Cholesterol analysis of Korean eat-out foods for national food composition database

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Abstract Information on cholesterol intake through restaurant meal is of high concern because of increasing eat-out population. Since nutrient labeling is not mandatory for restaurant food in Korea, cholesterol database on restaurant menu is unavailable. This study was performed to construct regional and national cholesterol database on primary Korean restaurant foods including 30 soup/stew, 24 rice dishes, and 27 noodles. From 2009 to 2012, Korea Ministry of Food and Drug Safety collected total 5832 foods (81 food types × 6 regions × 12 restaurants) nationwide and then 486 composites representing food types and regions were prepared for cholesterol analysis. Cholesterol contents of 486 composite samples were highly affected by recipe, food type, seasonality of ingredients, and geographical location, showing the range of 1.1–143.0, 1.5–85.1, and 0.4–62.2 mg/100 g for soup/stew, rice dishes, and noodles, respectively. The highest cholesterol value was observed in *Al-tang* (spicy fish roe soup) while *Maemil-guksu* (buckwheat noodle in beef stock) showed the lowest among all samples. Most foods contain relatively low cholesterol content, but the serving size and consumption frequency of dishes should be considered in order not to exceed the recommended daily intake limit (300 mg cholesterol). Saponification coupled with gas chromatography applied for cholesterol analysis was reliable based on accuracy (95% > recovery) and precision

(repeatability <4% and reproducibility <8%). Quality control chart monitored for 4 years showed that all analyses were under the control. This study provides reliable and representative cholesterol contents of Korean restaurant key foods, which can be utilized for assessments of cholesterol intake in the current Korean diet.

Keywords Cholesterol · Food composition database · Korean key food · Restaurant food · Method validation

Introduction

Cholesterol is a lipid molecule biosynthesized by animal cells. Biologically, it has been known to be an important precursor of bile acid, pro-vitamin D₃, and several steroidal hormones (Hanukoglu 1992). There are some contradicting evidences on the connection of dietary cholesterol to cardiovascular diseases (CVD). A review study by Huth and Park (2012) showed that in most prospective observational and meta-analyses, there was no association between milk fat intake and risk of CVD, coronary heart disease (CHD) and stroke, even showing inverse relationship in some cases. However, in a cohort study on 34,670 women aged 49–83 years living in Västmanland and Uppsala counties of Sweden, dietary cholesterol intake was found to be positively associated with risk of total stroke and cerebral infarction (Larsson et al. 2012). Rong et al. (2013) reported that increased consumption of egg was associated with significant elevated risk of CHD in diabetic populations based on the meta-analysis of cohort studies conducted on Asians and Americans (263,938 participants for CHD and 210,404 patients for stroke) from 8 articles and 17 independent reports. In addition, in in vivo studies, long-term feeding of cholesterol was shown to affect cerebral

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microcirculation (Ishikawa et al. 2004), induce cerebral inflammatory markers (Thirumangalakudi et al. 2008; Ullrich et al. 2010), affect learning and memory by affecting synaptic plasticity and spine morphology (Wang and Zheng 2015), promote colorectal (Du et al. 2016) and breast cancer (Li et al. 2016a), and activate inflammatory pathways along with blunted mitochondrial function (Li et al. 2016b). The foregoing studies clearly show that dietary cholesterol intake is highly related with risk of CHD and other diseases. A 300 mg daily intake limit of cholesterol is recommended by the World Health Organization (WHO) and Food and Agriculture Organization (FAO) of the United Nations. Therefore, to avoid exceeding the intake limit of cholesterol, reliable information on cholesterol content of foods is highly needed.

Food Composition Databases (FCDBs) are an important tool in educating consumers about the components of food relevant to their health, such as cholesterol. FCDBs provide relevant information to the food industry, researchers, dieticians, public health officers, policy makers, and educational facilities (Korošec et al. 2013). Hence, it is very important to periodically update FCDBs utilizing efficient analytical techniques and considering changes in available foods for consumption. The FCDBs in Korea include proximate composition, amino acid, vitamin, mineral, cholesterol, and sodium profiles of raw food ingredients, crops, and processed foods (Agro-Food Integrated Information System, Korean Rural Development Administration (KRDA); Food Safety Information Portal, KMFDS). However, majority of the available data were constructed without validation and nationwide sampling. Food composition tables of Japan and the United States were also used for unavailable FCDBs of Korea. Therefore, since 2009, the Korean Ministry of Food and Drug Safety (KMFDS) began to construct reliable national FCDBs.

Whether locals or foreigners in Korea, eating-out has become an important part of people's lifestyle due to their busy routine and great access to restaurants all over the country. Out of the expenses on 'Food and beverages', the share of 'Eating out' expenses skyrocketed by 38 times from 1.3% in 1960 to 48.9% in 2008 and is continuously increasing (Statistics Korea News 2010). In a typical Korean restaurant, soups/stews, rice dishes, and noodles are served as main dishes in a minimum of 200-g serving and with at least four to eight side dishes. With the increase in eating-out behavior of the consumers, information on the composition of restaurant meals should be also made accessible both to the domestic and international consumers. However, the Korean food regulation system by KMFDS cover only the mandatory nutrition labeling for processed foods, with calorie, carbohydrate, sugar, protein, fat, saturated fat, *trans* fat, cholesterol, and sodium as components (Food Labeling System, KMFDS). All

commercially processed foods being sold in the country are seen with nutrition labeling, but information on nutrient composition of restaurant foods is unavailable.

Therefore, the primary objective of this study is to provide reliable regional and national cholesterol database for Korean eat-out foods through the nationwide collection and analysis of highly consumed restaurant foods in 6 regions of the country.

Materials and methods

Reagents and standards

All reagents used in this study were of HPLC grade: ethanol, *n*-hexane and ethyl acetate (J.T Baker, Solusorb, USA), potassium hydroxide (purity > 85.0%, Daejung chemicals & metals Co. Ltd., Korea), pyrogallol (Tokyo Chemical Industry Co. Ltd., Japan), sodium chloride and sodium sulfate (Junsei Chemical Co. Ltd, Japan), butylated hydroxytoluene (BHT) and heptane (Sigma-Aldrich, St. Louis, MO, USA). Cholesterol (external standard) and 5 α -cholestane (internal standard) were purchased from TCI (Tokyo, Japan) and Sigma (MO, USA), respectively. Standard reference material (SRM) 1544 (frozen diet composite) and 1849 (infant formula) were purchased from the National Institute of Standards and Technology (NIST, Gaithersburg, MD, USA).

Standard preparation

Cholesterol stock solution (1 mg/mL) was prepared with *n*-hexane containing BHT (0.01%, w/v). Standard curves were obtained by regression analyses using six concentrations of cholesterol standards (0.05, 0.10, 0.20, 0.40, 0.80, and 1.00 mg/mL) for cholesterol quantification. For the internal standard, 5 α -cholestane was dissolved in heptane at a concentration of 0.1 mg/mL.

Sampling and sample preparation

For nationwide sampling of eat-out key foods, Korea is geographically divided into six regions Gangwon (R1), Gyeonggi (R2), Gyeongsang (R3), Seoul (R4), Jeolla (R5), and Chungcheong (R6) as classified based on administrative districts in order to investigate regional differences in the cholesterol content in Korean restaurant menu. All food samples were collected from six regions (R1–R6) of Korea according to the sampling protocol statistically designed by KMFDS. A total of 30 soup and stew, 24 rice dishes, and 27 noodles were sampled from 12 different restaurants located in each region for each type of food. Three cities that rank high in population density for each region were

first selected and then locations of four restaurants for each city were selected considering consumption frequency and consumer's preference to each menu (total 12 food samples by 3 cities and 4 restaurants). Total collected samples were 5832 by 81 types, 6 regions, and 12 restaurants. Restaurant locations and brand names were different depending on the type of food to be collected. Food samples were packaged in a plastic bag in restaurant, put into an ice box with an ice pack for transportation to laboratory, and then frozen at -70°C until sample preparation. Before freezing of samples, weight and information on ingredients of food sample were recorded with image photos.

