Determination of the Sugar Content in High-Sugar Beverages

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ABSTRACT: We determined the sugar content of 75 samples, including eight black sugar beverages (BSBs) and seven Dal-gona lattes (DLs) from Seoul, Korea, using high-performance liquid chromatography-evaporative light scattering detector. The mean sugar content per 100 g was 12.7 g and 12.3 g for BSB and DL, respectively. According to the World Health Organization, the mean sugar content per serving in BSB and DL were 34.8 g and 32.5 g, respectively, equivalent to 65∼70% of the recommended daily intake for added sugars. The highest sugar was sucrose (56.5% in BSB and 64.4% in DL). The sugar content could be adjusted in 27 out of 40 stores for BSB and 25 out of 35 stores for DL. The relative standard deviation of the content (g/100 g) per store by the manufacturer ranged between 5.7∼21.6% for BSB and 2.3∼29.5% for DL. This suggests that a uniform recipe is required for manufacturing beverages.

Keywords: beverages, high-performance liquid chromatography, sugars

INTRODUCTION

Total sugar is the sum of the monosaccharide and disaccharide amounts consumed in foods. The monosaccharides consist of fructose and glucose, and disaccharides include maltose and lactose (Oh and Park, 2000; Nishida et al., 2004). Added sugars refer to the sugars, such as syrup added, during manufacturing, processing, and cooking processes (Bowman, 2000). Although sugar is an important energy source for the body, excess sugars accumulate as fats and increase the risk of developing diseases, such as obesity and diabetes (Lustig et al., 2012; Jung, 2016).

Particularly, the prevalence of adult obesity due to excessive sugar intake increased by 2.9%, from 31.7% in 2007 to 34.6% in 2018 (Korea Disease Control and Prevention Agency, 2018). The obesity rate of adolescents in Seoul more than doubled, from 5.1% in 2010 to 11.4% in 2020 (Seoul Metropolitan Government, 2017). Obesity increases the socio-economic cost, which rose from 4.8 trillion won in 2006 to 11.47 trillion won in 2016 (National Health Insurance Service, 2018; Korea Health Promotion Institute, 2020).

The average daily sugar intake in Korea was less than 100 g (20% daily calorie intake). However, this daily intake went up from 14% in 2012 (68 g/d) to 16% in 2016 (74 g/d), showing a continuous increase (Ministry of Food and Drug Safety, 2019; Korean Nutrition Society, 2020). The Ministry of Food and Drug Safety proposed a comprehensive plan in 2016 to restrict the sugar consumed through processed foods to within 10% of the daily calorie limit by 2020. The Seoul Metropolitan Government also implemented a sugar reduction plan stating that although the total sugar intake is declining, the rate of exceeding the standard for added sugar intake is steadily increasing (Korea Health Industry Development Institute, 2020). Notably, the sugar consumed through processed foods among teenagers and young people aged 19 to 29 was higher than the standard for added sugar intake (National Health Insurance Service, 2018; Korea Health Industry Development Institute, 2020).

Among processed foods, beverages are the highest contributors of added sugars (Ministry of Food and Drug Safety, 2019) as they have faster social trends than other food types. Recently, sweet drinks advertised through online ‘Muk-bang’ and blogging have contributed to increased consumption of high-sugar beverages for stress relief during the COVID-19-related social activity restrictions, creating social and economic problems. In 2021, societies, including the Korean Obesity Society, emphasized the importance of preventing and managing obesity and metabolic syndrome in the COVID-19 era (Korean Society of Clinical Nutrition, 2021). Between 2017 and 2019, the seasonal average daily sugar intake consumed through processed foods by Koreans was the highest in summer (Ministry of Food and Drug Safety, 2021). The drinks consumed in summer with the highest sugar contribution were newly released beverages such as black
sugar beverages (BSBs) and Dalgona lattes (DLs). Based on the analysis, the Korean Government evaluated the risks for developing social systems, providing information on healthy eating habits, and making policies for the Seoul Sugar Reduction Project.

MATERIALS AND METHODS

Samples
In 2020, we purchased 75 samples, including BSB and DL, from top franchised stores in five regions in Seoul, Korea, including the northwest, southwest, northeast, southeast, and downtown areas. Ice was excluded from the purchased samples to investigate the amount of sugar. The beverages were homogenized and sealed using a hood mixer (Vita-Mix Manufacturing Corp., Strongsville, OH, USA), and stored at −20°C. The test solution was prepared and stored at 4°C the day before the experiment.

