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RESEARCH NOTE

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Seasonal and Market Group Variation in the Microbiological Quality of Seasoned Soybean Sprouts

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Abstract Mesophilic aerobic bacterial counts were measured and compared for seasoned soybean sprouts produced in different seasons and sold in different market types. Very significant differences in microbial counts were found among seasoned soybean sprouts produced in different seasons (winter, spring, and summer) and among different market types (a traditional market, discount store, and department store). However, there was no significant difference among the stores within each market group. The interactions were significant at a 1% significance level. The variance of summer counts was much lower than spring and winter counts. Discount and department stores showed a higher variation in microbial counts than traditional markets. The microbial counts differed substantially from season to season in the same market group (summer > spring > winter) except between spring and summer in traditional markets. The microbial loads in the winter and spring seasons of seasoned soybean sprouts in traditional markets were clearly higher than in other market groups, while discount stores had the highest microbial count in summer.

Keywords: microbial count, statistical difference, Korean side dish, market, seasonal variation, soybean sprout

Introduction

Varieties of Korean side dishes are manufactured in factories or shops, and are sold in traditional market and modern supermarkets. Because most Korean side dishes are prepared by seasoning the blanched vegetables with dry spice ingredients, they are highly perishable in nature. Thus, microbial quality is one of the most critical and important quality indexes of Korean side dishes with regard to the hygienic status and sensory properties of the food product (1, 2). Therefore, the microbial quality index is used as a criterion of quality control in the production and distribution of these products. However, for prepared foods that are not pasteurized or sterilized, there are usually large variations and irregularities in microbial contamination and load with regard to time, location, and processing conditions (3-6). Solid knowledge and information on microbial load and distribution are necessary for delivering safe food products of desired quality to consumers (7, 8). So far, there has been no systematic study on the microbial contamination of Korean side dishes relating to the season and type of market selling these products.

The microbial load of prepared foods should generally depend on the manufacturing and distribution conditions, which are also influenced by weather conditions. Stock rotation and shelf life should be designed and controlled by with regard to these variations. Seasoned soybean sprouts are a typical and versatile product of cooked and chill-stored side dishes in Korean market (1): it has been ranked one of the most frequently served vegetable side dishes in Korea (9). Because of the ingredients and preparation with microbiologically loaded sesame seeds, red pepper powder, minced garlic, and green onion, it's shelf life is determined mainly by microbiological quality change (1, 10). The data on microbial load and variation on the seasoned soybean sprouts can provide useful information and guide for proper control and improvement of current practice.

This study therefore aims to compare the microbiological counts of a typical Korean seasoned side dish, seasoned soybean sprouts, prepared in different seasons, and sold in different market environments.

Materials and Methods

Seasoned soybean sprouts Seasoned soybean sprouts were purchased from traditional markets, discount stores, and department stores in Seoul, Korea. Four shops were selected at random for each of the 3 market groupings. Samples were purchased 10 times from each shop in each of 3 different seasons, winter (February), spring (April), and summer (August) of the year 2006. Soybean sprouts were transported to the laboratory at low temperature (<7°C), stored at 4°C, and analyzed within 24 hr.

Microbiological analysis In order to assess the microbial contamination of seasoned soybean sprouts, duplicate packs from each sample were taken and 10 g portions were aseptically transferred to a sterile stomacher bag. Ninety mL of sterile 0.1% peptone water (Difco Laboratories, Detroit, MI, USA) was added to each bag, and the samples were macerated for 2 min. These samples were then subjected to serial dilution in 0.1% peptone water, plated out on plate count agar (PCA; Difco), and then incubated aerobically at 35°C for 48 hr. Microbial counts were expressed as colony forming units (CFU/g).

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Experimental design for statistical analysis This study was designed to address the significance of differences in initial microbial contamination among seasons, market types, and individual shops. Season (winter, spring, and summer) and market groups (traditional market, discount store, and department store) were compared statistically. For each market group, 4 shops were tested and the microbial load of their products compared. Ten samples from each season and market group were analyzed and subjected to statistical analysis. The data structure of this experiment is given in Table 1. The model for this experimental design is as follows:

$$Y_{ijkl} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \gamma_{k(j)} + (\alpha\gamma)_{ik(j)} + \varepsilon_{ijkl}$$
$$\varepsilon_{ijkl} \sim N\,(0,\sigma^2) \qquad (1)$$