For composite sample preparation, 12 samples from 12 restaurants for each type were individually homogenized using a blender (HGBSS, Torrington, CT, USA) and the same portion of the 12 sample homogenates (150 g each) were mixed together to produce composite samples representing each region. Finally, 486 composite samples representing food types and regions were prepared from the 5832 samples. Homogeneity of the composite samples was checked by determination of moisture and fat contents. The composite samples were divided into 50 g of subsamples into plastic containers, frozen at -70°C , and delivered to national laboratories selected by KMFDS for various nutrient analyses. All samples were stored at -70°C until analysis. All protocols were done based on Korean Food Standards Codex (2010). Cholesterol analysis was completed in national laboratory at Sunchon National University (Jeonnam, Korea) and each sample was analyzed in triplicates.

Saponification and extraction

Cholesterol was extracted according to the methods of Chun et al. (2006) and the Korean Food Standards Codex (2010) with minor modification. Five grams of completely thawed sample was weighed in extracting glass tubes. Ten milliliters of pyrogallol (6% in ethanol, w/v) and 1.0 mL of 5α -cholestane solution were added. After sonication for 10 min, 8.0 mL of 60% potassium hydroxide in deionized water was added. The extracting tube was flushed with nitrogen gas for 1 min, connected to an air condenser tube, and heated at 80°C for 1 h in a shaking water bath at 100 rpm (HB-205 SW Hanbaek Scientific Co., Korea). After cooling, 20 mL of 2% sodium chloride in deionized water and 15 mL of extracting solvent (hexane:ethyl acetate = 85:15, v/v) containing 0.01% BHT were added and mixed vigorously for about 2 min. The tubes were left undisturbed for 10 min, after which the upper layer was collected into a 50-mL volumetric flask. This extraction step was repeated 2 more times; extracts were combined and passed through anhydrous sodium sulfate as filter to remove water. Volume of the extracts was made up to

50 mL with extracting solvent. A 10 mL aliquot of the extract was dried under N_2 gas and was re-dissolved in 1.0 mL *n*-hexane. Extracts were filtered through a $0.45\ \mu\text{m}$ membrane filter (Advantec, PTFE, Tokyo Roshi Kaisha Ltd., Japan) and analyzed on GC.

GC analysis

Cholesterol separation was conducted by HP 5890 Series II (Hewlett-Packard Co., USA) GC system equipped with an HP-5 capillary column (30 mm $\times$ 0.32 mm, $0.25\ \mu\text{m}$, Agilent Technologies, Santa Clara, CA, USA) and a flame ionizing detector (H_2 : 30 mL/min and air: 300 mL/min). Flow rate of carrier gas (N_2) was 3 mL/min. Both injection and detection temperatures were 300°C . Cholesterol was separated on column set at 290°C for 15 min and elevated to 320°C at a rate of $15^{\circ}\text{C}/\text{min}$. Column temperature was decreased to 290°C at the rate of $15^{\circ}\text{C}/\text{min}$ and maintained for 2 min before next injection. Cholesterol peaks were identified by comparison with retention times of standards.

Method validation

Precision and accuracy of cholesterol analysis were determined with quality control (QC) sample (commercial infant formula, Mother's organic-3, Namyang, Korea) using two levels of precision: repeatability and reproducibility. Repeatability precision was determined by repeating analysis of cholesterol in QC sample five times on the same day. Reproducibility precision was determined by analyzing QC sample once a day in duplicates for 5 days. Accuracy was evaluated in two ways. First, recovery of cholesterol from QC sample was determined by spiking with known amount of cholesterol standard. Recovery was calculated by the following equation:

$$R(\%) = \{(C_{\text{spiked sample}} - C_{\text{unspiked sample}})/C_{\text{added}} \times 100\}$$

where $C_{\text{spiked sample}}$ the cholesterol content in spiked sample; $C_{\text{unspiked sample}}$ the cholesterol content in unspiked sample; C_{added} the amount of cholesterol spiked to the sample.

Secondly, accuracy of analysis was determined by analyzing cholesterol from SRM1544 (frozen diet composite) and SRM 1849 (infant formula). Analytical cholesterol contents in SRM samples were compared with the certified cholesterol values provided by NIST and the closeness of the analytical to true values was calculated. A linearity test of cholesterol standard curves was completed over the range of 3.9–500.0 $\mu\text{g}/\text{mL}$. LOD and LOQ were calculated based on the detector signal-to-noise (S/N) ratio (NAS 1996). To obtain the LOD, the standard detection of S/N ratio was multiplied by 3 as a factor and then added to

the average of the *S/N* ratio. LOQ was calculated by multiplying the standard deviation (SD) of the response by 10 and then added to the average of the *S/N* ratio.

Quality control (QC)

QC sample (commercial infant formula), purchased from a retail store (Seoul, Korea), was transferred in airtight poly-pack and stored at -20°C until analysis. The QC sample was assayed at 1 week intervals in duplicates to check the effect of minor change in the analytical parameters on the quantitative results during the entire study (about 4 years). QC chart was monitored using upper and lower control lines (UCL and LCL, respectively).

Statistical analysis

The analytical measurements were done in triplicates and results were presented as average of three analyses $\pm$ standard deviation (SD). Statistical analysis was done using the SPSS statistical package (IBM Corp., Released 2013, IBM SPSS Statistics for Windows, Version 22.0, Armonk, NY, USA) with one way ANOVA as a test for statistical significance and Tukey's multiple range tests for individual pair difference. A *p* value of <0.05 was taken as statistically significant.

Results and discussion

Method validation of cholesterol analysis

Results of accuracy and precision evaluation of the analytical method employed were presented in Table 1.

Analytical cholesterol values of SRM 1544 and SRM 1849 were 14.7 ± 0.05 and 12.4 ± 0.6 mg/100 g, respectively, which were within the range of the certified values for cholesterol content provided by NIST. With regard to repeatability and reproducibility precision, obtained values were 2.4 and 5.2%, respectively. These values indicate excellent precision, falling within the acceptable values for repeatability ($\leq 4\%$) and reproducibility ($\leq 8\%$) based on AOAC guidelines (2002). Recoveries of cholesterol from the spiked samples were about 95% (Table 2), which is within the 85–110% acceptable recovery percentage for 0.01% analyte concentration (AOAC 2002). Furthermore, the peak areas and the amount of injected cholesterol exhibited excellent linear relationship of ($r^2 = 0.998$; graph not shown). LOD and LOQ were also determined for the analytical method employed. LOD indicates the minimum amount or concentration of analyte (cholesterol) that can be consistently distinguished from zero, while LOQ is the minimum concentration of analyte (cholesterol) in the test sample that can be quantified with acceptable accuracy and precision (USFDA 2015). The LOD and LOQ of the saponification coupled with GC method employed for cholesterol analysis were 0.05 and 0.15 mg/100 g, respectively.

Cholesterol analysis for Korean restaurant foods was conducted from 2009 to 2012. In order to control quality of cholesterol analysis, QC chart (Fig. 1) was plotted by analyzing in-house QC sample with every sample analysis for the entire study period. The mean concentration of the QC sample ($n = 45$) was about 37.3 mg/100 g, with a low RSDr (relative standard deviation; 3.15%). All assays were monitored so as to fall within the range of UCL and LCL set by mean $\pm$ 2SD. Presence of outliers would result to a stricter monitoring of the protocols to produce reliable results.

