Color Evaluation of Red Pepper Powder

Q. Chen, H. K. Koh, J. B. Park

Abstract. *Red color, particle size, and moisture content are important quality attributes of red pepper (Capsicum annuum) powder. The effects of particle size and moisture content on CIE L*a*b* color parameters of red pepper powder (cultivar: Korean Buguang) were investigated in this study. Moisture content within 10-15% (wb) had no significant influence on all color parameters of the powder of the selected cultivar. Particle size at 18 and 30 mesh, commonly used in Korea, had a significant effect on lightness but no effect on hue angle and chroma of red pepper powder of this cultivar. The interaction of particle size and moisture contend were significant on all color parameters. More research is needed on other cultivars and on the mixture of certain cultivars.*

Keywords. *Red pepper powder, Color, Moisture content, Particle size.*

Red pepper (*Capsicum annuum*) is one of the most important vegetables in Korea, with 87 469 ha in production, compared to 50.75% of the whole seasoning vegetable growing area with an annual yield of 193 331 M/T in 1995 (Ministry of Agriculture and Forestry of Republic Korea, 1996). Many studies have been conducted in Korea on the cultivation, breeding, processing, and use of red pepper. Color of red pepper was emphasized as one of the quality attributes in most of these investigations. However, only the color of the whole fruit or extractable oil was measured.

Red pepper is used mainly in ground form. Its market value depends largely on the red color. Although color does not necessarily reflect nutritional, flavor or functional properties, it relates to consumer preference based on the appearance of the product. Therefore, color evaluation of red pepper powder is especially significant. Moreover, color is a quality characteristic that reflects the combined effects of oil content, water content, raw material compound (proportion of pod and seed, etc.) as well as the technological factors (drying conditions, grinding pressure, dispersion of granules, etc.) (Halasz-Fekete, 1993).

Nagle et al. (1979) compared the extractable color values of 15 selected cultivars of red pepper and two methods of measuring color intensity. Francis (1987) discussed the relationship between color and pigment content. Halasz-Fekete (1993) suggested an objective method for the qualification of color of Hungarian ground red pepper, with the help of instrumental color measurement and computerized qualification method of the CIE L*a*b* color parameters. Classification of the samples according to particle size was not mentioned in the study. Kim and Rhee (1980) developed a method using n-hexane to remove red color and capsaicin which were contaminated in crude oil extracted from red pepper seeds. Koh et al. (1987) studied the effects of various drying conditions on the quality of red pepper in terms of redness and capsanthin content. Shin and Lee (1991) analyzed the pungent principles, redness, size, and weight of seven different cultivars of Korean red pepper. Lee et al. (1975) investigated the metabolic changes in hot green pepper during an after-ripening period with treatment of ethephon either alone or with phenylalanine. The metabolic changes were explained in relation to color enhancement judged by the color score to explain the after-ripening processes.

Early methods to evaluate the color of peppers were visual, based upon comparison of the color of a diluted extract with a specially prepared potassium dichromate-cobaltous chloride solution (Guenther, 1948) or combinations of Lovibond glasses that matched the color (Moster and Prater, 1952). In recent decades, many advances have taken place in color measurement instrumentation. The desire to use spectrophotometric measurement to predict the color of fruits, vegetables, and foods has become increasingly popular for obvious reasons. The incorporation of electronic technology has made it possible to obtain results for several color parameter systems from just one instrument. The CIE L*a*b* color space, defined by CIE in 1976, and one of the most popular color spaces for measuring object color, was used in this study.

The purpose of this study was to determine the effects of moisture content and particle size on CIE L*a*b* color parameters of selected red pepper powder.

Materials and Method

Sample Preparation

The red pepper cultivar used in this study was Korean Buguang, harvested in Andong, Kyungbuk Province, on 20 September 1996. The stems and seeds were separated

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from the pods before milling. The pepper, composed of 90% pod and 10% seed (a popular ratio found in Korean markets), was milled using a prototype red pepper mill of the Korean Food Development and Research Institute. The milled red pepper was separated according to particle size with sieving equipment. Six samples with particles retained on 10, 14, 18, 30, 40, and 50 mesh sieves (Tyler designations; 1.65, 1.17, 0.91, 0.54, 0.37, 0.29 mm), respectively, were obtained.

