Bulgarian Chemical Communications, Volume 49, Number 4, (pp. 961 – 968) 2017

Quality grading system of Jadeite-Jade green based on three colorimetric parameters under CIE standard light sources D_{65}, CWF and A

GuoYing*

School of Gemology, China University of Geosciences, Beijing, China

Received June 1, 2016; Accepted May 25, 2017

The article deals with the color changes appearing under different light sources due to the individual and combined effects of lightness, hue and chroma. As a result, a green color grading system is created based on color evaluation from its appearance. We tested the color of 277 pieces of green jadeite specimens using Color i5 spectrophotometer based on CIE 1976 L*a*b* uniform color space and Munsell color matching system. It was concluded that the CIE standard light source D_{65} is more suitable for assessing jadeite-jade green compared with the CIE standard light sources CWF and A. After the alternate use of light sources D_{65} and A, the color shows a slight yellow tone. While the light source changed from D_{65} to CWF, the lightness of jadeite-jade green decreased sharply. The jadeite-jade green concentrates on the lightness scope of (5.64, 61.96), and most of them focus on the scope of moderate to brighter lightness of (30, 60). It is shown that the optimal green of jadeite-jade is deep and dark. The support vector machine (SVM) predicts that 20 of 35 unclassified jadeite-jade cabochons should have a corresponding level based on the color green grading system of jadeite-jade. Taking into account the combination of theory and practice, the conclusion is drawn that the color green grading system of jadeite-jade should be calculated in the CIE 1976 L*a*b* uniform color space combined with the Munsell color system for physical color comparison.

Keywords: Jadeite-Jade green, CIE standard light source, Color grade, Quality grading of Jadeite-Jade green

INTRODUCTION

Jadeite-jade is the uncrowned king of all kinds of jade, and it is the latest representative of China jade culture which lasts for thousands of years, and is eagerly pursued by modern Chinese. But because of the structure of polycrystalline aggregation and almost the whole range of transparency and color, jadeite-jade quality evaluation, especially color evaluation is always an unrevealed problem. Gemologists from the world have tried many ways for several decades, but the effect is not ideal, such as jargons combined with industry experience and commercial estimation. Strong, intense, vivid, right and even are the terms widely spread in hundreds of years for the qualitative evaluation of jadeite-jade color standard, for example apple green, vivid green. Although experts can appraise jadeite-jade according to their experience, due to the lack of modern quantitative analysis, it could not be used as the color grading standard. Based on color evaluation, Gem Dialogue is recommended by the American association of Gem stone (AGS). It is composed of 21 pieces of transparent color scales and transparent black-grey, opaque black-white and transparent brown masks, respectively. Each of these 21 color scales has 10 strips with different color chroma, and each of these 3 masks has 10 strips with different grey level from black to white, so a total of 60000 kinds of color chip combinations will be formed together with color scale and mask. However, this color specification system is supported by subjective evaluation by the naked eye and lacks a complete theoretical system, so to evaluate the different combinations of color scale and color mask, there is no only color scheme for the same color sample. On account of this, China gem faculties attempted to try unified standards to regulate jadeite-jade quality evaluation, and encourage industry. But with the booming development of jewelry industry and rapid gemological progress, these standards also gradually exposed some problems [1,2]. The provincial standard Jadeite-jade Jewelry Grading was issued in 2003 from the Yun Nan province, with the help of Gem Dialogue (GIA) and Gem Set (GIA). A photo album was issued according to the two most widely used international color description and classification systems of gemstones. But this does not avoid the disadvantage of subjective quantitative description and the practical problems such as color fades through ageing; therefore it is not good for color difference presentation of high-quality jadeite-jade color. Another example is the GB/T 23885-2009 Jadeite Grading issued in 2009 [3], which is an attempt to evaluate and classify the quality of jadeite-jade color. While not applied in the jewelry industry, it still takes an abandoned CIE 1931 two-dimensional

* To whom all correspondence should be sent:
E-mail: guoying@cugb.edu.cn

color system as the theoretical basis. In that system the color tone is described as a dominant wavelength, the color purity or excitation purity (Pe) is described as chroma, Gem Dialogue grey scale is described as lightness, and Gem Dialogue is regarded as the color matching system. The standard appendix B illustrates that jadeite-jade (green color) color evaluation should employ a spectral photometric method of color measurement with an alternative standard light source A (color temperature 2856K) or D (color temperature of D_{65} is 6504K). It is well known that the color temperature difference of different light sources, background color difference of different chroma and different illumination intensity can affect the jadeite-jade color appearance apparently, which leads to additional color and illuminant metamerism [4-10], and especially to high chroma color.