Standards and reagents
For the sugar analysis, we used fructose, glucose, sucrose, maltose, and lactose standards with a purity of 99.5% or higher (Sigma-Aldrich Co., St. Louis, MO, USA). We used distilled water with a resistance value of Milli-Q® Integral 5 (Millipore, Molsheim, France) of 18 Ω M or more for the dilution. High-performance liquid chromatography grade acetonitrile (J.T. Baker, Pittsburgh, PA, USA) was used as the mobile solvent. For preparing the standards, approximately 1 g each of fructose, glucose, sucrose, maltose, and lactose were used. They were placed in a 100-mL volumetric flask, diluted with distilled water to a level of 0.03 ~ 1%, and filtered using a 0.2-μm polyvinylidene fluoride filter (Goettingen, Germany). The calibration curve was prepared using a quadratic equation and displayed good linearity (between 0.999 and 0.9992).

Instrumentation
The Waters Acquity UPLC H-Class system (Waters, Milford, MA, USA) equipped with evaporative light scattering detector was used to determine the sugars using a 250 mm×4.6 mm Shodex Asahipak NH2P-50 4E column (Shoko Science Co., Ltd., Tokyo, Japan) with a 5-μm diameter. The solvent system was an isocratic mixture of acetonitrile and water (75/25, v/v). The column temperature was 35°C, and the injection volume was 10 μL. The gas pressure was 40 psi, gain 50, drift tube 5°C, and nebulizer 50°C in the detector.

Method validation
For validating the analytical method, the standard certi-

![Fig. 1. Chromatograms of the standard (A) and the sample (B). LSU, light scattering unit.](image)
RESULTS

Sugar content per 100 g and serving size
The mean sugar content in BSBs was 12.7 g, ranging between 7–20 g/100 g, showing a maximum difference of 2.9 times. The mean sugar content per serving of BSB was 34.8 g, ranging from 21.6 g to 54.4 g, with a maximum difference of 2.5 times (Table 1). The mean sugar content per 100 g of DL was 12.3 g, ranging from 6.7–19.7 g/100 g, with a maximum difference of 2.9 times. Further, the mean sugar content per serving of DL was 32.5 g, ranging from 18.6 g to 50.4 g, and the maximum difference was 2.7 times (Table 1). There is a significant difference in the sugar content (g/100 g) of the drinks depending on the brand (P<0.001). The sampled BSB brands were classified into three groups: S1, S3, S5, S2, S6> S4> S7 and S8 (Table 1). The DL brands were categorized into six groups B1> B7> B2> B3> B5> B4 and B6 (Table 1). S1 was the highest in BSB and DL per brand. S7 was the highest in BSB, while B7 was the highest in DL per serving size. The %RSD of the difference in sugar content (g/100 g) between brands was 5.7% to 21.6% for BSBs and 2.3% to 29.5% for DLs (Fig. 2). There was no significant difference in the sugar content of BSBs and DLs among the five studies regions.

Evaluation of health risks from sugar intake of high-sugar beverages
In Korea, the total sugar intake is limited to 10–20% (2,000 kcal, 100 g) of the daily sugar intake. The contribution of added sugars through processed foods must be limited to 10% (2,000 kcal, 50 g) of the total calorie intake (Seoul Metropolitan Government, 2021). The main...
sources of added sugar include sugar, liquid sugar, honey, syrup, and concentrated fruit juice (Bowman, 2000). According to international standards (WHO, 2015), sugar intake should be limited to 10% of the total energy intake per day (based on the average adult body weight, 50 g) (Bowman, 2000).

A single glass of BSB and DLs contain an average of 34.8% and 32.5% added sugars, respectively, accounting for 33∼35% of Korea’s daily nutrient standard (100 g). If a maximum of 54.4% of BSB and 50.4% of DL is consumed, it is equivalent to 50∼55% of the daily nutritional standard for sugar.

According to the daily intake recommendations for added sugar (50 g), BSBs and DLs averaged at 69.6% and 65%, respectively, exceeding the recommended global standard (25 g) for total sugar intake specified by WHO in 2015.

### Distribution of sugar content in high-sugar beverages by type

The types of sugar in high-sugar beverages include sucrose, which is the highest at 60.2%, followed by lactose (24.3%), glucose (8.1%), fructose (6.7%), and maltose (0.7%). In BSBs, sucrose was the highest at 56.5%, followed by lactose (23.5%), glucose (9.9%), fructose (8.8%), and maltose (1.4%) (Table 2). The high sucrose content is due to the added sugar and syrup while making the BSBs. Starch syrup is added while making the bubbles, contributing to a small amount of maltose.

In DLs, sucrose was the highest at 64.4%, followed by lactose (25.4%), glucose (6.2%), and fructose (4.2%). Maltose was not detected. The high sucrose contents are due to the 'Dalgona', made from melted sugar and added as a topping.

