30

Table 1: Level of health-compromising ingredients analyzed in the selected fizzy drinks.

The current pH findings for the SfD are consistent with results from studies done in Saudi Arabia, where the mean (±SD) was 2.8 (±0.2) [22] and the range was 2.4 to 3.2 [12]. In contrast, a much higher level of pH (3.2 to 4.0) was reported by another study in Bangladesh [23]. This higher level of pH can probably be explained due to the difference in the study site and digital meter used for measuring pH.

For EgD, the level of pH found in this present study was also similar to other studies, where the reported level ranged from 2.5 to 4.0 and 2.9 to 3.1, respectively [21,24]. In contrast, higher pH (5.9 to 6.4) in EgD was reported by Tautua et al. (2014) [25] when compared to the findings of this present study. The possible reason for this high pH might be due to the differences in the manufacturing process and the use of acidulants.



*SfD- Soft drinks; EgD-Energy drinks

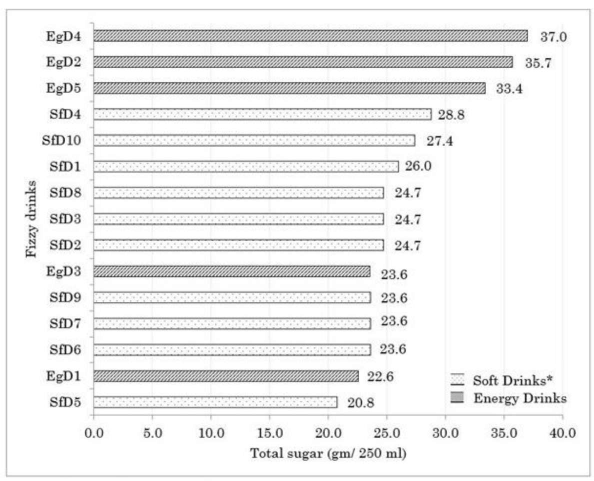
Figure 1: pH of fizzy drinks

3.2 Total soluble solids

Table 1 demonstrates the level of total soluble solids (TSS) present in fizzy drinks, where, median (range) level of TSS for SfD and EgD were 11.0 (10.0-12.0)˚ Brix and 15.0 (9.5-16.0)˚ Brix, respectively. Bangladesh Standards and Testing Institution recommend the standard limit of TSS should be not less than 8˚ Brix [26]. Thus, the TSS value found in this study is accordant with the above-mentioned limit. Similar levels of TSS in SfD were reported by studies conducted by Sharma (2018) and Agbazue et al. (2014), where the level ranged from 7.34 to 12.35˚ Brix and 10.5 to 14.1˚ Brix, respectively [27,28]. On the contrary, a much higher level (15.5 to 16.1˚ Brix) was reported by Omer [29]. For EgD, the level of TSS identified in this present study is similar to research conducted by Cho et al. (2014), where the mean (±SD) TSS of EgD was 13.5 (±2.0)˚ Brix [30].

3.3 Total sugar and reducing sugar

The median (range) of total sugar for SfD and EgD were 9.9 (8.3-11.5) gm/100 ml and 13.4 (9.0-14.8) gm/100 ml, respectively as presented in Table 1. The content of total sugar in one serving (250 ml) of three SfD and three EgD (Figure 2) from this present study exceeds the maximum allowable limit for sugar intake per day as recommended by World Health Organization [31]. The level of total sugar content in SfD found in this present study is consistent with other studies, where they found the level ranged from 9.9 to 13.6 gm/100ml [32] and 11.2 to 12.8 gm/100 ml [12]. For EgD, the total sugar content finding of this study is comparable with the other studies, 2.9 to 15.6 gm/100 ml [33], and 2.1 to 16.0 gm/100 ml [34], where a wide range was reported.



*SfD- Soft drinks; EgD-Energy drinks

Figure 2: Total sugar in fizzy drinks (gm/250 ml serving)

The level of reducing sugar for SfD and EgD median (range) 19.8 (5.5-23.5) gm/250 ml and 23.6 (19.3-35.8) gm/250 ml, respectively (Table 1). For reducing sugar, contrasting results to the present finding were reported by Hossain et al. (2015), where a much lower range of reducing sugar in EgD was observed (0.07 gm/250 ml serving to 0.13 gm/250 ml) [24]. This difference was most probably due to differences in the study site (Rajshahi) or methodology, where reducing sugar was determined spectrophotometrically by measuring absorbance at 575 nm, but Lane and Eynon's method was used in this present study. Fizzy drinks available in the markets of Bangladesh may be harmful to the consumer's health since one serving of the six fizzy drinks had higher levels of total sugar exceeding the allowable limit of daily intake (25 grams/ day).

