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Quality evaluation of processed ginger products (*shokyo* and *kankyo*) according to their color values and pungent compound contents

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Abstract

In Japan, dried ginger is called *shokyo*, and ginger dried after soaked in hot water or steamed is called *kankyo*. The quality of processed ginger might be affected by the processing methods. Previously, we reported that the heating method used to process fresh ginger affected the color of the resultant product and how its color was correlated with its 6-shogaol to 6-gingerol ratio ([S/G]); i.e., the *a** value (indicating redness) of steamed ginger positively correlated with its [S/G], the *a** value of ginger soaked in hot water remained constant regardless of its [S/G], and the *a** value of ginger heated at 180℃ displayed a logarithmic correlation with [S/G]. In this paper, we used the above results to evaluate the quality of *shokyo* and *kankyo* products on the market.

As a result, we found that the *a** values of most *shokyo* products logarithmically correlated with their [S/G]. However, *shokyo* products with whitish surfaces displayed *a** values of less than + 2, and their *a** values and [S/G] showed no correlations.

Meanwhile, *kankyo* products were divided into 3 groups by the relationships between the *a** values and [S/G]; i.e., samples whose *a** values correlated with their [S/G], those with *a** values around + 9, and those with *a** values less than + 8. These *kankyo* samples might be produced by steaming, soaking in hot water, and soaking in warm water, respectively. Therefore, we confirmed that the combination of color values and [S/G] could be used to infer processing methods of ginger products.

Key words ginger, processing, color, gingerol, shogaol.
Abbreviation [S/G], 6-shogaol to 6-gingerol ratio.

Introduction

Ginger is a crude drug that is processed in various ways for specific medicinal purposes in Japan and China. In the 16th Japanese Pharmacopoeia,[1] dried ginger is called *shokyo*, and ginger that has been soaked in hot water or steamed before being dried is called *kankyo*. In China, ginger is processed by other methods, and ginger products are classified slightly differently; i.e., fresh ginger is called *shokyo* (*Sheng Jiang* in Chinese), dried ginger is called *kankyo* (*Gan Jiang* in Chinese), roasted ginger is called *hokyo* (*Pao Jiang* in Chinese), and ginger that has been roasted until it turns dark is called *kyotan* (*Jiang Tan* in Chinese).[2]

Processing ginger alters the contents of its main compounds. In addition, these changes differ according to the processing method, including the duration and

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temperature of heating. It has been reported that gingerol is transformed to shogaol during the heating process, and a longer heating period produces an increased amount of shogaol.[3,4] In addition, it was reported that gingerol strongly inhibited the growth of *Helicobacter pylori*,[5] while 6-shogaol had strong antioxidant, anti-inflammatory,[6,7] and anti-allergic[8] effects. Therefore, criteria for assessing the processing methods used to produce ginger products are needed because it affects their medicinal effects.

We[9] previously prepared ginger samples that had been steamed, soaked in hot water, or heated at 180℃ used Japanese ginger and found that their color values could be used to evaluate how they had been processed. The *a** values (indicating redness) of processed ginger products and the relationship between *a** value and 6-shogaol to 6-gingerol ratios ([S/G]) differed according to the processing method; i.e., the *a** value of steamed ginger was positively correlated with its [S/G], the *a** value of ginger that had been soaked in hot water remained constant regardless of its [S/G], and the *a** value of ginger that had been heated at 180℃ displayed a logarithmic correlation with its [S/G]. In addition, the *L** (brightness) and *b** (yellowness) values of the products were correlated with their 6-shogaol contents (Fig. 1).

Many processed ginger products with different surface colors are commercially available, and their pungent compound contents might also differ. Therefore, in this study, we evaluated the qualities of ginger products sold at Japanese, Chinese, and Korean markets using the above findings regarding the relationships among the color values, pungent compound contents, and processing methods of ginger products.

Material and Methods

Ginger materials: Dried ginger products (Japanese *shokyo* and Chinese *Gan Jiang* (both dried ginger), *Pao Jiang* (roasted ginger), and *Jiang Tan* (ginger that has been roasted until it turns dark) were purchased from Japanese, Chinese, Hong Kong, and Korean markets. Some Japanese *shokyo* products were donated from a project that received a Health and Labour Sciences Research Grant. Most of the Japanese *kankyo* products were donated by Japanese companies, and the rest were purchased.

Information about these materials is shown in Table 1, and all of the materials were deposited at the Faculty of Pharmacy, Kanazawa University.