Equilibrium Moisture Content Control

The equipment used was a constant temperature and humidity controller (Young Kwang, Korea), with programmable temperature and humidity controls attached (Shinko, Japan). The samples were held inside the equipment for 24 h. Different equilibrium moisture contents (EMC) were achieved through dry bulb temperature and humidity settings (table 1). The actual EMC values of the samples were measured by oven drying method.

Color Measurement

A spectrophotometer (CE 310, Macbeth, Japan), connected to a printer (DPU-201G, Seiko, Japan), was used to measure the color of the samples. Illuminant and observer were set to CIE Standard Illuminant C and CIE 10° Standard Observer respectively. The display was set to CIE L*a*b* color coordinates. The L* coordinate measures the value or lightness of a color and ranges from black at 0 to white at 100. The a* coordinate measures red when positive and green when negative, and b* measures yellow when positive and blue when negative. Hue angle (θ) and chroma (C*) can be determined from the a* and b* parameters. Hue is the name of a color (red, yellow, blue, green, etc.), and hue angle is equal to the arc-tangent (b*/a*). Red pepper samples typically have hue angles between 0° to 45°, which is the range from red to orange. Chroma is a measure of color saturation or purity, calculated from the square root of sum of $(a*)^2$ and $(b*)^2$.

Each sample with the same particle size was divided into five parts and measured separately. The measured data were averaged. The spectrophotometer used has an automatic averaging function of multiple measurements at one position. In this study, five measurements were made and averaged automatically at each position.

Results and Discussion

Equilibrium Moisture Content

The equilibrium moisture content of samples after constant moisture treatment varied slightly with respect to particle size (table 2). Generally, the smaller the particle size, the lower the moisture content. This can be explained as follows. After milling, variation of the particle size of the ground seeds in the samples was slightly smaller than that of ground pods. Therefore, the finer sieved samples involve more seed powder, and their moisture contents would be lower due to the lower moisture content of seeds. However, because the moisture content variation within one treatment is very small, the average can be taken as the moisture content of all samples within one treatment.

Table 1. Equilibrium moisture content (EMC) of the samples

Dry Bulb Temperature (°C)	Relative Humidity (%)	EMC (% w.b.)
30	50	10.40
20	40	11.99
20	51	13.93
20	60	15.05
20	70	15.97

Table 2. Equilibrium moisture content of red pepper powder samples (% w.b.)

Particle Size* (mesh)	Dry Bulb Temperature - Relative Humidity Setting: 30°C - 50%	20°C - 40%	20°C - 51%	20°C - 60%	20°C - 70%
10	10.73	12.21	14.48	15.17	16.46
14	11.17	12.19	14.13	15.12	16.52
18	10.72	12.18	14.09	15.12	16.40
30	10.28	11.90	13.69	14.98	15.74
40	9.86	11.87	13.64	14.97	15.66
50	9.65	11.61	13.54	14.94	15.06
Mean	10.40	11.99	13.93	15.05	15.97

* Particle size represents materials retained on the corresponding mesh size.

Effects of Moisture Content and Particle Size on Color Parameters of Red Pepper Powder

Data were subjected to a two-way analysis of variance (O'Mahony, 1986), treating moisture content and particle size as main effects with interaction. Main effects and their interaction were considered significant at $p < 0.05$. The results of F-statistic for main effects and their interaction on color parameters of red pepper powder are presented in table 3. Moisture content, particle size and their interaction had a significant effect on all color parameters.

Least significant difference (LSD) analysis (O'Mahony, 1986) was used to make multiple-comparison tests to establish which are the means that are actually differing

Table 3. F-statistic for main effects for color parameters of red pepper powder

Color Parameters	F-statistic† for Effects of: Moisture Content	Particle Size	Interaction
L*	32.7190	54.6914	2.4706
a*	8.5958	7.3950	5.0138
b*	16.2977	28.1248	5.1298
Hue angle (θ)	5.1913	23.1864	8.8049
Chroma (C*)	22.2614	34.0230	4.6061

† $F_{0.05}$ is 2.7109 for moisture content, 2.8661 for particle size, and 1.6587 for interaction.

Table 4. Least significant difference for moisture content effect on color parameters of red pepper powder†

Color Parameters	Moisture Content (% w.b.): 10.40	11.99	13.93	15.05	15.97	LSD
L*	34.02b	34.05b	34.38b	34.72b	37.00a	0.71
a*	29.79a	30.00a	30.03a	29.54a	27.39b	0.72
b*	30.26a	30.58a	30.46a	30.43a	25.68b	0.92
Hue angle (θ)	45.43a	45.54a	45.39a	45.83a	43.09b	0.72
Chroma (C*)	42.46a	42.85a	42.78a	42.41a	37.55b	1.02

† Means pooled over particle size.

ab Means in same row followed by same letter are not significantly different ($p < 0.05$).