Table 1 Accuracy and precision of cholesterol analysis for standard reference materials (SRMs) and commercial infant formula

Variables	Accuracy		Precision ^f	
	SRM 1544 ^a	SRM 1849 ^a	Repeatability Commercial infant formula	Reproducibility
Certified cholesterol value ^b (mg/100 g)	14.8 ± 0.09	12.7 ± 1.5	–	–
Analytical cholesterol value ^c (mg/100 g)	14.7 ± 0.05	12.4 ± 0.6	37.2 ± 0.9	36.1 ± 1.9
Recovery ^d (%)	99.3	97.6	–	–
CV ^e (%)	–	–	2.4	5.2

^a SRM 1544: diet composite; SRM 1849: infant formula

^b The certified value supplied by NIST (Mean $\pm$ SD)

^c The measured value by saponification coupled with GC-FID (Mean $\pm$ SD)

^d Recovery (%) = (analytical value/certified value) $\times$ 100

^e Coefficient of variation (%) = (SD/mean) $\times$ 100; Acceptable CV: Repeatability = $<4\%$, Reproducibility = $<8\%$ (AOAC 2002)

^f Repeatability was determined by repeating analysis of cholesterol in QC sample five times on the same day; reproducibility was determined by analyzing QC sample once a day in duplicates for 5 days

Table 2 Recovery of cholesterol in infant formula by saponification coupled with GC analysis

Amount of spiked cholesterol ^a (% , mg/100 g)	Analytical cholesterol value ^b (mg/100 g)	Recovery ^c (%)	Acceptable recovery ^d (%)
0% (unspiked)	36.1 ± 1.9	–	–
50% (18 mg/100 g)	60.2 ± 1.8	95.9 ± 2.1	85–110
100% (36 mg/100 g)	82.9 ± 2.4	94.7 ± 2.7	85–110

^a The amount of spiked cholesterol to infant formula sample. Percent value indicates the amount of the spiked cholesterol equivalent to the cholesterol content of infant formula

^b The cholesterol content of the spiked infant formula measured by saponification-GC assay

^c Recovery obtained by assay

^d Acceptable recovery guided by AOAC (2002)

Fig. 1 A quality control chart of cholesterol analysis. Upper action line (UAL) = mean + 3 × standard deviation (SD); Lower action line (LAL) = mean - 3SD; Upper control line (UCL) = mean + 2SD;

Lower control line (LCL) = mean - 2SD. Quality control sample: infant formula

Representative GC chromatograms of standards and quality control sample are given in Online Resource 1.

Cholesterol content in soup and stew

In Western or Chinese traditions, soup is usually served at either the beginning or end of the main course, but in Korean cuisine, soup is served as part of the main meal. Korean soup and stew mainly consist of *Guk*, *Tang*, and *Jjigae*. *Guk* and *Tang* refer to watery soup (ingredient: water = ~3:7, w/v) while *Jjigae* is a thicker stew (ingredient: water = ~6:4, w/v). These dishes are often prepared with vegetables, mushroom, meat, bones and cartilage, seafood, and soybean curd (tofu), from which their names are usually derived, and are often flavored with salt, soy sauce, *Doenjang* (thick soybean paste), or *Gochujang* (fermented soybean paste and mixed with red chili powder). Many varieties of these soup and stew have also been developed depending on the region. The types of stew and soup also vary with the seasons and available ingredients.

In this study, the representative Korean *Tang* (n = 16), *Guk* (n = 8), and *Jjigae* (n = 6) were analyzed for cholesterol and summarized in Table 3. Mean cholesterol contents of *Tang*, *Guk*, and *Jjigae* varied by 16.3–143.0, 4.1–36.2, and 1.1–19.1 mg/100 g, respectively. *Al-Tang* had the highest cholesterol content (143.0 mg/100 g) among the 30 kinds of soup and stew analyzed. Although it is a type of *Tang*, which is watery, its cholesterol content is much higher than any other type of *Guk* and *Jjigae*, which has less water. Its main ingredient is roe or fish eggs, usually obtained from Pollock fish. Other ingredients include radish and chili sauce. Raw fish egg is estimated to have 374 mg cholesterol per 100 g (USDA SR28 2015), while radish and chili sauce contain no cholesterol (USDA SR28 2015), making roe the only source of cholesterol in *Al-tang*. In terms of *Guk*, *Seonji-guk* had the highest cholesterol content (36.2 mg/100 g) with blood curd as its main ingredient; as for *Jjigae*, the highest was from *Sundubu-Jjigae* (19.1 mg/100 g), with Pollock fish as its chief ingredient. Among the 30 types of soup and stew analyzed,

Table 3 Cholesterol contents of soup and stew consumed in Korea (*Tang*, *Guk*, and *Jjigae*) (mg/100 g edible weight)