EXPERIMENTAL

Materials

277 pieces of cabochon jadeite-jade with smooth surface, fine texture and good purity were selected as samples. All gemstones were sized from 6mm×8mm×5mm to 8mm×10mm×7mm that is below the upper limit of the national standard 50mm×30mm×50mm. They displayed even color within the range from bluish green to vivid green to yellowish green, with continuous changing of color shade and depth.

Analytical methods

Spectrophotometer Color i5 was used to collect reflective signals from the jadeite-jade surface *via* the integrating sphere. Testing conditions: geometry D\8 tri-beam simultaneous SCE, specular component setting-excluded (SCE), light source D_{65} with light source A and CWF calibrated, measurement time < 2.5 sec (flash & data acquisition), spectral range 360 to 750 nm, wavelength interval 10 nm, voltage 240V, current 50~60HZ.

The research followed three steps: firstly, the three-dimensional coordinates L*, a*, b* of jadeite-jade green were quantitatively tested in the CIE 1976 L*a*b* uniform color space, so the distance of each couple of points could be calculated to show their color difference; secondly, based on that, the color metamerism characteristics could be confirmed, and the color evaluation system would be set up while the lightness is taken as the primary factor; thirdly, with the correction of most popular color system Munsell, the final color grading system of jadeite-jade green is formed which has 5 grades from the top grade to the last, and is in accordance with international gem color grading system.

RESULTS AND DISCUSSION

Jadeite-jade Green under Different Light Source

For a specific CIE observer and standard light source, if two jadeite-jade color with same tristimulus values have different spectral power distribution within the visible spectrum, these two color called metamerism color [11]. Its measurement includes alternating standard observer and alternating light source, while the method of light source alternation is often used, especially for small size gemstone samples.

For the sake of significantly different color distribution of jadeite-jade green under three CIE standard light sources it is required that the contribution to jadeite-jade color appearance from the smoothness of the spectral power distribution curve and the effect on the color rendering should be analyzed. The plot areas of L*, a*, b* are significantly different, and with the temperature increase they gradually move toward the blue area, as shown in Figure 1.

It is confirmed that the CIE standard light source A is more suitable for the performance of low chroma or bluish green samples for its orange to red background, and as a result it benefits the chroma promotion of green with the naked eye because its orange-red background significantly turns jadeite-jade green into a warm color. CIE standard light source CWF is more suitable for the performance of jadeite-jade bluish green, its light yellow and light fluorescence can promote stone chroma and make the color greener. CIE standard light source D_{65} is more suitable for the performance of lightness and transparency of jadeite-jade green because of its high color temperature and slight blue background, such as for nearly colorless and transparent glass-like samples with fine texture. But D_{65} is not suitable for the performance of jadeite-jade green with blue tone, because it will reduce the chroma of green especially compared with the other two CIE standard light sources. China National Standard GB/T23885-2009 “Jadeite-Jade Grading” defines that the upper limit of color temperature of the light source should be below 5503K, that is, the CIE standard light source D_{55}. Both D_{55} and D_{65} are the light sources recommended by CIE to simulate the sun light, so they exhibit very close appearance of CIE standard green and CIE high chroma green with small color difference less than 3, which belongs to the just perceivable range by the naked

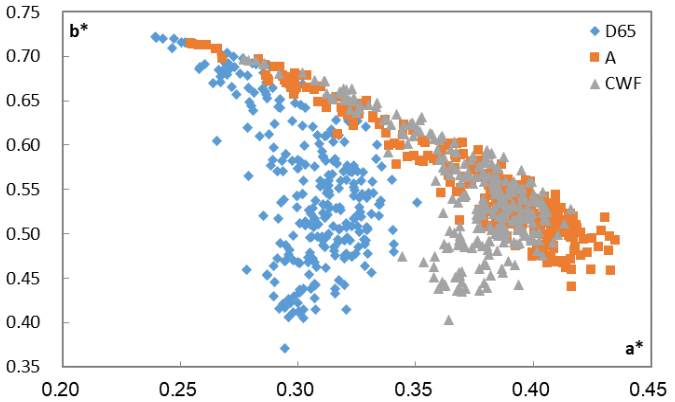

Fig. 1. Chromatic diagram of Jadeite-Jade green under 3 CIE standard light sources D_{65}, A and CWF