Monosaccharides and disaccharides are sugars that are often used to add sweetness. Their structure is more eas-

### Table 2. Distribution of sugars is based on the type of black sugar beverages and Dalgona latte (unit: %)

| Name of sample | Fructose | Glucose | Sucrose | Lactose | Maltose |
|----------------|----------|---------|---------|---------|---------|
| **Black sugar beverage** (n=40) | | | | | |
| S1 (n=5) | 0.0±0.0 (0.0–0.0) | 0.0±0.0 (0.0–0.0) | 76.4±4.6 (72.5–82.4) | 21.7±4.8 (17.5–27.5) | 1.8±4.1 (0.0–9.2) |
| S2 (n=5) | 11.6±1.7 (9.0–13.3) | 8.7±1.5 (7.1–10.3) | 58.9±5.5 (55.0–65.6) | 20.7±6.2 (14.6–28.0) | 0.0±0.0 (0.0–0.0) |
| S3 (n=5) | 13.1±1.5 (10.8–15.0) | 10.1±1.3 (8.5–11.2) | 57.8±2.7 (55.0–62.1) | 19.1±5.0 (11.8–25.7) | 0.0±0.0 (0.0–0.0) |
| S4 (n=5) | 12.9±1.6 (10.8–14.2) | 9.8±1.6 (8.5–11.9) | 50.0±3.7 (45.2–55.5) | 27.4±6.1 (19.6–35.4) | 0.0±0.0 (0.0–0.0) |
| S5 (n=5) | 7.3±0.4 (6.9–8.0) | 7.7±0.4 (7.2–8.3) | 66.9±2.5 (63.0–69.6) | 18.2±1.7 (16.0–20.7) | 0.0±0.0 (0.0–0.0) |
| S6 (n=5) | 12.9±1.3 (10.6–13.7) | 10.9±1.6 (8.1–12.2) | 46.8±2.6 (45.8–47.2) | 20.0±3.8 (16.9–26.5) | 9.1±1.7 (7.6–11.3) |
| S7 (n=5) | 0.0±0.0 (0.0–0.0) | 23.7±4.8 (16.0–27.9) | 46.2±2.6 (40.3–57.1) | 30.1±2.7 (26.9–32.9) | 0.0±0.0 (0.0–0.0) |
| S8 (n=5) | 12.9±2.2 (10.5–15.8) | 8.0±4.6 (6.0–11.6) | 49.0±2.7 (37.2–54.7) | 30.1±4.7 (24.9–35.4) | 0.0±0.0 (0.0–0.0) |
| **Dalgona latte** (n=35) | | | | | |
| B1 (n=5) | 14.5±5.8 (5.8–21.5) | 14.3±5.4 (6.3–20.9) | 51.4±11.5 (35.7–65.4) | 19.7±3.5 (14.0–22.5) | 0.0±0.0 (0.0–0.0) |
| B2 (n=5) | 10.7±14.9 (0.9–12.0) | 13.2±10.0 (11.5–13.9) | 52.8±7.0 (40.4–57.2) | 23.4±2.8 (18.2–38.7) | 0.0±0.0 (0.0–0.0) |
| B3 (n=5) | 3.9±3.6 (0.0–7.1) | 10.3±2.8 (7.9–14.9) | 64.9±2.8 (61.9–68.9) | 20.6±2.7 (19.4–23.2) | 0.0±0.0 (0.0–0.0) |
| B4 (n=5) | 0.0±0.0 (0.0–0.0) | 4.9±11.0 (0.0–24.6) | 61.6±20.3 (28.3–82.5) | 33.4±11.0 (17.5–47.1) | 0.0±0.0 (0.0–0.0) |
| B5 (n=5) | 0.0±0.0 (0.0–0.0) | 0.0±0.0 (0.0–0.0) | 76.2±4.6 (73.2–78.8) | 24.0±2.4 (21.2–26.8) | 0.0±0.0 (0.0–0.0) |
| B6 (n=5) | 0.0±0.0 (0.0–0.0) | 0.0±0.0 (0.0–0.0) | 65.0±5.2 (0.0–0.0) | 30.0±5.2 (28.7–42.7) | 0.0±0.0 (0.0–0.0) |
| B7 (n=5) | 0.0±0.0 (0.0–0.0) | 0.0±0.0 (0.0–0.0) | 76.6±1.1 (77.5–80.2) | 21.4±1.1 (19.8–22.0) | 0.0±0.0 (0.0–0.0) |