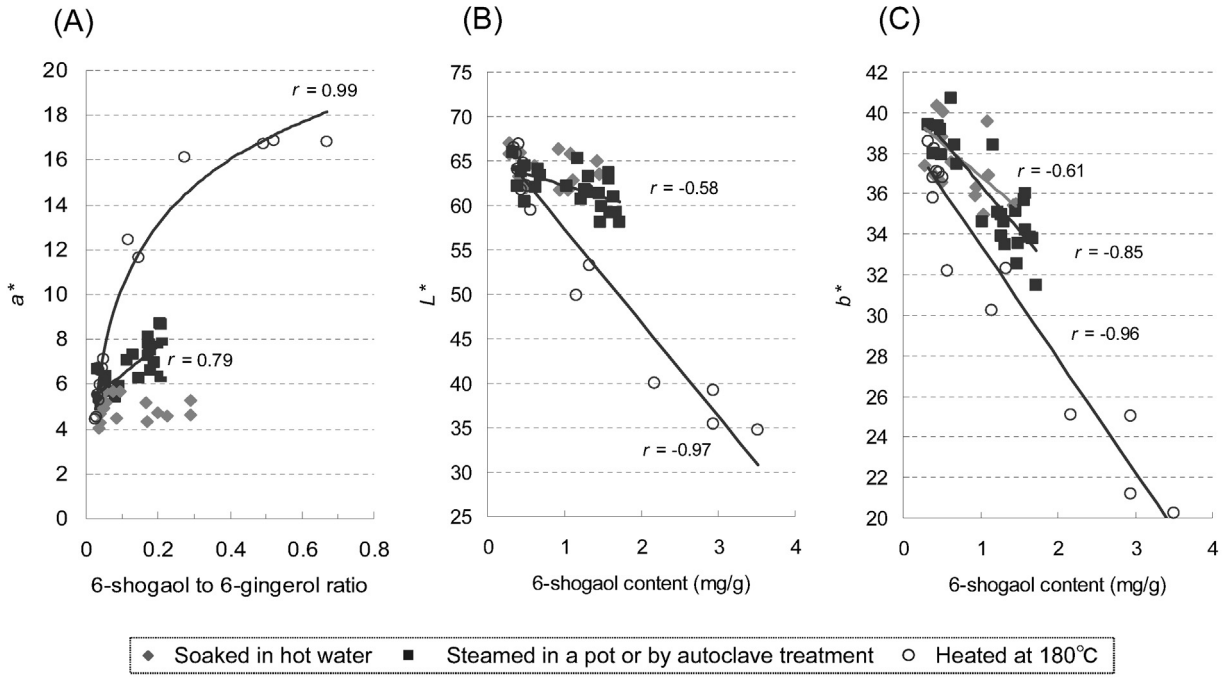


Fig. 1 The relationship between the *a** values and 6-shogaol to 6-gingerol ratios of processed ginger samples (A) and the relationships between their *L** (B) or *b** (C) values and their 6-shogaol contents.

Table 1 Crude drug materials used in this study

No.	Sample name	Production area	Collection site **	Collection date	KANP No. ***
S1	*Shokyo*	Yunnan Prov., China	A	2003.3	6141
S2	*Shokyo*-1st grade		A	1995.11	4139
S3	*Shokyo*-2nd grade		A	1995.11	3300
S4	*Shokyo* (processed with sulfur)	Guangdong Prov., China	A	2003.3	6137
S5	*Shokyo* (processed with sulfur)	Guangdong Prov., China	A	2003.3	6154
S6	*Shokyo*		B	2009.10	9095
S7	*Shokyo*		B	2004.7	6934
S8	*Shokyo*		C	2004.7	6465
S9	*Shokyo*	Yunnan Prov., China	Sample donated by a project ****	2010.10	NIB-008 *****
S10	*Shokyo*	Yunnan Prov., China	Sample donated by a project	2010.10	NIB-039
S11	*Shokyo*	Yunnan Prov., China	Sample donated by a project	2010.10	NIB-055
S12	*Shokyo*	Yunnan Prov., China	Sample donated by a project	2010.10	NIB-060
S13	*Shokyo*	Yunnan Prov., China	Sample donated by a project	2010.10	NIB-075
S14	*Shokyo*	Yunnan Prov., China	Sample donated by a project	2010.10	NIB-091
S15	*Shokyo*	Yunnan Prov., China	Sample donated by a project	2010.10	NIB-110
S16	*Shokyo*	Yunnan Prov., China	Sample donated by a project	2010.10	NIB-147
S17	*Shokyo*	Yunnan Prov., China	Sample donated by a project	2010.10	NIB-169
S18	*Gan Sheng Jiang*		Anguo, Hebei Prov., China	2011.8	8249
S19	*Gan Jiang*	Yunnan Prov., China	Anguo, Hebei Prov., China	2011.8	8263
S20	*Gan Jiang*	Sichuan Prov., China	Xinjiang, China	2011.6	8140
S21	*Gan Jiang*		Shenyang, Liaoning Prov., China	2011.10	8941
S22	*Gan Jiang*		Shanghai, China	2011.10	8942
S23	*Gan Jiang*	Sichuan Prov., China	Hong Kong	2011.12	9008
S24	*Gan Jiang*	Korea	Korea	2010.5	7702
H1	*Pao Jiang*	Guangxi Prov., China	Anguo, Hebei Prov., China	2011.7	7991
H2	*Pao Jiang*		Anguo, Hebei Prov., China	2011.8	8250
H3	*Pao Jiang*	Sichuan Prov., China	Hong Kong	2011.12	9009
C1	*Jiang Tan*		Shanghai, China	2011.10	8943
K1	*Kankyo*		A	1992.3	1918
K2	*Chirou Gan Jiang**		A	1995.6	2902
K3	*Chirou Gan Jiang*		A	1992.3	1530
K4	*Chirou Gan Jiang*		A	1995.6	2923
K5	*Kankyo*		B	2010.11	7785
K6	*Kankyo*		B	2010.11	8925
K7	*Kankyo*	Yunnan Prov., China	B	2009.6	8208
K8	*Kankyo*	Yunnan Prov., China	B	2011.5	8209
K9	*Kankyo*	Japan	C	2007.9	8200
K10	*Kankyo*	China	C	2005.4	8201
K11	*Kankyo*	China	C	2006.6	8202
K12	*Kankyo*	China	C	2009.3	8203
K13	*Kankyo*	China	C	2009.9	8204
K14	*Kankyo*		D	1990.7	1012
K15	*Kankyo*		D	2011.7	8211
K16	*Kankyo*		D	2011.3	8212
K17	*Kankyo*		D	2011.3	8213
K18	*Kankyo*		D	2010.5	8214
K19	*Kankyo*		D	2011.2	8215
K20	*Kankyo*	Guangdong Prov., China	E	2011.6	8195
K21	*Kankyo*	Guangdong Prov., China	E	2010.11	8196
K22	*Kankyo*	Guangdong Prov., China	E	2009.11	8197
K23	*Kankyo*, without peel	Guangxi Prov., China	F	2011.9	8198
K24	*Kankyo*, with peel	Guangxi Prov., China	F	2011.9	8199
K25	*Kankyo*	Guangxi Prov., China	G	2011.9	8205
K26	*Kankyo*	Guangxi Prov., China	G	2011.9	8206
K27	*Kankyo*	Guangxi Prov., China	G	2011.9	8207
K28	*Kankyo*		H	2011.9	8210
K29	*Kankyo*		I	2011.9	8228
K30	*Kankyo*		I	2011.9	8229