Table 1. Imitation of CIE Standard green color under different light sources

	D_{65}(6504K)	A(2856K)	CWF(4500K)	D_{55}(5503K)
CIE standard green				
CIE 1976 L*a*b*	56, -32, 0	52.49, -29.08, -9.85	53.43, -22.20, 1.59	55.54, -31.67, -1.68
RGB	55, 149, 133	33, 138, 140	84, 140, 125	51, 149, 136
Main-wavelength	——	509 nm	——	——
color difference	——	$\Delta E_{D65\text{-}A}$=10.86	$\Delta E_{D65\text{-}CWF}$=10.26	$\Delta E_{D65\text{-}D55}$=1.77
CIE standard high chroma green				
CIE 1976 L*a*b*	56, -45, 0	51.22, -43.30, -12.72	52.34, -33.28, 0.82	55.40, -45.00, -2.08
RGB	0, 154, 133	0, 141, 141	39, 134, 124	0, 151, 134
Main-wavelength	——	534 nm	——	——
color difference		$\Delta E_{D65\text{-}A}$=13.69	$\Delta E_{D65\text{-}CWF}$=12.31	$\Delta E_{D65\text{-}D55}$=2.16

Table 2. Correlation coefficients of the mean values of L*, a*, b*, C* and $\overline{h_0}$ under 3 measuring light sources

	$\overline{L^*}$			$\overline{a^*}$			$\overline{b^*}$			$\overline{c^*}$			$\overline{h_0}$		
D_{65}	D_{65}	A	CWF	D_{65}	A	CWF	D_{65}	A	CWF	D_{65}	A	CWF	D_{65}	A	CWF
D_{65}	1	—	—	1	—	—	1	—	—	1	—	—	1	—	—
A	0.999	1	—	0.988	1	—	0.991	1	—	0.987	1	—	0.979	1	—
CWF	1	0.999	1	0.986	0.995	1	0.967	0.954	1	0.980	0.948	1	0.925	0.930	1

$$\Delta E_{2000} = \sqrt{\left(\frac{\Delta L'}{k_L S_L}\right)^2 + \left(\frac{\Delta C'}{k_C S_C}\right)^2 + \left(\frac{\Delta H'}{k_H S_H}\right)^2 + R_T\left(\frac{\Delta C'}{k_C S_C}\right)\left(\frac{\Delta H'}{k_H S_H}\right)} \quad \textbf{CIE 2000}$$

$$\Delta E_{LAB} = \sqrt{\left(\Delta L^*\right)^2 + \left(\Delta a^*\right)^2 + \left(\Delta b^*\right)^2} \quad \textbf{CIE LAB}$$

eye. Consequently, D_{55} can act as a light source for jadeite-jade evaluation, as shown in Table 1.

Considering the light source and the characteristics of jadeite-jade green, each CIE standard light source has its advantages for their different spectral power distribution. The conclusion can be drawn: compared with CIE standard light sources A and CWF, the light source D_{65} is more suitable for the jadeite-jade green evaluation.

Effect of light source change

The analysis of the impact from different CIE standard light sources on jadeite-jade green should be done from lightness (L*), chromaticity coordinates (a* and b*), chroma (C*) and hue angle (h_o), respectively based on the CIE 1976 L*a*b uniform color space, as shown in Table 2.

The color differences from the light source alteration were calculated in pairs.

CIE 2000 formula is the latest color difference formula recommended by CIE, including not only also a cross-function which is similar to the BFD formula. So, as a result, the capability of the neutral gray color prediction is improved. But because of the low resolution of green, the basic color difference has the greatest influence on the color difference from Δa* and the color appears as lightly yellowish. Formula CIE LAB is used within the uniform color space instead of CIE 2000, the results are shown in table 3.