where, Y_{ijkl} is the microbial count in log (CFU/g); μ is the grand mean; α_I is the main effect of the i^{th} level of seasons, i=1, 2, 3; β_j is the main effect of the j^{th} level of market groups, j=1, 2, 3; $\gamma_{k(j)}$ is the main effect of the k^{th} level of shops within market groups, k=1, 2, 3, 4 for all j; $(\alpha\beta)_{ij}$ is the interaction between the i^{th} level of seasons and the j^{th} level of marketing groups; $(\alpha\gamma)_{ik(j)}$ is the interaction between the i^{th} level of seasons and the k^{th} level of shops within market groups; and ε_{ijkl} is the random error, l = 1, 2, ⋯,10 for all i, j, k.

In this model, seasons are compared as with market groups and shops; shops are nested within the market groups. This experiment is a nested-factorial design because both factorial and nested factors appear in the same experiment. This experimental design was used to test the hypothesis that there is a difference in the microbial contamination level of seasoned soybean sprouts among seasons, market groups and shops within market groups. Levels of both factorial and nested factors may be either fixed or random. In this study, the seasons and market groups are fixed and the shops within groups are random. The statistical package of SAS 9.1.3 (SAS Institute, Cary, NC, USA) was used to analyze the data.

Results and Discussion

Microbiological analysis Table 2 shows the initial microbial counts of seasoned soybean sprouts for different seasons and shops within each market group. Analysis of variance (ANOVA) was conducted for the experimental data and the results are given in Table 3. The results of ANOVA show that there was a very significant difference in the microbial counts between seasons (winter, spring, and summer) and market types (a traditional market, discount store, and department food floor) at 1% significance. However, there was no significant difference among the shops within each market group at 1% significance. The grand mean of microbial counts was estimated to be 4.608 and R^2 of the model estimation according to Eq. 1 was 0.949 (Table 3). This level of microbial load is greatly higher than 2.0×10^2 CFU/g in food service location which serves the freshly prepared dish (11). Bhandare *et al.* (6) have also reported that the level of contamination of goat meat is significantly different between traditional meat shops and an abattoir. In the case of fresh vegetables, however, no significant difference was observed in microbial contamination levels between supermarkets and traditional markets (12). Surveys of bacteria levels on several kinds of foods in regional areas showed no significant difference between months or seasons, but did show significant differences among markets (13). As suggested by Park *et al.* (13), the results in Table 2 indicate that microbiological food quality can differ with different handling and environmental conditions, which means that levels of microbial quality need to be improved in certain seasons and/or market conditions. The effects of individual factors will be discussed below.

Statistical analysis Boxplots were drawn to see the differences among each group. A boxplot of bacteria levels in different seasons shows that the median microbial count of seasoned soybean sprouts produced in the summer was the highest, followed by those of spring and winter in that order (Fig. 1). The variance of summer counts was much lower than in the spring and winter. High temperatures in the summer should have helped mesophilic bacteria grow well during preparation of the soybean sprouts. There was a smaller difference in microbial counts between summer and spring than between spring and winter. Larger variation in the

Table 1. Data structure for seasoned soybean sprouts analysis

	B_1 (Traditional markets)				B_2 (Discount stores)					B_3 (Department stores)		
	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
	Y_{1111}	Y_{1121}	Y_{1131}	Y_{1141}	Y_{1251}	Y_{1261}	Y_{1271}	Y_{1281}	Y_{1391}	Y_{13101}	Y_{13111}	Y_{13121}
A_1 (Winter)	Y_{1112}	Y_{1122}	Y_{1132}	Y_{1142}	Y_{1252}	Y_{1262}	Y_{1272}	Y_{1282}	Y_{1392}	Y_{13102}	Y_{13112}	Y_{13122}
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	Y_{11110}	Y_{11210}	Y_{11310}	Y_{111410}	Y_{12510}	Y_{12610}	Y_{12710}	Y_{12810}	Y_{13910}	Y_{131010}	Y_{131110}	Y_{131210}
	Y_{2111}	Y_{2121}	Y_{2131}	Y_{2141}	Y_{2251}	Y_{2261}	Y_{2271}	Y_{2281}	Y_{2391}	Y_{23101}	Y_{23111}	Y_{23121}
A_2 (Spring)	Y_{2112}	Y_{2122}	Y_{2132}	Y_{2142}	Y_{2252}	Y_{2262}	Y_{2272}	Y_{2282}	Y_{2392}	Y_{23102}	Y_{23112}	Y_{23122}
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	Y_{21110}	Y_{21210}	Y_{21310}	Y_{211410}	Y_{22510}	Y_{22610}	Y_{22710}	Y_{22810}	Y_{23910}	Y_{231010}	Y_{231110}	Y_{231210}
	Y_{3111}	Y_{3121}	Y_{3131}	Y_{3141}	Y_{3251}	Y_{3261}	Y_{3271}	Y_{3281}	Y_{3391}	Y_{33101}	Y_{33111}	Y_{33121}
A_3 (Summer)	Y_{3112}	Y_{3122}	Y_{3132}	Y_{3142}	Y_{3252}	Y_{3262}	Y_{3272}	Y_{3282}	Y_{3392}	Y_{33102}	Y_{33112}	Y_{33122}
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	Y_{31110}	Y_{31210}	Y_{31310}	Y_{311410}	Y_{32510}	Y_{32610}	Y_{32710}	Y_{32810}	Y_{33910}	Y_{331010}	Y_{331110}	Y_{331210}