Samples ¹	Regions ²						Total mean ³	Cholesterol content/serving ⁴
	R1 (Gangwon)	R2 (Gyeonggi)	R3 (Gyeongsang)	R4 (Seoul)	R5 (Jeolla)	R6 (Chungcheong)		
<i>Tang</i>								
<i>Al-Tang</i> (Spicy fish roe soup)	132.23 ± 24.5 ^b	137.08 ± 3.2 ^{ab}	131.9 ± 12.2 ^b	136.4 ± 20.9 ^{ab}	152.8 ± 6.7 ^{ab}	175.0 ± 17.7 ^a	143.0	286.0
<i>Yeompo-Tang</i> (Octopus soup)	138.1 ± 4.9 ^a	137.5 ± 14.6 ^a	101.8 ± 16.6 ^{bc}	77.3 ± 5.2 ^{cd}	107.0 ± 5.5 ^b	72.7 ± 7.0 ^d	105.7	211.4
<i>Daegumaewoon-Tang</i> (Spicy codfish soup)	87.0 ± 4.1 ^{ab}	99.7 ± 22.5 ^a	59.2 ± 12.8 ^b	106.6 ± 13.2 ^a	86.1 ± 7.5 ^{ab}	87.0 ± 6.5 ^{ab}	87.7	175.4
<i>Naejang-Tang</i> (Beef tripe and intestine soup)	81.5 ± 4.0 ^a	67.1 ± 13.8 ^{ab}	83.7 ± 5.5 ^a	60.3 ± 12.3 ^{ab}	54.4 ± 0.8 ^b	49.1 ± 5.2 ^b	64.6	129.2
<i>Gwangeo-Maewoon-Tang</i> (Spicy flatfish soup)	53.9 ± 4.2 ^b	54.3 ± 5.3 ^b	59.0 ± 7.7 ^{ab}	74.6 ± 5.1 ^a	73.5 ± 6.8 ^a	71.3 ± 8.9 ^{ab}	64.4	128.8
<i>Wooluk-Maewoon-Tang</i> (Spicy black rockfish soup)	61.0 ± 10.5 ^{abc}	37.1 ± 2.3 ^c	73.3 ± 10.0 ^a	85.1 ± 18.1 ^a	38.3 ± 4.2 ^{bc}	68.0 ± 12.2 ^{ab}	60.5	121.0
<i>Dakbokkeum-Tang</i> (Pan-fried chicken soup)	53.6 ± 1.2 ^{bc}	48.2 ± 4.9 ^{bc}	61.7 ± 11.8 ^b	43.9 ± 2.2 ^c	84.8 ± 8.7 ^a	55.2 ± 1.4 ^{bc}	57.9	115.8
<i>Ganja-Tang</i> (Potato and pork soup)	56.7 ± 1.8 ^a	49.6 ± 0.9 ^{ab}	57.0 ± 8.4 ^a	63.0 ± 9.6 ^a	61.0 ± 2.3 ^a	40.3 ± 6.0 ^b	54.6	109.2
<i>Sangae-Tang</i> (Chicken soup with ginseng)	54.7 ± 8.4 ^a	52.9 ± 0.2 ^a	47.4 ± 4.5 ^{ab}	34.7 ± 2.8 ^b	54.9 ± 7.3 ^a	46.1 ± 3.9 ^{ab}	48.9	97.8
<i>Ggorigom-Tang</i> (Ox tail soup)	33.1 ± 9.7 ^{ns}	45.2 ± 4.8	35.4 ± 3.3	29.2 ± 7.0	40.5 ± 3.1	43.6 ± 5.8	37.8	75.6
<i>Jangeo-Tang</i> (Eel soup)	44.5 ± 3.4 ^a	27.4 ± 3.5 ^{bc}	35.6 ± 1.7 ^b	34.5 ± 2.4 ^b	50.4 ± 4.6 ^a	21.6 ± 1.5 ^c	35.7	71.4
<i>Gom-Tang</i> (Beef bone soup)	39.2 ± 6.9 ^a	32.3 ± 5.0 ^{ab}	13.7 ± 0.3 ^c	18.5 ± 1.3 ^{bc}	35.0 ± 9.8 ^a	28.2 ± 3.7 ^{abc}	28.4	56.8
<i>Seolleong-Tang</i> (Ox bone soup)	27.6 ± 2.0 ^b	19.0 ± 2.7 ^c	26.7 ± 1.6 ^b	28.3 ± 0.7 ^b	34.8 ± 2.1 ^a	25.9 ± 3.4 ^b	27.1	54.2
<i>Dogan-Tang</i> (Ox knee soup)	24.4 ± 1.1 ^{ab}	28.5 ± 3.5 ^{ab}	15.3 ± 1.2 ^c	25.7 ± 3.0 ^{ab}	23.4 ± 1.5 ^b	29.5 ± 1.4 ^a	24.4	48.8
<i>Galbi-Tang</i> (Short rib soup)	35.4 ± 1.2 ^a	17.0 ± 2.5 ^{ab}	22.3 ± 11.7 ^{ab}	17.5 ± 7.3 ^{ab}	8.6 ± 1.2 ^b	13.4 ± 4.3 ^b	18.6	37.2
<i>Chueo-Tang</i> (Loach in hot bean paste soup)	17.4 ± 4.9 ^{ns}	14.6 ± 2.8	16.4 ± 3.8	14.8 ± 3.2	17.0 ± 2.8	17.0 ± 0.4	16.3	32.6
<i>Guk</i>								
<i>Seonji-Guk</i> (Ox blood soup)	36.8 ± 2.5 ^b	35.2 ± 7.3 ^b	50.6 ± 2.7 ^a	32.9 ± 1.2 ^b	34.3 ± 7.3 ^b	26.2 ± 2.8 ^b	36.2	72.4
<i>Sundae-Guk</i> (Korean sausage soup)	40.2 ± 8.2 ^{ns}	41.4 ± 10.6	18.7 ± 4.9	22.9 ± 2.8	32.1 ± 15.7	32.0 ± 10.6	31.8	63.6
<i>Sogogiyukgaejang</i> (Spicy beef and vegetable soup)	22.3 ± 6.5 ^{ab}	23.8 ± 8.2 ^{ab}	9.8 ± 5.7 ^b	11.5 ± 6.2 ^{ab}	21.9 ± 0.5 ^{ab}	27.7 ± 3.6 ^a	19.7	39.4
<i>Tteokmandu-Guk</i> (Rice cake and dumpling soup)	25.0 ± 8.4 ^{ns}	16.5 ± 2.1	13.5 ± 2.1	25.6 ± 4.2	18.6 ± 1.4	19.1 ± 4.7	19.7	39.4
<i>Tteok-Guk</i> (Rice cake soup)	18.2 ± 4.4 ^{ab}	12.8 ± 1.4 ^b	20.6 ± 5.3 ^{ab}	16.3 ± 2.2 ^{ab}	26.7 ± 6.4 ^a	15.6 ± 3.8 ^{ab}	18.4	36.8
<i>Kongnamoolhaejang-Guk</i> (Soybean sprouts soup)	18.2 ± 2.6 ^{abc}	14.3 ± 1.7 ^{bc}	22.2 ± 3.7 ^{ab}	23.5 ± 4.7 ^a	13.7 ± 0.3 ^c	18.2 ± 1.3 ^{abc}	18.3	36.6
<i>Mandu-Guk</i> (Dumpling soup)	21.8 ± 2.0 ^a	14.1 ± 4.4 ^{ab}	11.1 ± 0.9 ^b	10.7 ± 0.9 ^b	8.8 ± 2.0 ^b	14.5 ± 5.2 ^{ab}	13.6	27.2
<i>Eomuk-Guk</i> (Fish cake soup)	2.5 ± 3.5 ^{ns}	3.8 ± 3.3	5.9 ± 1.0	5.0 ± 3.3	5.0 ± 5.3	2.6 ± 4.5	4.1	8.2
<i>Jjigae</i>								
<i>Sundubu-Jjigae</i> (Tofu stew)	8.9 ± 0.5 ^b	27.4 ± 1.6 ^a	14.0 ± 5.0 ^{ab}	24.5 ± 8.3 ^a	15.5 ± 5.5 ^{ab}	22.1 ± 0.6 ^{ab}	19.1	38.2
<i>Budae-Jjigae</i> (Spicy sausage stew)	17.9 ± 1.7 ^a	13.1 ± 0.4 ^b	11.7 ± 1.5 ^b	13.0 ± 1.3 ^b	12.5 ± 2.2 ^b	14.5 ± 1.6 ^{ab}	13.8	27.6
<i>Dodejigogimchi-Jjigae</i> (Pork and Kimchi stew)	5.0 ± 0.4 ^{ns}	7.8 ± 3.5	5.6 ± 3.0	7.7 ± 1.0	7.7 ± 1.8	4.0 ± 1.8	6.3	12.6

Table 3 continued

Samples ¹	Regions ²						Total mean ³	Cholesterol content/serving ⁴
	R1 (Gangwon)	R2 (Gyeonggi)	R3 (Gyeongsang)	R4 (Seoul)	R5 (Jeolla)	R6 (Chungcheong)		
<i>Kongbiji-Jjigae</i> (Pureed soybean stew)	4.8 ± 0.3 ^b	4.2 ± 0.5 ^b	4.5 ± 0.4 ^b	5.3 ± 0.1 ^b	12.1 ± 2.4 ^a	5.3 ± 0.9 ^b	6.2	12.4
<i>Doenjang-Jjigae</i> (Soybean paste (<i>Doenjang</i>) stew with vegetables)	1.2 ± 1.5 ^{ns}	2.8 ± 2.4	3.9 ± 3.2	5.1 ± 3.7	4.0 ± 4.9	0.3 ± 0.5	2.9	5.8
<i>Cheonggukjang-Jjigae</i> (Rich soybean paste (<i>Cheonggukjang</i>) stew with vegetables)	ND ^{ns}	1.9 ± 1.8	2.0 ± 1.0	0.3 ± 0.4	0.4 ± 0.4	1.2 ± 0.7	1.1	2.2

¹ Sample names were expressed as the notation of Korean Roman and the English descriptions in brackets

² Cholesterol content (Mean ± SD) of composite samples obtained from 12 restaurants for each region. Values with same superscripts within a row are not significantly different from each other ($p < 0.05$); $a > b > c > d$; ns not significant

³ Mean of the 6 respective mean cholesterol content from the six regions

⁴ Computed based on total mean; minimum amount of one serving is approximately 200 g

the lowest in cholesterol content was *Cheonggukjang-Jjigae* (1.1 mg/100 g) which does not contain any meat or fish. Since these soup and stew generally contain only water, vegetables, and fish and animal products, the source of cholesterol content in Korean soup and stew is its main ingredient: meat, meat products, and seafood.