Values are presented as mean±SD (range).
Table 3. Comparison of the sugar content per 100 g and serving size of black sugar drinks in 2019 and 2020

| Name of sample | Average content of sugar | g/100 g | 2019 | 2020 | Changes by yr (%) | Changes by yr (%) | g/serving size | 2019 | 2020 | Changes by yr (%) | Changes by yr (%) |
|----------------|--------------------------|---------|------|------|-------------------|------------------|----------------|------|------|-------------------|------------------|
| S4 (n=5)       |                          |         | 13.2 | 11.6 | -1.6              | -12.1            | 41.7           | 37.0 | -4.7 | -11.3             |
| S5 (n=5)       |                          |         | 14.5 | 14.2 | -0.3              | -2.1             | 32.6           | 31.9 | -0.7 | -2.1              |
| S6 (n=5)       |                          |         | 15.8 | 14.2 | -2.4              | -15.2            | 47.4           | 36.9 | -10.5 | -22.2             |
| S7 (n=5)       |                          |         | 10.6 | 10.0 | -0.6              | -5.7             | 37.2           | 39.3 | 2.1  | 5.6               |
| S8 (n=5)       |                          |         | 12.2 | 9.1  | -3.1              | -25.4            | 34.6           | 29.4 | -5.2 | -15.0             |
| Total (n=25)   |                          |         | 13.2 | 11.6 | -1.6              | -12.1            | 38.7           | 34.9 | -3.8 | -8.9              |

Fig. 3. Graph showing the nutritional information by brand and whether sugar can be adjusted.

Comparison of 100 g sugar content and serving sugar content of BSBs in 2019 and 2020

We compared the sugar content of five BSB brands (S4, S5, S6, S7, and S8) in 2019 and 2020. The average sugar content per 100 g in 2020 significantly decreased by 1.6 g and 12% compared to that in 2019 (Table 3). Compared to 2019, the sugar content was lower in 2020. Specifically, in S8, the sugar content was significantly reduced to 25.4%. The average sugar content per cup also significantly decreased by 3.8 g and 8.9% in 2020 compared to 2019. Overall, we found that the sugar content per serving size decreased in all brands except for S7.

Sugar content management by the company

In this study, we requested the staff working for the brands store to control the sugar content, if possible, and received a positive answer. It was possible to control the sugar in 27 out of 40 BSB brand stores, while for DLs, it was possible in 25 out of 35 (Fig. 3).

Sugar control guidance was not displayed on the products by all the brands. Moreover, the error range in the vitamin and mineral content on the label on processed foods is at least 80%, and for fat and sodium, it is less than 120%. However, the food service business does not apply the sugar control guidance except for children’s favorite foods such as hamburgers and pizza.

Moreover, even if the beverage recipe is the same for each brand, discrepancies in the criteria for displaying sugar content arise due to differences in the amount added by the person in charge of manufacturing. In the case of BSB and DL, it is difficult to control the sugar content, especially in manufactured beverages. Nevertheless, paying attention to consumers and developing a uniform recipe and quality control to reduce sugar content is necessary.

DISCUSSION

We investigated the sugar content per 100 g in BSBs and DLs, which was 12.7 g and 12.3 g, respectively. The sugar content per cup constituted 33~35% of Korea’s daily nutrient standard and 65~70% of the daily intake recommended by WHO. This exceeded the total sugar intake standard (25 g) according to the global WHO guidelines in 2015 (WHO, 2015).

Among the individual sugars, sucrose was the highest in both BSBs and DLs, as both recipes include added sugar. The most important ingredient of BSB is the black sugar or syrup; in DLs is the Dalgona topping, consisting of melted sugar. Lactose was the second highest as milk is one of the main ingredients in both beverages.

Recently, the percentage of energy intake from beverages has been increasing with an increase in sugar intake by approximately 100 g over ten years (Korea Disease Control and Prevention Agency, 2018). The consumption of sugar-sweetened beverages (SSBs) has increased by approximately 41.1% among the youth and adolescents.
Beverages are high-calorie, low-nutritional foods that have attracted the attention of the younger generations in Korea.

The consumption of beverages was 208 g in 2008, which is more than quadrupled from that in 1998 (45 g). People in their 20s and 30s are the highest consumers (Korea Disease Control and Prevention Agency, 2018).

SSBs, such as BSBs and DLs, are the most frequently consumed beverages by adolescents (Kim et al., 2019). These unhealthy beverages are usually consumed mindlessly to satiate thirst. SSBs are one of the three beverages that adolescents often drink and are responsible for causing obesity (Luger et al., 2017), even in adults and children (Luger et al., 2017). In fact, obesity and high SSBs intake were found to be closely associated (Lee et al., 2013). In Korea, the dietary guidelines emphasize reducing SSBs consumption to promote good health.

It is necessary to educate the public by informing them about the sugar content per serving size whenever they order their beverages. We also think reducing the sugar content during manufacturing is important, which few brands have already done. Therefore, a similar system can be utilized by other brands and restaurants. When comparing sugar content in BSBs in 2019 and 2020, we have observed an apparent decline (Table 3), and continuous promotion of sugar reduction seems to be effective.

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The authors declare no conflict of interest.

**AUTHOR CONTRIBUTIONS**

Concept and design: SUK. Analysis and interpretation: NYK, SUK. Data collection: NYK, SRK. Writing the article: NYK, SUK. Critical revision of the article: SUK. Final approval of the article: all authors. Statistical analysis: SUK. Overall responsibility: SUK.

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