*: *Chirou Gan Jiang* is the Chinese name for *kankyo*.
**: A-I indicate Japanese companies that sell crude drugs.
***: KANP No. is the voucher number under which the specimen was deposited at the Faculty of Pharmacy, Kanazawa University.
****: The project was performed with a Health and Labour Sciences Research Grant.
*****: NIB indicates the sample No. given to the specimens in the above project.

Reagents: The 6-gingerol (purity: 98%) standard was purchased from Nacalai Tesque Inc., and the 6-shogaol (purity: more than 98%) standard was obtained from Wako Pure Chemical Industries, Ltd. All chemicals were of analytical grade, and the chromatographic solvents were of HPLC grade.

Color analysis: Each powdered sample (particle size was less than 300 μm) was placed into a small Petri dish (1.2 cm × 1 cm, i.d.), and the light reflected when the dish was exposed to a D65 standard illuminant was analyzed using a spectral photometer (CM-3500d, Konica Minolta Holdings, Inc.). We evaluated the reflected light using the parameters L^* (brightness), a^* (redness), and b^* (yellowness).

HPLC method: We used an HPLC method to determine the 6-gingerol and 6-shogaol contents of the products. The HPLC method was performed as described in a previous paper.[9)]

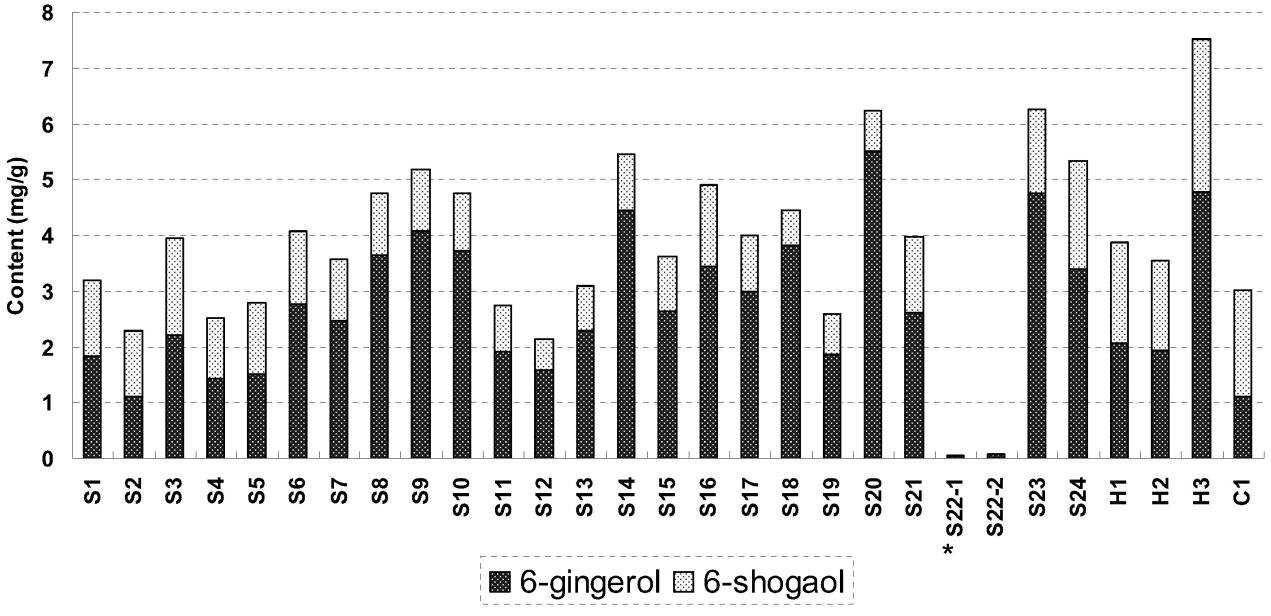
Results

The relationship between the color values and pungent compound contents of the *shokyo* (*Gan Jiang*), *Pao Jiang,* and *Jiang Tan* products: The 6-gingerol contents of the *shokyo* (*Gan Jiang*) products were 2.87 ± 1.14 mg/g (ranged from 1.11 to 5.50 mg/g), while their 6-shogaol contents were 1.13 ± 0.33 mg/g (ranged from 0.55 to 1.93 mg/g), except for that of S22, which was obtained from Shanghai market and contained almost no pungent compounds (Fig. 2).

The shogaol contents of the *Pao Jiang* and *Jiang Tan* products were higher than those of the *shokyo* (*Gan Jiang*) products except for S3. Among the three *Pao Jiang* samples, H3 had the highest shogaol and gingerol contents.