The cholesterol contents of the analyzed food dishes were comparable with the published data on soups and stews. For example, beef stew with vegetables has cholesterol content of 15.0 mg/100 g, chicken back meat stew has 85.0 mg/100 g, beef and vegetable soup 5.0 mg/100 g, wonton soup 4.0 mg/100 g (Canadian Nutrient File 2015), tripe soup 59.0 mg/100 g, egg drop soup 23.0 mg/100 g (USDA SR28 2015), beef and vegetable soup 12.0 mg/100 g, chicken and vegetable soup 14.0 mg/100 g, *tom yum* soup 26.0 mg/100 g, offal soup 37.0 mg/100 g, *miso*, *tofu*, and seaweed soup 1.0 mg/100 g, mussel, oyster, or scallop soup 18.0 mg/100 g, and shark's fin soup 28.0 mg/100 g (Australian Food, Supplement and Nutrient Database 2011–2013).

The minimum serving size of Korean restaurant foods is about 200 g. In this study, data are presented as mg cholesterol per 100 g edible weight, thus cholesterol content based on the actual serving size could be much higher. For instance, one serving of *Al-Tang* can have a cholesterol content of 286.0 mg/100 g. This shows that one serving of this soup almost contain the recommended limit of 300 mg/day cholesterol intake. With this in consideration, it can be recommended to control the intake of high-cholesterol soup or stew to at most once a day.

Cholesterol content in rice dishes

In traditional Korean meal, steamed rice, *Bap*, is served along with different kinds of soup or stew, pan-fried dishes, and side dishes such as *Kimchi* (fermented Korean cabbage), salted anchovies, or seasoned bean sprouts, to name a few. In this manner, a person can choose what type of dish and side dishes he or she can eat with rice to have a complete intake of nutrients for the day. Nowadays, due to the demand for convenience in Korea, restaurants employed a new style of serving a full meal. Rice dishes are prepared simpler but contain a complete set of rice, main dish, and side dish. One serving of a rice dish is made up of steamed or pan-fried rice mixed or topped with meat or fish and vegetables in thick sauce or soup together with side dish.

In the present study, a total of 24 kinds of rice dishes widely consumed in Korean restaurants were analyzed for cholesterol content and summarized in Table 4. These dishes contain about 40–60% steamed or pan-fried rice (*Bokkeumbap*). Mean cholesterol content ranged from 1.5 to 85.1 mg/100 g, depending on the type and amount of

Table 4 Cholesterol contents of rice dishes consumed in Korea (mg/100 g edible weight)

Samples ¹	Regions ²						Total mean ³	Cholesterol content/ serving ⁴
	R1 (Gangwon)	R2 (Gyeonggi)	R3 (Gyeongsang)	R4 (Seoul)	R5 (Jeolla)	R6 (Chungcheong)		
<i>Samseon-Bokkeumbap</i> (Pan-fried rice with seafood)	86.8 ± 9.1 ^{ns}	78.6 ± 1.6	90.4 ± 13.9	80.0 ± 10.1	88.6 ± 5.3	89.1 ± 1.7	85.1	170.2
<i>Huamul-Bokkeumbap</i> (Pan-fried rice with seafood and vegetables)	66.6 ± 3.5 ^b	87.2 ± 3.6 ^a	47.5 ± 7.6 ^c	63.4 ± 4.6 ^b	34.2 ± 5.0 ^c	63.8 ± 6.6 ^b	60.5	121.0
<i>Jangoh-Deophap</i> (Rice topped with eel)	77.3 ± 4.4 ^a	58.0 ± 5.9 ^{bc}	40.2 ± 2.5 ^c	71.2 ± 10.6 ^{ab}	42.2 ± 9.9 ^c	62.9 ± 3.2 ^{ab}	58.6	117.2
<i>Ojingo-Deophap</i> (Rice topped with squid and vegetables)	36.6 ± 4.5 ^b	68.5 ± 12.3 ^{ab}	80.1 ± 13.8 ^a	49.6 ± 8.8 ^{ab}	54.4 ± 13.8 ^{ab}	58.6 ± 14.2 ^{ab}	58.5	117.0
<i>Omeurice</i> (Fried rice wrapped in thin omelet)	41.6 ± 13.9 ^{ns}	55.0 ± 18.1	39.8 ± 9.4	63.2 ± 23.5	42.3 ± 8.4	33.3 ± 16.4	48.3	96.6
<i>Jabang-Deophap</i> (Rice topped with seafood and vegetables)	42.0 ± 7.1 ^{ns}	38.1 ± 2.2	36.3 ± 3.5	51.4 ± 7.0	52.6 ± 10.5	37.4 ± 9.7	43.5	87.0
<i>Haemul-Deophap</i> (Rice topped with seafood)	30.3 ± 3.2 ^b	52.5 ± 8.6 ^a	34.0 ± 4.4 ^b	56.6 ± 8.2 ^a	42.3 ± 2.6 ^{ab}	29.6 ± 3.1 ^b	42.3	84.6
<i>Bokkeumbap</i> (Pan-fried rice with meat and vegetables)	40.2 ± 5.6 ^{ns}	46.9 ± 14.4	34.6 ± 6.5	38.9 ± 10.4	43.0 ± 10.9	45.4 ± 4.0	41.9	83.8
<i>Saew-Bokkeumbap</i> (Pan-fried rice with shrimp)	40.6 ± 6.2 ^{ns}	33.6 ± 6.6	54.7 ± 2.7	36.7 ± 9.4	44.7 ± 10.9	31.4 ± 15.1	39.9	79.8
<i>Somoriguk-Bab</i> (Rice in cow head soup)	34.5 ± 4.5 ^{ab}	43.8 ± 9.5 ^a	36.4 ± 4.8 ^{ab}	21.2 ± 2.2 ^b	28.9 ± 5.8 ^{ab}	22.8 ± 1.6 ^b	32.7	65.4
<i>Kinchi-Bokkeumbap</i> (Pan-fried rice with <i>Kimchi</i>)	34.5 ± 12.7 ^{ns}	34.5 ± 11.1	24.3 ± 4.2	41.8 ± 5.6	30.6 ± 3.4	23.6 ± 5.1	31.5	63.0
<i>Jjumppong-Bab</i> (Chinese spicy soup with rice, vegetable, seafood)	14.9 ± 1.9 ^c	28.2 ± 3.1 ^{ab}	26.9 ± 5.8 ^{ab}	32.3 ± 4.0 ^{ab}	36.9 ± 3.0 ^a	23.9 ± 1.5 ^{bc}	26.6	53.2
<i>Yukhoe-Bibimbap</i> (Rice with raw beef and vegetables)	14.9 ± 3.4 ^c	26.4 ± 0.8 ^b	22.7 ± 3.0 ^b	25.9 ± 0.7 ^b	44.0 ± 1.3 ^a	24.7 ± 1.4 ^b	26.5	53.0
<i>Bibimbap</i> (Rice mixed with beef and vegetables)	17.4 ± 1.6 ^{ns}	25.4 ± 5.7	26.0 ± 0.3	28.6 ± 8.7	22.4 ± 2.9	19.0 ± 4.2	23.6	47.2
<i>Usanseul-Bab</i> (<i>Usanseul</i> rice)	25.9 ± 1.5 ^{ab}	22.2 ± 3.5 ^{bc}	30.2 ± 2.9 ^a	15.6 ± 2.2 ^b	18.8 ± 3.4 ^{bc}	22.3 ± 1.0 ^{bc}	22.9	45.8
<i>Chamchi-Deophap</i> (Rice topped with tuna)	21.0 ± 4.6 ^b	21.9 ± 2.9 ^{ab}	17.9 ± 0.3 ^b	32.0 ± 4.8 ^a	22.2 ± 1.9 ^{ab}	19.6 ± 0.7 ^b	22.7	45.4
<i>Al-Bab</i> (Rice topped with fish eggs)	20.1 ± 3.1 ^{ns}	20.4 ± 4.3	21.7 ± 2.3	20.9 ± 5.9	20.6 ± 5.5	23.9 ± 0.1	21.2	42.4
<i>Jae yuk-Deophap</i> (Rice topped with pork)	30.2 ± 5.2 ^a	12.5 ± 2.1 ^b	12.3 ± 0.5 ^b	20.6 ± 5.3 ^{ab}	16.5 ± 3.5 ^b	10.7 ± 0.9 ^b	17.4	34.8
<i>Hoe-Deophap</i> (Rice topped with seafood and shellfish)	18.4 ± 2.9 ^{abc}	20.0 ± 3.2 ^{ab}	22.1 ± 0.3 ^a	18.2 ± 4.3 ^{abc}	14.2 ± 2.5 ^{bc}	11.3 ± 0.8 ^c	17.3	34.6
<i>Bulgogi-Deophap</i> (Rice topped with beef)	13.7 ± 1.5 ^b	11.6 ± 1.5 ^{bc}	12.1 ± 1.1 ^{bc}	19.2 ± 1.9 ^a	9.5 ± 0.8 ^c	13.6 ± 1.6 ^b	13.3	26.6
<i>Songgi-Deophap</i> (Rice topped with button mushroom)	1.5 ± 0.3 ^c	8.6 ± 0.9 ^{bc}	10.6 ± 0.5 ^b	6.5 ± 1.9 ^{cd}	5.1 ± 0.3 ^d	13.4 ± 0.2 ^a	8.3	16.6
<i>Jijang-Bab</i> (Rice topped with black soybean paste sauce)	3.6 ± 0.2 ^{ns}	3.7 ± 1.0	3.2 ± 1.0	7.2 ± 4.7	3.6 ± 1.2	2.8 ± 1.2	4.4	8.8
<i>Jabchae-Bab</i> (Rice topped with glass noodles, beef, and vegetables)	2.9 ± 0.4 ^{ns}	5.8 ± 1.3	2.0 ± 2.8	2.4 ± 1.4	3.2 ± 0.1	4.3 ± 0.3	3.3	6.6
<i>Kare-rice</i> (Curry rice)	2.0 ± 1.4 ^{ns}	2.1 ± 1.3	1.2 ± 0.1	0.9 ± 1.3	0.5 ± 0.5	2.1 ± 0.3	1.5	3.0