Table 2. Experimental data for microbial counts of seasoned soybean sprouts[1)] (log CFU/g)

	B_1 (Traditional markets)				B_2 (Discount stores)				B_3 (Department stores)				Season
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	
A_1 (Winter)	4.34±0.12	4.32±0.06	4.41±0.10	4.24±0.07	3.46±0.11	3.56±0.09	3.71±0.17	3.54±0.09	3.45±0.25	3.22±0.27	3.25±0.18	3.72±0.14	3.77±0.45
	4.33±0.11				3.57±0.15				3.41±0.29				
A_2 (Spring)	5.21±0.17	5.25±0.34	5.24±0.35	5.35±0.04	4.49±0.22	4.44±0.04	4.45±0.05	4.44±0.04	4.43±0.03	4.41±0.03	4.43±0.04	4.42±0.03	4.71±0.42
	5.26±0.26				4.45±0.11				4.42±0.03				
A_3 (Summer)	5.36±0.23	5.28±0.24	5.19±0.22	5.27±0.09	5.54±0.16	5.31±0.24	5.54±0.18	5.28±0.16	5.31±0.19	5.32±0.19	5.34±0.23	5.33±0.29	5.34±0.22
	5.27±0.21				5.42±0.22				5.33±0.22				
Market groups	4.96±0.49				4.48±0.78				4.38±0.81				4.61±0.75

[1)]Values are average±SD.

Table 3. ANOVA for seasoned soybean sprouts experiment

Source	Degree of freedom	Sum of squares	Mean square	F value	Pr> F
A	2	149.686	74.843	680.39	<0.0001
B	2	22.280	11.140	106.09	<0.0001
AB	4	15.565	3.891	35.37	<0.0001
C(B)	9	0.948	0.105	0.95	0.5072
AC(B)	18	1.992	0.110	3.54	<0.0001
Error	324	10.303	0.031		
Total	359	200.776			
	Y Mean: 4.608		R^2 : 0.949		

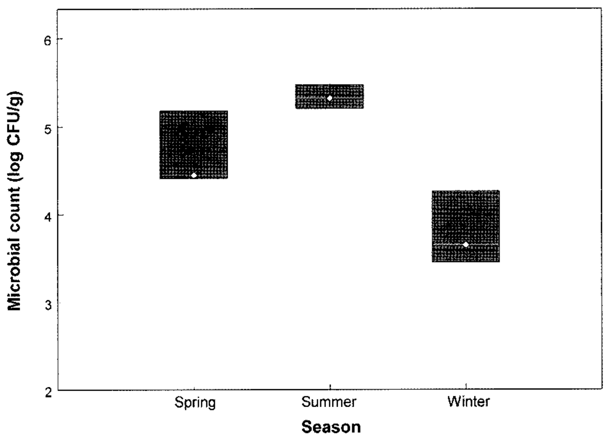

Fig. 1. Boxplot of microbial levels for different seasons.

microbial counts of winter versus spring might be due to the higher temperature fluctuations and variations in these seasons. For the spring and summer seasons, there is some need to improve the preparation and distribution conditions by lowering the temperature in preparation areas and/or storage showcases. Temperature control is also important in the winter and spring to maintain consistent microbial quality.