We examined the relationships between the a^* values and [S/G] of the *shokyo* (*Gan Jiang*), *Pao Jiang*, and *Jiang Tan* products. In most samples, these two parameters were logarithmically correlated (r = 0.77). These samples were defined as group 1. However, the a^* value of S23, which was bought from Hong Kong market, was higher than those of the other samples; therefore, it did not belong to group 1. The *shokyo* (*Gan Jiang*) products with whitish surfaces displayed a^* values of less than + 2 and no correlations between their a^* values and [S/G] (group 2). As S22 contained almost no pungent compounds, it did not belong to either of the above two groups (Fig. 3).

Furthermore, the L^* values of the commercial sam-



*: S22-1 (whose surface was whitish-brown) and S22-2 (whose surface was white) were subsamples derived from S22.
Sample numbers are indicated in table1.

Fig. 2 The pungent compound contents of *shokyo* (*Gan Jiang*), *Pao Jiang*, and *Jiang Tan* products.

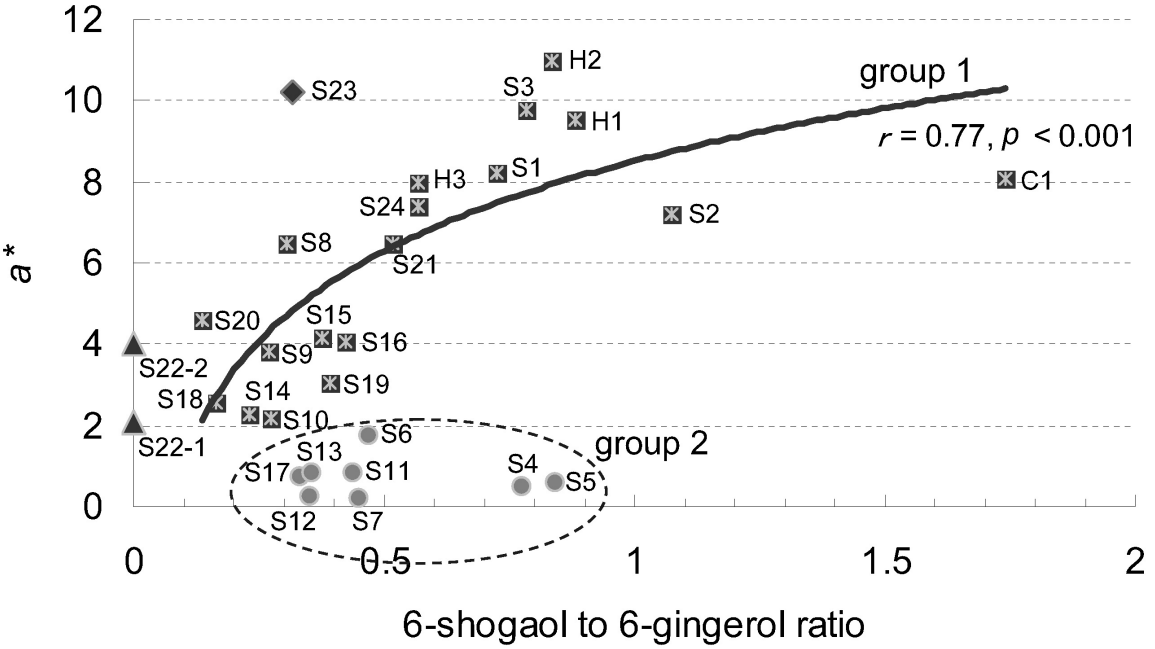


Fig. 3 The relationship between the *a** values and 6-shogaol to 6-gingerol ratios of *shokyo* (*Gan Jiang*), *Pao Jiang*, and *Jiang Tan* products.