¹ Sample names were expressed as the notation of Korean Roman and the English descriptions in brackets² Cholesterol content (Mean ± SD) of composite samples obtained from 12 restaurants for each region. Values with same superscripts within a row are not significantly different from each other ($p < 0.05$); a > b > c > d; ns not significant³ Mean of the 6 respective mean cholesterol content from the six regions⁴ Computed based on total mean; minimum amount of one serving is approximately 200 g

Table 5 Cholesterol contents of noodles consumed in Korea (mg/100 g edible weight)

Samples ¹	Regions ²						Total mean ³	Cholesterol content/ serving ⁴
	R1 (Gangwon)	R2 (Gyeonggi)	R3 (Gyeongsang)	R4 (Seoul)	R5 (Jeolla)	R6 (Chungcheong)		
<i>Samseon-Udon</i> (Thick white noodle soup with seafood)	44.7 ± 4.0 ^b	90.6 ± 8.7 ^a	60.4 ± 9.6 ^b	87.0 ± 10.6 ^a	40.6 ± 10.7 ^b	49.3 ± 7.6 ^b	62.2	124.4
<i>Ul-Myeon</i> (Noodle with seafood and vegetables in thick broth)	34.6 ± 2.3 ^b	58.3 ± 9.2 ^a	42.9 ± 7.4 ^{ab}	52.1 ± 9.1 ^{ab}	35.2 ± 14.0 ^{ab}	44.4 ± 5.8 ^{ab}	44.8	89.6
<i>Cream-haemeul</i> spaghetti (Seafood spaghetti with cream sauce)	41.6 ± 2.1 ^{ab}	42.3 ± 0.1 ^{ab}	36.0 ± 4.3 ^b	49.1 ± 4.3 ^a	45.6 ± 2.4 ^a	45.2 ± 0.9 ^a	43.4	86.8
<i>Giseul-Myeon</i> (Noodle in chicken broth)	41.5 ± 1.8 ^b	37.8 ± 5.1 ^b	44.3 ± 8.1 ^{ab}	58.8 ± 1.9 ^a	32.6 ± 2.4 ^b	45.2 ± 6.6 ^{ab}	42.5	85.0
<i>Samseon-Jjiamppong</i> (Chinese-style noodle with seafood and vegetables)	28.7 ± 2.9 ^b	47.4 ± 3.6 ^a	30.7 ± 6.5 ^b	38.0 ± 5.5 ^{ab}	32.5 ± 7.3 ^b	30.9 ± 5.2 ^b	34.5	69.0
Tomato- <i>haemeul</i> spaghetti (Seafood spaghetti with tomato sauce)	32.8 ± 1.6 ^{ab}	43.4 ± 5.8 ^a	28.3 ± 7.6 ^b	31.6 ± 1.9 ^{ab}	32.7 ± 5.2 ^{ab}	31.5 ± 2.8 ^{ab}	33.4	66.8
Cream sauce spaghetti (Spaghetti with cream sauce)	29.2 ± 8.6 ^{ab}	31.9 ± 1.9 ^{ab}	31.9 ± 5.3 ^{ab}	40.9 ± 2.3 ^a	25.8 ± 3.5 ^b	30.1 ± 1.5 ^{ab}	31.5	63.0
<i>Samseon-Jajang</i> (Noodle with vegetable, seafood in stir-fried black bean sauce)	16.4 ± 7.7 ^c	39.0 ± 7.4 ^a	32.5 ± 3.9 ^{ab}	17.8 ± 6.4 ^{bc}	24.5 ± 4.0 ^{abc}	12.5 ± 0.7 ^c	23.8	47.6
<i>Udon</i> (Chinese style thick white noodle soup)	20.4 ± 3.0 ^{ns}	20.4 ± 0.7	19.2 ± 2.4	22.3 ± 9.3	18.8 ± 5.3	24.0 ± 9.9	21.2	42.4
<i>Gul-Jjiamppong</i> (Spicy noodle soup with oyster and vegetables)	11.8 ± 0.9 ^b	17.1 ± 3.3 ^{ab}	22.1 ± 4.3 ^a	18.0 ± 2.0 ^{ab}	16.6 ± 2.3 ^{ab}	23.3 ± 2.8 ^a	18.1	36.2
<i>Hoe-Naengmyeon</i> (Cold buckwheat noodle with raw beef or raw fish)	9.1 ± 6.2 ^{ns}	20.3 ± 1.2	16.9 ± 1.9	14.8 ± 11.5	15.4 ± 8.4	22.3 ± 4.4	15.8	31.6
<i>Jjol-Myeon</i> (Spicy cold chewy noodle)	9.2 ± 5.6 ^{ns}	12.5 ± 4.3	8.8 ± 1.9	15.0 ± 8.3	10.9 ± 1.8	13.0 ± 3.0	11.7	23.4
Tomato sauce spaghetti (Spaghetti with tomato sauce)	9.8 ± 4.6 ^{ns}	10.8 ± 5.3	12.9 ± 6.5	13.9 ± 5.7	7.2 ± 6.7	13.3 ± 5.6	11.3	22.6
<i>Jjiamppong</i> (Spicy noodle soup with seafood and vegetable)	7.7 ± 1.4 ^{ns}	10.0 ± 5.3	13.8 ± 4.0	5.0 ± 4.1	11.9 ± 4.5	17.1 ± 6.9	10.5	21.0
<i>Janchi-Guksu</i> (Plain white noodle with vegetable in anchovy stock)	8.0 ± 1.4 ^{bc}	11.8 ± 2.1 ^{ab}	6.8 ± 0.5 ^b	6.5 ± 0.4 ^b	15.3 ± 2.7 ^a	3.4 ± 1.0 ^b	9.3	18.6
<i>Mak-Guksu</i> (Noodle with beef or vegetable in broth)	9.9 ± 5.1 ^{ns}	13.6 ± 12.2	11.0 ± 2.2	6.4 ± 3.7	4.8 ± 2.8	5.4 ± 6.7	8.9	17.8
Oil sauce spaghetti (Spaghetti seasoned with olive oil)	6.9 ± 4.2 ^{ns}	5.9 ± 3.7	8.8 ± 3.3	10.1 ± 0.5	3.5 ± 2.1	12.3 ± 1.6	7.7	15.4
<i>Yeolmu-Naengmyeon</i> (Cold buckwheat noodle with young radish <i>Kimchi</i>)	12.6 ± 3.6 ^a	12.3 ± 0.2 ^a	4.9 ± 1.0 ^{ab}	6.0 ± 4.5 ^{ab}	2.3 ± 1.2 ^b	ND	6.6	13.2
<i>Mul-Naengmyeon</i> (Cold buckwheat noodle soup with beef and egg)	5.4 ± 4.0 ^{ab}	11.8 ± 0.4 ^a	8.6 ± 3.3 ^{ab}	3.6 ± 2.7 ^{ab}	2.3 ± 2.9 ^{ab}	ND	5.5	11.0
<i>Bibim-Guksu</i> (Noodle mixed with vegetables and spicy red pepper sauce)	4.9 ± 1.8 ^{ab}	3.0 ± 0.6 ^{ab}	2.4 ± 0.7 ^b	6.7 ± 1.3 ^a	5.5 ± 1.4 ^{ab}	6.1 ± 1.4 ^{ab}	4.8	9.6
<i>Gan-Jajang</i> (Noodle with pork, vegetable and black soybean sauce)	3.5 ± 1.0 ^{ns}	5.6 ± 1.4	5.1 ± 0.7	5.0 ± 0.8	2.7 ± 1.1	4.7 ± 3.5	4.2	8.4
<i>Kong-Guksu</i> (Cold bean-soup noodle)	6.1 ± 0.8 ^{ns}	6.0 ± 5.0	2.4 ± 2.0	4.5 ± 3.4	1.7 ± 1.2	2.7 ± 3.9	3.9	7.8
Japanese- <i>Udon</i> (<i>Udon</i> noodle with tofu and fish cake)	8.6 ± 3.6 ^a	1.9 ± 1.6 ^{bc}	0.1 ± 0.2 ^c	8.0 ± 2.2 ^{ab}	2.0 ± 1.8 ^{abc}	1.6 ± 2.1 ^{bc}	3.8	7.6
<i>Haemulhal-Guksu</i> (Noodle soup with seafood and vegetable)	3.9 ± 3.3 ^{ns}	3.4 ± 1.9	2.1 ± 1.5	3.5 ± 2.9	1.9 ± 2.7	1.1 ± 1.9	2.5	5.0