Table 5. Least significant difference for particle size effect on color parameters of red pepper powder†

Color Parameters	Particle Size (mesh) 10	14	18	30	40	50	LSD
L*	32.48 e	33.77 d	33.69 d	34.82 c	36.56 b	37.63 a	0.77
a*	29.78 b	28.74 c	28.02 c	28.21 c	29.75 b	31.58 a	0.79
b*	31.03 ab	29.03 c	27.53 d	27.41 d	30.04 bc	31.83 a	1.01
Hue angle (θ)	46.15 a	45.16 b	44.43 c	44.13 c	45.24 b	45.21 b	0.79
Chroma (C*)	43.02 b	40.87 c	39.29 d	39.34 d	42.29 b	44.85 a	1.12

† Means pooled over moisture content.
abcd Means in same row followed by at least one same letter are not significantly different ($p < 0.05$).

from each other. The LSD values (table 4, 5) were calculated by using:

$$LSD = t_{0.05}\sqrt{\frac{2MS_E}{n}} \qquad (1)$$

where $t_{0.05}$ was the critical value of the t-test at the significant level of 0.05, MS_E was error mean square for the ANOVA, and n was the number of scores in each treatment sample. If the LSD value is larger than difference between the means, the means are not significantly different. If the LSD value is smaller, the means are significantly different.

The LSD analysis showed that the means of color parameters of red pepper powder were significantly different among all particle sizes. Among the moisture contents tested, only 15.97% (w.b.) showed a significant effect (tables 4, 5). Therefore, it is considered that moisture content within 10 to 15% had no significant influence on color parameters of red pepper powder. The higher limits of moisture content of red pepper powder in Korean Agricultural Products Standard and Korean Standard (KS) are 15.0 and 13.0% (w.b.), respectively (Hong, 1996), but the former is widely used by Korean red pepper powder producers.

Particle size had a much more significant and complicated effect than moisture content on the color parameters of red pepper powder. The particle size of red pepper powder in Korean markets varies from 18 to 30 mesh. Table 5 shows that the particle size within this range affected the color parameters of red pepper powder to a relatively small extent. Particle size of 18 and 30 mesh had no significant effect on a*, b*, hue angle (θ), and chroma (C*). ANOVA with data related to particle size 18 and 30 also showed insignificant effect of interaction on hue angle (θ) and chroma (C*) ($F_{0.05} = 2.6060$, $F_{interaction} = 1.9624$ and 1.6442 for hue angle and chroma). Consumers may take lightness (L*) as the standard for selecting their favorite colors of red pepper powder, since visual color is the integration of lightness, hue and chroma, and the parameters which have the largest difference between samples will affect the human judgment of color. Suppose $\overline{L*}_i$, $\overline{\theta}_i$ and $\overline{C*}_i$ (i = 10, 14, 18, 30, 40, 50) stands for the means of L*, θ, and C* at particle size i, the significance of particle size effects on color parameters of red pepper powder is further interpreted as follows. $\overline{L*}_{14}$ and $\overline{L*}_{18}$ were not significantly different, but means of lightness at other particle sizes differed significantly. $\overline{\theta}_{10}$ was significantly different from $\overline{\theta}_i$ (i = 14, 40, 50) and $\overline{\theta}_j$ (j = 18, 30), so was $\overline{\theta}_i$ (i =14, 40, 50) from $\overline{\theta}_j$ (j = 18, 30).

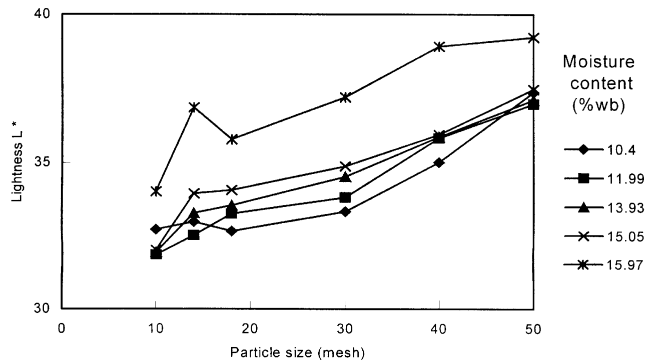

Figure 1–Relationship between particle size and lightness of red pepper powder.