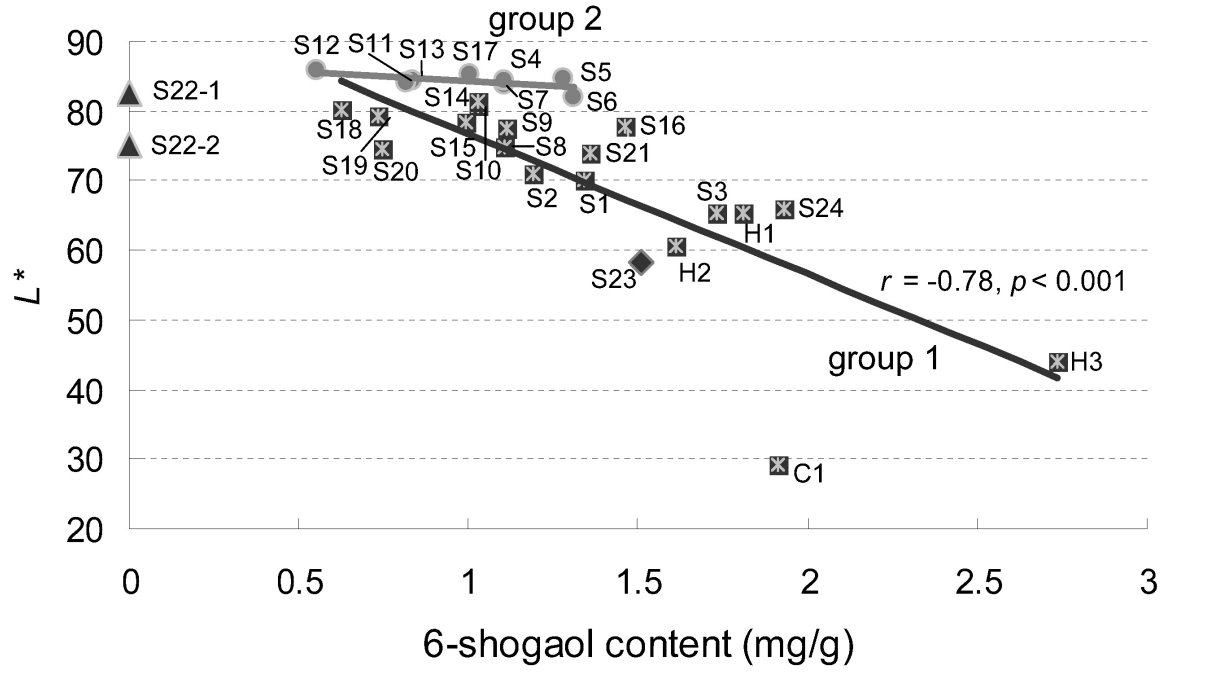


Fig. 4 The relationship between the *L** values and 6-shogaol contents of *shokyo* (*Gan Jiang*), *Pao Jiang*, and *Jiang Tan* products.

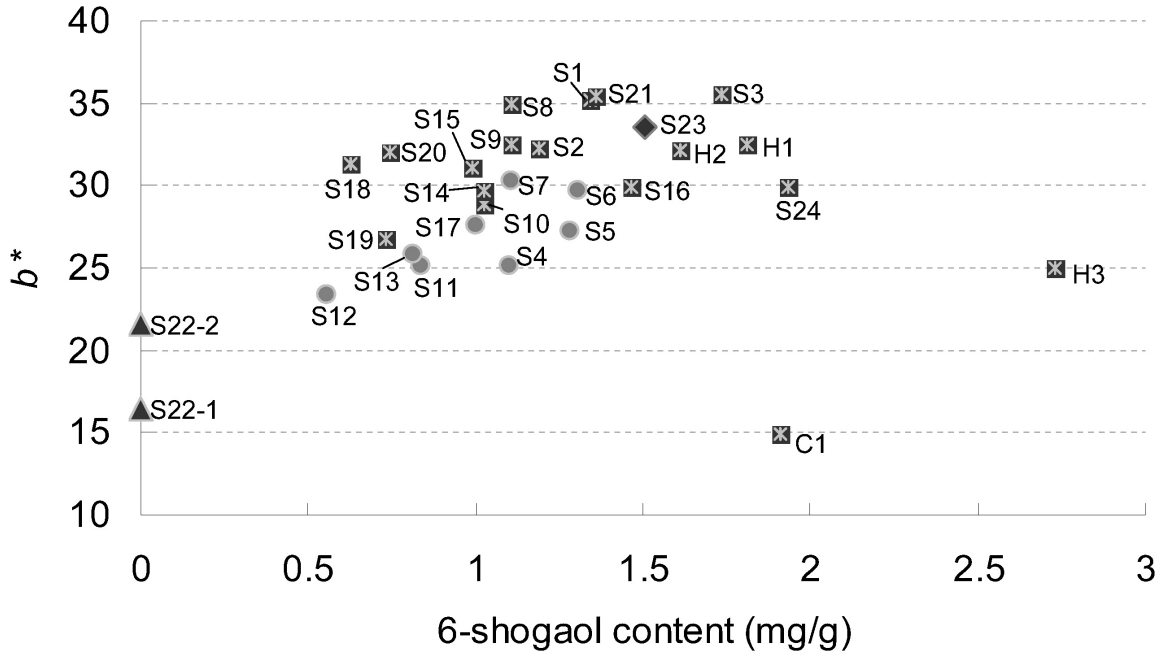


Fig. 5 The relationship between the *b** values and 6-shogaol contents of *shokyo* (*Gan Jiang*), *Pao Jiang*, and *Jiang Tan* products.