3.4 Caffeine

The current study revealed the median (range) of caffeine content in the SfD was 18.1 (0.0-145.0) ppm, whereas, for EgD, it was 111.8 (91.3-321.7) ppm (Table 1). Studies from Africa revealed caffeine levels in SfD ranged from 32.4 to 133.3 ppm [35], to a much lower and narrow range of 43.7 to 45.8 ppm [25]. For EgD, a study in Bangladesh reported the range of caffeine level was 149.4 to 978.3 ppm [24]. Different ranges of caffeine levels were published by other researchers in different countries, such as in Sudan it was ranged between 170.6 to 324.0 ppm [35], and in two additional Nigerian studies, it was found to be 1.1 to 237.95 ppm and 47.6 to 58.3 ppm [25,36]. In the present study, only one brand of EgD revealed a high level (EgD3: 321.7 ppm) of caffeine, exceeding the standard range recommended by U.S. Food and Drug Administration (FDA) (200 ppm) and BSTI (145 ppm) [26,37]. Consumption of caffeine beyond the US FDA level is known to affect health adversely [38]. Therefore, self-vigilance is required while consuming fizzy drinks with high caffeine content.

3.5 Heavy metals (Pb, Cr) in fizzy drinks

As shown in table 1, the median (range) of Pb in SfD was 0.21 (0.19-0.29) mg/L and for EgD it was 0.19 (0.19-0.22) mg/L. The median (range) of Cr in SfD was 0.13 (0.08-0.26) mg/L and in EgD 0.13 (0.07-0.30)

4. Conclusion

The majority of the fizzy drinks had extremely erosive pH, and six among the fifteen had sugar exceeding the maximum allowable limit for daily sugar intake. All the fizzy drinks contained heavy metals (Pb, Cr) at a higher level than the allowable limit recommended by WHO and CAC. The presence of these health-compromising ingredients may lead to detrimental health consequences. Awareness among the consumers and strict monitoring by the regulatory bodies of Bangladesh should be raised to reduce the negative impact of fizzy drinks on health. More research is recommended to evaluate the health-compromising ingredients in fizzy

mg/L. The levels of both the heavy metals were found to be higher than the maximum allowable limit recommended by Codex Alimentarius Commission (CAC) and WHO; for Pb, it was 0.02 mg/L [39] or 0.01 mg/L [40], and for Cr, it was 0.05 mg/L [40,41]. These heavy metals are known to be carcinogenic in nature, usually affecting the kidney and liver. The presence of these metals in the fizzy drinks can be possibly accounted for by their presence in the water used for the manufacturing of these drinks [42]. In contrast to this study findings, lower Pb content in SfD was reported by other researchers where they found the range as 0.001 to 0.053 mg/L and 0.01 to 0.02 mg/L. Much lower Cr content was also reported by Akhter in Bangladesh and Garcia in Spain, where they ranged from 0.01 to 0.02 mg/L in canned SfD and 0.004 to 0.061 mg/L in SfD, respectively [43,44]. From the study conducted in Nigeria, Orisakwe and Ajaezi reported Cr content in energy drinks ranged from 0.001 to 0.699 mg/L [45]. Some limitations that should be considered before concluding the study include: fizzy drinks contained in glass bottles and cans were not considered in this study. Also, the study was conducted in Dhaka city. Thus the findings may not be generalized for all the fizzy drinks available in Bangladesh.

drinks manufactured in different sites and packaging forms in the whole country.

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Conflicts of Interest

All the authors declared that they have no conflict of interest.

Author Contributions

A.H.M.G.K., M.K., F.A.K., S.E.R., M.M.H.K., M.R.A., S.S.I were responsible for the conception and design of the study; A.H.M.G.K., F.A.K., and M.K. were responsible for the conduction of field survey and the collection of data; A.H.M.G.K., M.M. and B.K.S. were responsible for the laboratory analyses of the samples; A.H.M.G.K., S.S.I., M.K., S.E.R., F.A.K., M.M.H.K., K.M.T.R. and M.R.A. were responsible for the data analysis, interpretation of data and drafting of the manuscript. All the authors reviewed and approved the final version of the manuscript and have agreed to its submission for publication.

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