Table 3. General averages of ΔE*, ΔL*, Δa*, Δb*, ΔC*, Δho obtained with 277 pieces of jadeite-jade according to 3 measuring light sources

	$\overline{\Delta E^*}$	$\overline{\Delta L^*}$	$\overline{\Delta a^*}$	$\overline{\Delta b^*}$	$\overline{\Delta c^*}$	$\overline{\Delta h_0}$
$D_{65} \to A$	8.36	1.89	-3.63	7.30	7.46	-3.94
$D_{65} \to A$	8.33	0.78	-8.05	-1.98	3.93	9.07
$A \to CWF$	10.33	-1.11	-4.42	-9.27	-3.53	13.01

Compared with the CIE standard light source D_{65}, the lightness of jadeite-jade green decreased greatly under A, and this is obviously the result of the decrease in color temperature from D_{65} to A (6504K to 2856K). The sharp increase of chromaticity coordinates a* reveals a change to the direction of red, while the sharp decrease of chromaticity coordinates b* reveals a change to the direction of blue. And for the sake of the greatest influence on color difference from Δb*, the color appearance shows a slight yellow tone after light source alteration from D_{65} to A.

The lightness of jadeite-jade green decreased sharply when the light source changed from D_{65} to CWF, which is related to the decrease in color temperature from 6504K to 4150K. The sharp increase of chromaticity coordinates a* reveals a change to the direction of red tone, while the light increase of chromaticity coordinates b* reveals a change to the direction of yellow tone. For the sake of the greatest influence on color difference from Δa*, the color appears lightly yellowish green after light source alteration. The different color temperature of the different light sources has an effect on jadeite-jade green, for example, if under the same illuminance, the lightness and chroma of green will gradually increase with the increase in color temperature of the light source. The color appearance of jadeite-jade changes is obviously accompanied by changes in light source illuminance. As a result, with the increase in light source illuminance, both visual chroma and visual lightness would increase, and both color saturation and lightness would also increase (Hunt effect and Stevens effect). Jadeite-jade green can appear brighter when illuminated by a high illuminance lightness, chroma and hue weighed function, but light source, and the color grade can be noticed by the naked eye.

This illustrates that the light source alteration (D_{65}→A, D_{65}→CWF, A→CWF) has little impact on the lightness, while it has bigger impact on the chromaticity coordinates and chroma, and has the biggest impact on hue angle. So, it is concluded that the green tones can present obvious visual difference in the process of light source conversion.

Grade by lightness

Under the circumstance of standard light source A, the dominant wavelengths λ of the 277 pieces of cabochon jadeite-jade were tested in the range of 513-562 nm. The dominant wavelengths of 58 samples were higher than 550 nm and were not graded as green according to Jadeite Grading, though they showed apparent vivid green with the naked eye. The chroma of 219 pieces of jadeite-jade was calculated and graded. 13 pieces of jadeite-jade were not classified to any chroma level for the sake of Pe<10.

Jadeite Grading introduces a grey scale of Gem Dialogue, and grades 206 pieces of green jadeite-jade chroma at four levels consequently, that is, 19 pieces of V1 with G<10, 113 pieces of V2 with 10≤G<30, 55 pieces of V3 with 30≤G<*50*, and 19 pieces of V4 with G≥50.

The results revealed that compared with the equal lightness L* of yellowish green jadeite-jade, there is a little grey tone in the visual effect, and black/grey masks are always used with the grey scale range of 10-40. Lightness of yellowish green usually belongs to V2, while the grey scale is significantly stronger only when the color is dark, such as jargons of "Yin green" and "Melon-Peel green". Among them the yellowish green of jadeite-jade with L*∈(38, 55) is the main source of V1, and is also the main source of high-quality green jadeite-jade, such as "Huang-Yang green". The value of low-lightness jadeite with grey scale G≥30 (especially G≥50) will decrease.

In the uniform color space CIE 1976 L*a*b*, CIE stipulates that the lightness of green and high chroma green is 56, the lightness of yellowish green and high chroma yellowish green is 65, that is L*=56 while green jadeite-jade has optimum chroma C*=45, and L*=65 while yellowish green jadeite-jade has optimum chroma C*∈(16.40, 49.20).