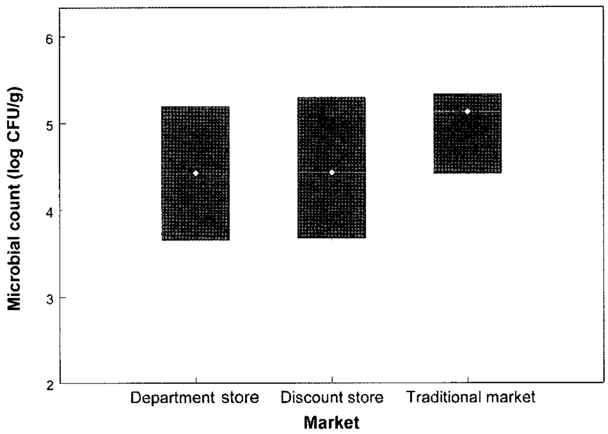

Fig. 2. Boxplot of microbial levels for different market groups.

A boxplot of bacteria levels among market groups shows that the median microbial counts of seasoned soybean sprouts at traditional markets was much higher than those at discount and department stores (Fig. 2). Considering that 48.5% of side dish purchase is made in traditional markets and individual shops compared to 44.1% of discount stores and 5.3% of supermarkets (14), it is emphasized important to improve the practices of preparing and distribution of the side dishes in those locations. The variation in microbial counts was much higher at discount and department stores than at traditional markets. The high variance within the market group reflects inconsistent conditions of manufacturing and/or storage, and display conditions. It is interesting that the more modern discount and department store environments have higher microbial variation even with lower microbial contamination. It is usual practice that many seasoned foods are prepared on site or in a kitchen behind the shelves. Some modern places of discount and department stores are controlled well in temperature in the preparation sites, while the other places are usually not so. Thus, there may be large a variability in hygienic control of such

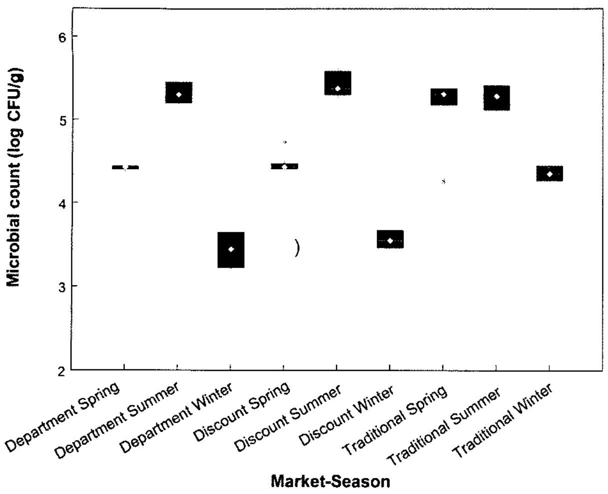

Fig. 3. Boxplot of seasonal microbial levels in different market groups.

modernized facilities. Better and more consistent practices in processing and distribution seem to be required in such environments. The microbial load of viable cells on commercial dry foods was reported to vary widely from 2.0×10^3 to 1.6×10^7 CFU/g depending on the processor (15). Kim *et al.* (16) found that salt fermented shrimp products sold in traditional markets had poor microbial quality as shown by mesophilic bacterial counts. Manufacturing and distribution conditions that are better designed and operated would reduce the microbial load to desirable levels.

Figure 3 shows the median and variance of microbial counts of seasoned soybean sprouts from different seasons and market groups. This figure indicates specific market group/season combinations that require special care or quality management. It is clear that the median microbial counts differed substantially from season to season in the same market group (summer > spring > winter) except between spring and summer at traditional markets. Traditional markets had clearly higher microbial loads in winter and spring than other market groups. On the other hand, discount store had the highest microbial count in summer. The differences in median microbial count values were relatively small in summer among the three market groups, as were the winter and spring counts between department and discount stores. Department stores in winter had particularly high variability. As discussed above, manufacturing and distribution conditions in the summer season need to be carefully controlled with lower temperatures for all market types. Traditional markets in particular need to improve the preparation and display environment.

This study provides valuable information on the hygienic status of seasoned prepared side dishes in Korean markets, and indicates the need for improved food processing practices. This type of study may be used an example for investigating the microbial and hygienic status of other food products.

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