Table 5 continued

Samples ¹	Regions ²						Total mean ³	Cholesterol content/ serving ⁴
	R1 (Gangwon)	R2 (Gyeonggi)	R3 (Gyeongsang)	R4 (Seoul)	R5 (Jeolla)	R6 (Chungcheong)		
<i>Jajang-Myeon</i> (Noodle with vegetable, pork, and stir-fried bean paste)	1.4 ± 0.3 ^{ns}	1.1 ± 1.5	0.6 ± 0.9	3.1 ± 0.5	1.2 ± 0.2	2.6 ± 1.5	1.7	3.4
<i>Kimchi-Udon</i> (<i>Udon</i> noodle with <i>Kimchi</i>)	1.6 ± 1.7 ^{ns}	0.8 ± 0.7	0.8 ± 0.8	1.4 ± 1.2	1.5 ± 1.9	0.9 ± 0.8	1.2	2.4
<i>Maemil-Guksu</i> (Buckwheat noodle with egg in beef stock)	ND ^a	0.2 ± 0.3 ^a	ND ^a	ND ^a	2.3 ± 2.1 ^a	ND ^a	0.4	0.8

¹ Sample names were expressed as the notation of Korean Roman and the English descriptions in brackets

² Cholesterol content (Mean ± SD) of composite samples obtained from 12 restaurants for each region. Values with same superscripts within a row are not significantly different from each other ($p < 0.05$); a > b>c; ns not significant

³ Mean of the 6 respective mean cholesterol content from the six regions

⁴ Computed based on total mean; minimum amount of one serving is approximately 200 g

ingredients used in the recipe. Among the 24 rice dishes analyzed, *Samseon-Bokkeumbap* was found to have the highest cholesterol content (81.6 mg/100 g). This dish contained rice and mixed portions of cuttlefish, sea cucumber, oyster, and clam. Cholesterol contents are about 224.0, 79.0, and 67.0 mg/100 g of cuttlefish, oyster, and clam, respectively; while rice and sea cucumber contain no cholesterol (USDA SR28 2015). Next to *Samseon-Bokkeumbap* is *Haemul-Bokkeumbap* (60.5 mg/100 g). Similar to *Samseon-Bokkeumbap*, this dish contained rice and mixed portions of seafood such as shrimp and sea cucumber with egg and vegetables. Although the cholesterol of these two abovementioned rice dishes can come from more than one source, rice comprised half of the dish, thus, its cholesterol content was lower compared to soup and stew. On the other hand, the lowest in cholesterol content was the curry rice (1.5 mg/100 g), which contained only rice, potato, onion, curry powder, and traces of chicken meat. Rice dishes containing seafood had high cholesterol content while the ones containing vegetables had much lower cholesterol content.

The cholesterol contents of the rice dishes in the present study are similar to rice dishes from published databases or studies, such as chicken fried rice, with peas, onion and eggs, which contained 47.0 mg cholesterol/100 g (CNF 2015), Latino chicken and rice 36.0 mg/100 g, chicken fried rice 41.0 mg/100 g (USDA SR28 2015); *paella* with chicken, chorizo, and vegetables 39.0 mg/100 g, *paella* with chicken, chorizo, vegetables, and seafood 74.0 mg/100 g, brown rice with bacon or ham, egg, and mixed vegetables 61.0 mg/100 g, brown rice with chicken, egg, and mixed vegetables 68.0 mg/100 g, chicken and rice curry 34.0 mg/100 g, fish and rice curry 24.0 mg/100 g, lamb and rice curry 30.0 mg/100 g, pork and rice mixed dish 27.0 mg/100 g, roast pork with rice 32.0 mg/100 g, stir-fry beef and vegetable with rice 29.0 mg/100 g, fried rice with beef, lamb, or pork and mixed vegetables 24.0 mg/100 g, risotto with cheese, prawn, and mixed vegetables 30.0 mg/100 g (AUSNUT 2011–2013), Jollof rice (a one-pot rice dish popular in West African countries) 11.8 mg/100 g (Afolabi et al. 2013), fried rice in *Yangzhou*-style with pork and shrimp 75.0 mg/100 g, fried rice with shredded chicken and shrimp 36.0 mg/100 g, fried rice with chicken and dried octopus 86.0 mg/100 g, steamed rice with curry beef brisket 16.0 mg/100 g, steamed rice with *satay* beef 3.7 mg/100 g, baked pork chop with rice 22.0 mg/100 g, steamed minced pork and dried squid with rice 33.0 mg/100 g, and steamed grass carp with rice 21.0 mg/100 g (Food and Environmental Hygiene Department, Hongkong 2006).