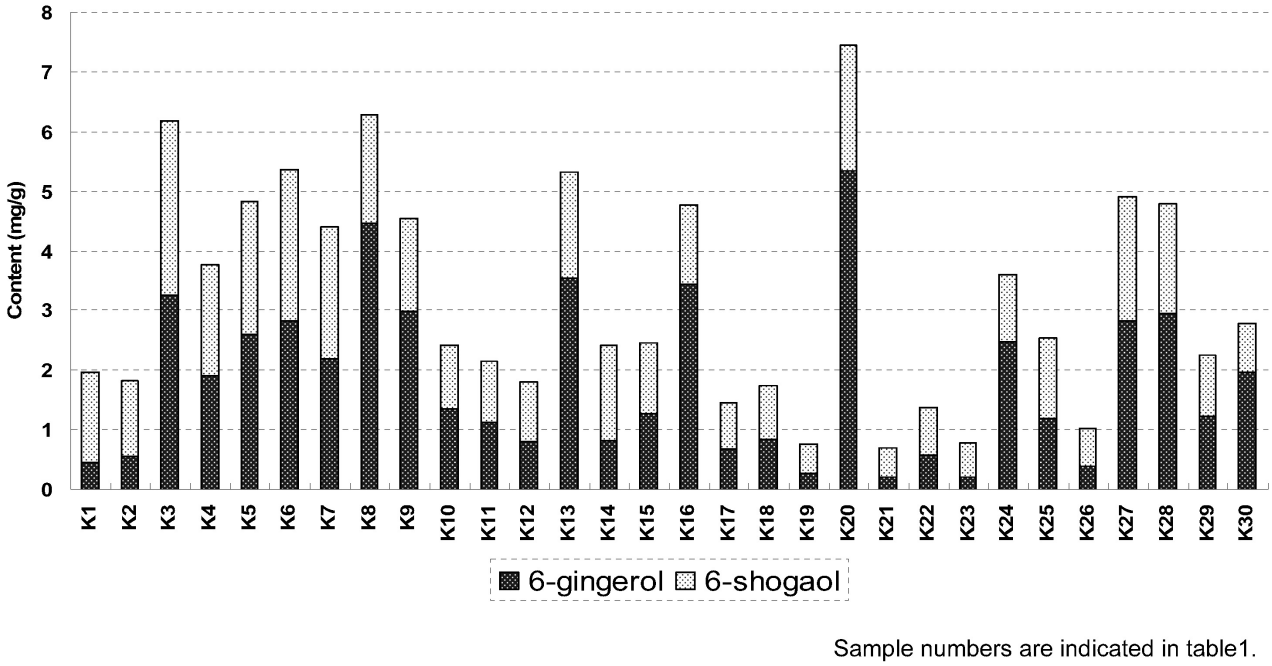


Fig. 6 The pungent compound contents of *kankyo* products.

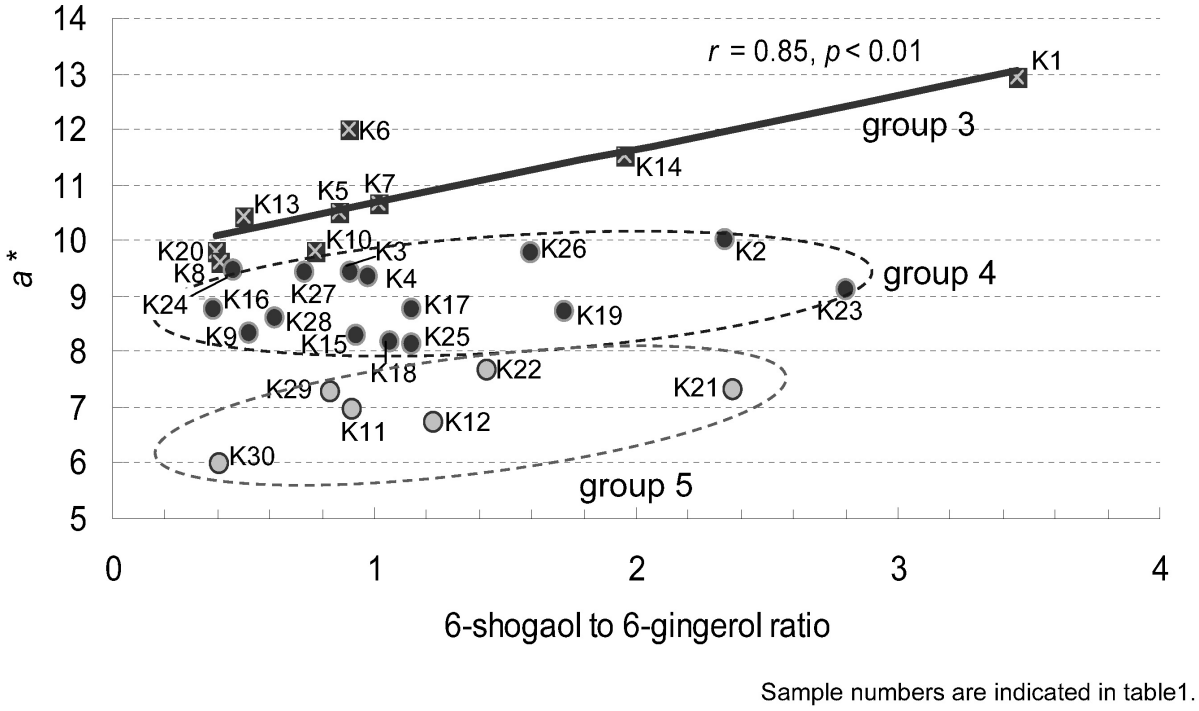


Fig. 7 The relationship between the *a** values and 6-shogaol to 6-gingerol ratios of *kankyo* products.