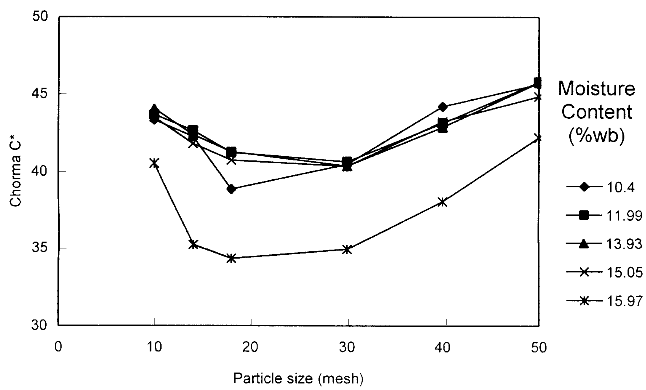

Figure 2–Relationship between particle size and chroma of red pepper powder.

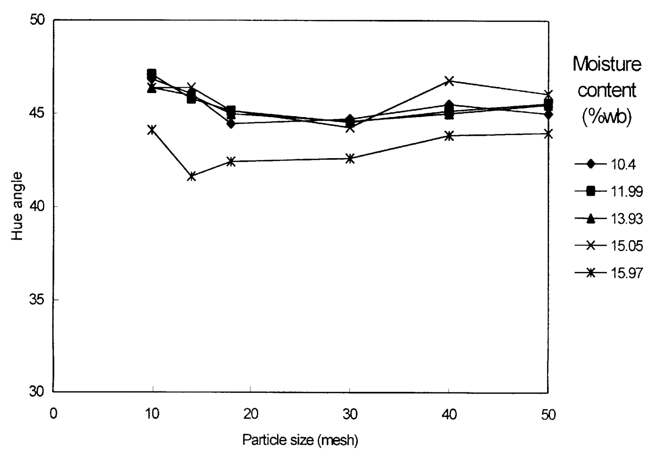

Figure 3–Relationship between particle size and hue angle of red pepper powder.

$\overline{C*}_{10}$, $\overline{C*}_{14}$, $\overline{C*}_{18}$, and $\overline{C*}_{50}$ were significantly different, but $\overline{C*}_{18}$ and $\overline{C*}_{30}$ were not.

The particle size of red pepper powder in Chinese and some European markets is much smaller than 30 mesh. For example, Chinese consumers like red pepper powder whose particle size varies between 40 and 50. In this situation, the effect of particle size and its interaction with moisture content must be put into consideration.

Lightness increased with decreasing particle size, from 32.73, 31.87, 31.95, 32.03, and 34.02 for particle size of 10 mesh, with moisture content of 10.4, 11.99, 13.93, 15.05, and 15.97% (w.b.), to 37.36, 36.97, 37.11, 37.47, and 39.23, respectively (fig. 1). A linear regression analysis of L* and particle size indicated high correlation coefficients, 0.9245, 0.9938, 0.9862, 0.9428, and 0.9106 with moisture content of 10.40, 11.99, 13.93, 15.05, and 15.97% (w.b.), respectively. The chroma (C*) of red pepper powder showed different trends with particle size from those of lightness (L*) (fig. 2). Chroma (C*) of red pepper powder with moisture content of 11.99, 13.93, and 15.05% (w.b.) decreased between 10 and 30 mesh, then increased. Chroma (C*) at moisture content of 10.4 and 15.97% (w.b.) showed similar trends, increasing only slightly from 18 to 30 mesh. Hue angle varied very slightly with particle size (fig. 3).

Conclusions

Both particle size and moisture content produced significant effects on CIE L*a*b* parameters of red pepper powder used in the study. However, moisture content within 10.0 to 15.0% (w.b.) [(the higher limit for moisture content of red pepper powder in Korean Agricultural Product Standard which is widely used is 15.0% (w.b.)] had no significant influence on the color parameters. The effects of particle size at 18 and 30 mesh were not significant for hue angle and chroma, but were for lightness. Lightness (L*) was considered the most important factor to affect human color judgment for the cultivar used in this study. The interaction of particle size and moisture content were significant on all color parameters of the selected red pepper powder samples. It is suggested that studies be conducted on the color-particle size-moisture content relationships of other cultivars and mixed red pepper powder of certain cultivars.

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