Over-all, the cholesterol content of Korean rice dishes was about half of the cholesterol content of soup/stew due to the addition of rice. Considering the recommended

cholesterol intake limit of 300 mg/day, eating about 200 g of *Samseon-Bokkeumbap* for breakfast, for instance, can yield to 170.2 mg cholesterol intake, which is already more than half of the daily intake limit. Therefore, although half of the meal comprises of steamed rice, consumption of Korean rice dishes that are high in cholesterol should also be controlled.

Cholesterol content in noodle dishes

Noodles or noodle dishes in Korean cuisine are collectively referred to as *Guksu*, *Myeon*, or *Udon* and are eaten with meat or seafood and vegetable in hot broth, cold soup, or thick sauce. This dish is usually eaten for lunch as a light and convenient meal.

In this study, cholesterol contents in 27 kinds of noodles frequently consumed in Korea were analyzed and shown in Table 5. Like soup and rice dishes, cholesterol contents of the noodles varied due to the main ingredients used in the recipe and ranged from 0.4 to 62.2 mg/100 g. The noodle with the highest cholesterol content was *Samseon-Udon* (62.2 mg/100 g). This dish contained cuttlefish, oyster, and clam. Similar to *Samseon-Bokkeumbap*, its cholesterol content came from the three aforementioned ingredients. Moreover, this type of noodle is not watery. About 80% of one serving comprises of noodles and seafood. Most noodle dishes with seafood contain about 45.0 mg of cholesterol, particularly *Ulmyeon* (44.8 mg/100 g), cream *Haemeul*-spaghetti (43.4 mg/100 g), and *Giseu-Myeon* (42.5 mg/100 g).

Generally, a 100-g portion of noodle dish contains moderate level of cholesterol. For instance, in a home-made chicken noodle soup, the cholesterol content is 25.0 mg/100 g (CNF 2015), another chicken noodle soup contained 36.0 mg/100 g, beef noodle soup 8.0 mg/100 g, family-style spaghetti and meatballs 19.0 mg/100 g (USDA SR28 2015), carbonara pasta dish with bacon and vegetables 76.0 mg/100 g, dairy-based sauce pasta dish with seafood and vegetables 26.0 mg/100 g, stir-fry noodles with prawn, egg, and vegetables 75.0 mg/100 g, stir-fry beef with noodles 31.0 mg/100 g (AUSNUT 2011–2013), wheat noodles in soup with meat and vegetable dumpling 13.0 mg/100 g, flat noodles in soup with meat dumpling with fish wrap 2.8 mg/100 g, wheat noodles (thick) in soup with stewed beef brisket 15.0 mg/100 g, wheat noodles (thin) in soup with beef tendon 15.0 mg/100 g, wheat noodles (thick) in soup with cattle tripe 22.0 mg/100 g, wheat noodles (thick) in soup with cattle offal 20.0 mg/100 g, wheat noodles (thin) in soup with beef balls 8.4 mg/100 g, fried noodles with assorted meat, seafood and chili sauce 30.0 mg/100 g, and fried *udon* noodle with seafood 14.0 mg/100 g (FEHD 2006).

Compared to rice dishes, noodle dishes analyzed in this study contain wheat noodles more than the amount of rice in a rice dish. Wheat noodles do not contain cholesterol (USDA SR28 2015) and is used in large portions in a recipe, hence, the cholesterol content of these dishes is lower compared to soup/stew and rice dishes. However, some people eat noodles in considerable amounts in a day. For instance, some people can eat around 500 g of *Samseon-Udon* for lunch, it means taking in about 311.0 mg of cholesterol for that particular period alone, thus, consuming more than the 300 mg/day intake limit of cholesterol. Although most noodles contain lower cholesterol than soup and stew and rice dishes, its consumption is relatively significant in the Korean diet. Therefore, the type and amount of noodles to be consumed should also be taken into consideration.

Variations in cholesterol content

Differences in cholesterol content were observed among restaurant food samples with regard to its origin, i.e. the region from where it was prepared and consumed. Significant differences by regions were found in majority of the samples. The Korean peninsula is surrounded by sea water. Especially, the regions R1 and R3 are at the coast facing the East Sea; R2 is located at the West coast facing the Yellow Sea; and R5 is near the southernmost area of Korea towards the northern part of the East China Sea. However, R4 and R6 are located between other regions, therefore are not surrounded by sea water. Fish markets are an attraction in the country, thus it is common in Korean restaurants to serve seafood dishes. In this study, it was observed that most eat-out foods in Korea that are high in cholesterol content were those prepared with seafood as its main ingredient. Geographical location can also contribute to the difference in cholesterol content of seafood dishes due to the proximity of the seafood source. The amount of seafood added in the recipe could be increased because of abundant supply. For example, in *Wooluk-Maewoon-Tang*, the main ingredient used is the black rockfish. Significant differences were found among the samples from R1 to R6. Significantly higher values were observed in R3 and R4 than in other regions. It may be due to the abundance of rockfish in R3, which contributes to about 70% of the country's output for rockfish production in 2007 (Global Aquaculture Alliance 2009). It also serves as supplier to the capital region, R4. The same variations can be observed in *Haemul-Bokkeumbap* and *Yeonpo-Tang*. Significant differences in cholesterol content of *Haemul-Bokkeumbap* were found among the six regions with the highest from R2 (87.2 mg/100 g) and lowest from R5 (34.2 mg/100 g). In *Yeonpo-Tang*, samples from R1 and R2 were significantly higher than those from R4 and R6. This dish is prepared by

dumping live small octopus into boiling broth before consumption. This means that live catch is a requirement, which can only be attained if the restaurant is in close proximity to the sea. *Yeonpo-Tang* is not a popular dish in R4 and R6 because the regions are not surrounded by the sea. This causes the use of less amount of live octopus, resulting in low cholesterol content in samples from R4 and R6.

In addition, each region in Korea has its own style of preparing the dish because of its rich history and traditions. Characteristic tastes and cooking methods are well preserved especially in regions where the royalties and noble classes during ancient times were housed (National Research Institute of Cultural heritage, Korea).

On the other hand, only 31 out of 81 dishes analyzed showed no significant difference. In noodles, about 50% showed no significant regional difference because the dishes were mainly comprised of wheat noodles whereas meat and seafood were only added as toppings.

Overall, significant differences in cholesterol content can be found among restaurant foods. Based on method validation performed, results of this study can be used as reliable cholesterol database for the construction of dietary guidelines both in the regional and national level.

Conclusion

In order to construct database on the cholesterol content in eat-out restaurant foods in Korea, 5832 food samples were collected nationwide from 6 regions in Korea and their 486 composite samples representing each region and type were prepared. The collection was performed according to the sampling protocol statistically designed by KMFDS. The samples mainly comprised of soup/stew, rice dishes, and noodles which are frequently consumed in Korean restaurants. Cholesterol contents of restaurant foods were highly affected by recipe, the type of dish, seasonality of ingredients such as vegetables, animal sources, and seafood, and geographical location i.e. proximity to material sources. Almost all of the analyzed restaurant foods were found to have cholesterol but most foods contain relatively low amount. Relatively high quantity of cholesterol was found in most soup/stew compared to rice and noodle dishes. With regard to high-cholesterol dishes, the amount per serving and the type of dish should be considered before consumption in order not to exceed the recommended daily intake limit of 300 mg cholesterol. Method validation and analytical quality control revealed that the applied analytical method was reliable and all assay conducted for about 4 years was completed under the control. The present study provides reliable regional and national representative

database for cholesterol content of frequently consumed Korean restaurant foods.

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