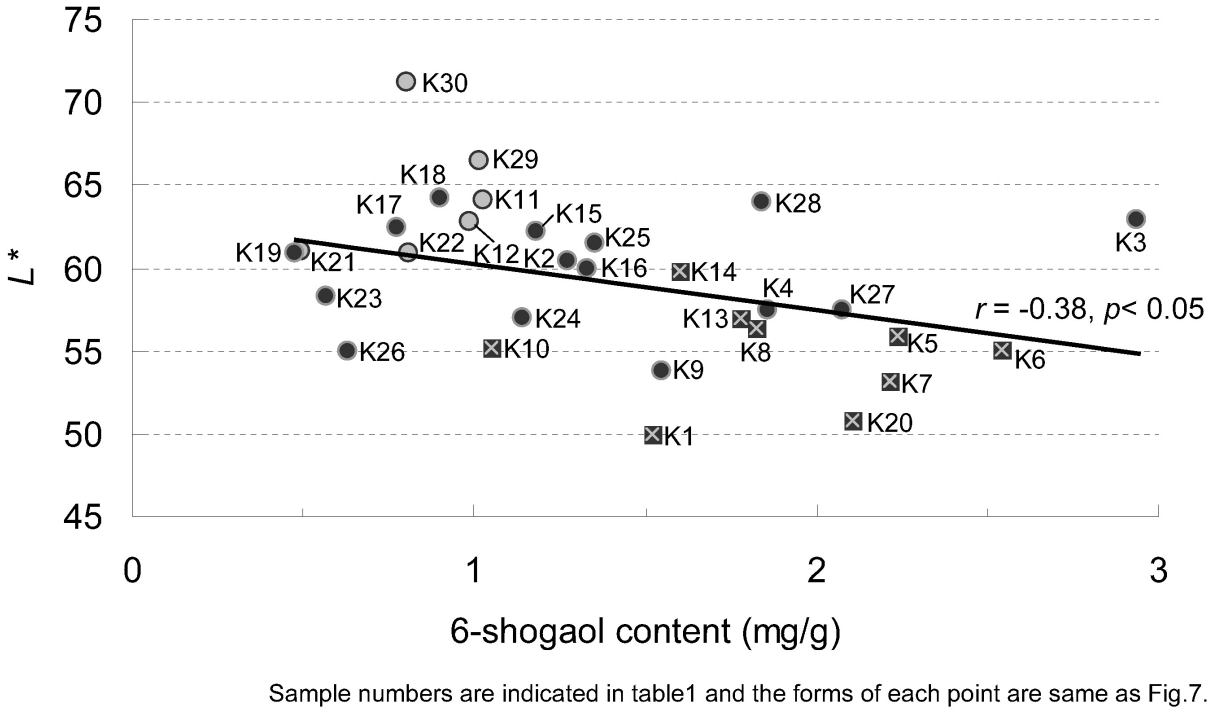


Fig. 8 The relationship between the *L** values and 6-shogaol contents of *kankyo* products.

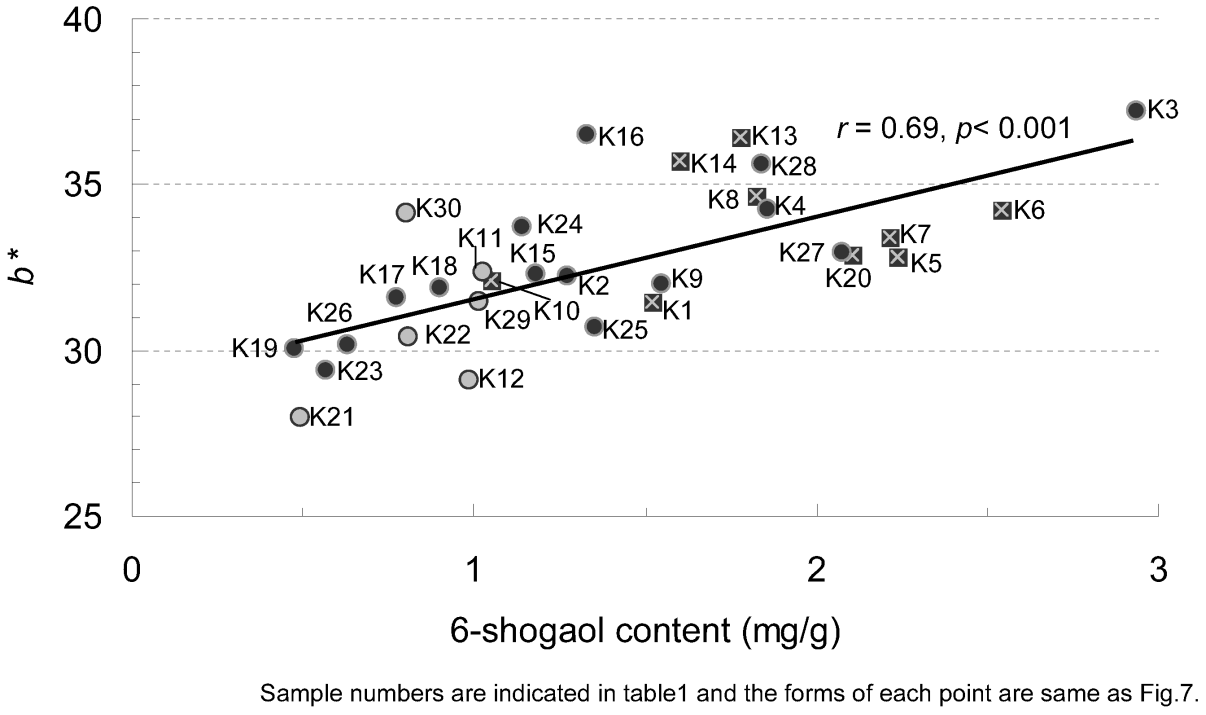


Fig. 9 The relationship between the *b** values and 6-shogaol contents of *kankyo* products.

ples in group 1 was negatively correlated with their 6-shogaol contents (r = -0.78), and the value of group 2 tended to negatively correlate with their 6-shogaol contents (Fig. 4). While their *b** values were not correlated with their 6-shogaol contents (Fig. 5).

The relationships between the color values and pungent compound contents of the *kankyo* products: The 6-gingerol contents of the *kankyo* products were 1.82 ± 1.34 mg/g (ranged from 0.20 to 5.35 mg/g), while their 6-shogaol contents were 1.40 ± 0.63 mg/g (ranged from 0.45 to 2.94 mg/g) (Fig. 6).

When we plotted the relationships between their *a** values and [S/G] on a graph, the samples were divided into three groups; i.e., one in which the samples' *a** values (> + 9.5) were positively correlated with their [S/G] (r = 0.85) (group 3), a second group in which the samples' *a** values were around + 9 regardless of their [S/G] (group 4), and a third group in which the samples' *a** values were less than + 8 (group 5) (Fig. 7).

In addition, the *L** values of the *kankyo* products were slightly negatively correlated with their 6-shogaol contents (r = -0.38), regardless of which group they belonged to (Fig. 8), while their *b** values were positively correlated with their 6-shogaol contents (r = 0.69) (Fig. 9).

Discussion

We estimated the quality of processed ginger products according to their color values and pungent compound contents as follows:

1. The relationships between the *a** values and [S/G] of the *shokyo* (*Gan Jiang*), *Pao Jiang*, and *Jiang Tan* products were mainly divided into two groups; i.e., group 1 displayed a logarithmic correlation between these two parameters (r = 0.77), while the *a** values of the group 2 samples were lower than + 2 regardless of their [S/G].

We[9] previously elucidated that the *a** values of ginger samples that had been heated at 180℃ were logarithmically correlated with [S/G] (Fig. 1). In this study, those relationships of the group 1 samples also displayed logarithmic correlation. Although the drying temperature of group 1 samples might not be so higher than 180℃, we think that the *a** values of the group 1 samples differed according to the strength at which they

were heated. Thus we found group 1 samples were dried high temperature, and those samples of *a** value can estimate [S/G] values.

The surface colors of the samples belonging to group 2 were relatively white. Among them, S4 and S5 samples had been processed with a small amount of sulfur and have been bleached, thus another samples might be also blanched. Otherwise there is another possibility that the ginger has been dried at quite low temperature, which does not affect surface color. Thus we need further examination for determining those processing methods.

2. The *L** values of the samples belonging to group 1 was negatively correlated with their 6-shogaol contents (r = -0.78), and those two values of group 2 samples tended to correlate. Therefore *L** values were found to be useful for predicting the 6-shogaol content of the *shokyo* samples of which processing methods were already clear.

3. Almost no pungent compounds were present in sample S22, which was purchased at Shanghai market. The sample displayed a mixture of two colors; i.e., some of the sample was white while the rest was whitish-brown. When S22 was crushed, we found that its surface was very crumbly so it might have been subjected to a process that caused its pungent compounds to break down.

4. The *a** value of S23, which was purchased at Hong Kong market, was higher than those of the group 1 samples. However, it was similar to those of the group 3 *kankyo* products (Fig. 7). Thus, we think that the sample was subjected to steaming before being dried, even though it was sold under the name *Gan Jiang*.

5. *Kankyo* products were divided into 3 groups by the relationships between the *a** values and [S/G]; i.e., group 3 displayed a positive correlation between the two variables, group 4 displayed *a** values of around + 9 regardless of the [S/G], and group 5 demonstrated *a** values of less than + 8. We[9] previously elucidated that the *a** values of steamed ginger products were positively correlated with their [S/G] and that the *a** values of ginger samples that have been soaked in hot water remained constant regardless of their [S/G] (Fig. 1). Therefore, we estimated that the group 3 and 4 samples had been subjected to steaming and soaking in hot water, respectively.

However, in this study, other samples belonged to group 5. Thus, we examined other processes that might have been used to produce these samples, i.e., soaking ginger in water that had been heated to 70℃ or less, or soaking ginger in hot water without peeling the skin off, and we found that the *a** values of the ginger samples soaked in water that had been heated to 70℃ or less were lower than those of the ginger samples soaked in water heated to 100℃ (data not shown). Therefore, we think that the group 5 samples were prepared by soaking them in warm water.

Thus, we found that the combination of *a** value and [S/G] is useful for evaluating the processing methods of *kankyo* as well as *shokyo* (*Gan Jiang*) products.

6. We found the 6-shogaol content of group 3 samples were higher than those of group 5 samples (Fig. 8, Fig. 9). We think the transformation of 6-gingerol to 6-shogaol did not proceed significantly in the group 5 samples because the temperature of boiling water was not higher. While, we previously indicated that steaming was the best way to produce ginger with a high 6-shogaol content, and it also coincident commercial ginger products.

7. The *L** values of the *kankyo* products were slightly negatively correlated with their 6-shogaol contents, regardless of the group they belonged to. However, the correlation coefficient for this relationship was relatively low. Two types of *kankyo* products are sold in Japanese markets; i.e., those in which the peel has and has not been removed; thus, we think that this difference might affect the color value of *kankyo* products and hence decrease the correlation coefficient between their color values and 6-shogaol contents.

8. The *b** values of the *shokyo* (*Gan Jiang*), *Pao Jiang*, and *Jiang Tan* products were not correlated with their 6-shogaol contents, whereas those of the *kankyo* products were positively correlated with their 6-shogaol contents. However, our previous study showed that the *b** values of processed ginger samples were negatively correlated with their 6-shogaol contents, and we obtained the opposite result for commercial ginger products. Mikage *et al.*[10] previously reported that the *b** values of steamed ginseng samples were higher than those of unprocessed ginseng, which is similar to the findings of this study. Therefore, we think that commercial crude drugs might be subjected to processes that

affect their *b** values, which requires further examination.

9. In this study, we collected many *kankyo* products sold in Japan and found that their pungent compound contents varied. As for K23 and K24, which belonged to group 4 (subjected to soaking in hot water), K23 had been peeled and K24 was unpeeled, and K23 displayed markedly lower pungent compound contents than K24. Thus, we found that *kankyo* products that were processed after being peeled tended to displayed lower pungent compound contents, possibly because these compounds dissolved in the hot water.

10. We previously examined samples of Japanese ginger and obtained the data described in Fig. 1. While this time examined commercial ginger products are mainly derived from Chinese ginger, thus we think color value and pungent compound contents of those samples were different from above data. However we elucidated that the relationship between color value and pungent compound content were similar in Japanese and Chinese ginger.

Conclusion

We found that the combination of *a** values (indicating redness) and the 6-shogaol to 6-gingerol ratios was a suitable index for inferring the processing methods used to produce the processed ginger products. In addition, the 6-shogaol contents of *shokyo* samples, of which the processing method was clearly known, could be predicted by those *L** values (brightness).

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