Through the measurement of Color i5, the lightness of 206 pieces of jadeite-jade green

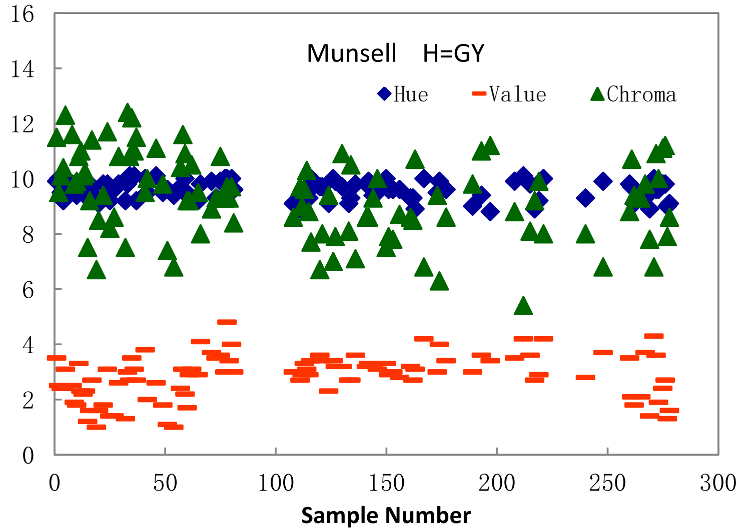

Fig. 2. Color parameters of 105 pieces of jadeite-jade greenish yellow under Munsell color system

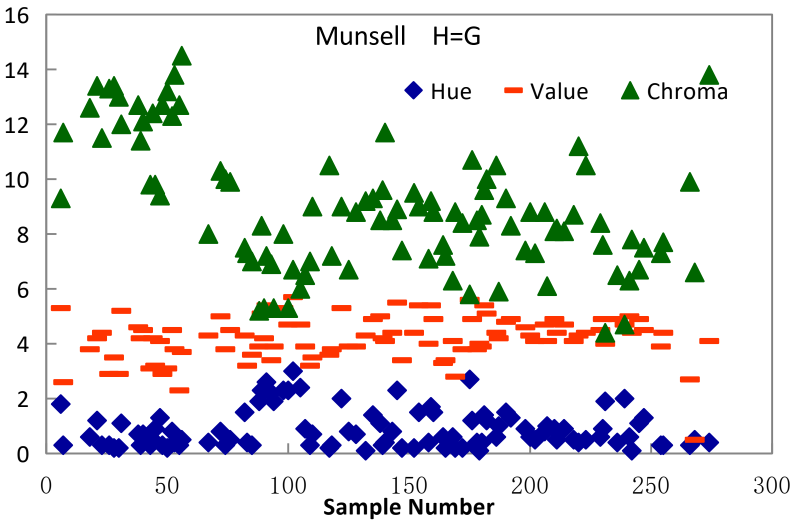

Fig. 3. Color parameters of 101 pieces of jadeite-jade green under Munsell color system

concentrates on the scope $L^* \in (5.64, 61.96)$, and most of them focus on the scope of moderate to brighter $L^* \in (30, 60)$, but failed to meet the best green lightness. This agrees with the deep tone of visual effect of jadeite-jade vivid green or yellowish green. Through comparison of samples and Munsellcolor chips, the better moderate lightness is testified adequately, see Figs. 2 and 3. They illustrate that the optimal color of jadeite-jade green has a relative low lightness, meaning that the optimal green of jadeite-jade is a little deep and dark, but not the standard green of color science.

Quality grading of jadeite-jade green

According to Jadeite Grading, the quality of color green of 206 pieces of jadeite-jade should be graded into 5 levels from excellent (12 pieces) to very good (71 pieces), good (22 pieces), fair (51 pieces) and poor (15 pieces), described as the acronyms EX, VG, G, F and P. Other 35 pieces did not belong to any level. According to the known level of samples, the tested lightness and chroma data of 206 samples, using Support Vector Machines (SVM) the vacancy levels in Table 3 and 35 unknown level samples were predicted, see Table 4.

Table 4. Evaluation sheet of jadeite-jade green color

	Ch1	Ch2	Ch3	Ch4	Ch5
V1	EX	EX	VG	G	G_p
V2	VG	VG	G	F	G_p
V3	F	F	F	P	P
V4	F_p	F_p	F_p	P	P

Note: G_p and F_p are SVM predicted level G and F

SVM is put forward by Vapnik in the mid-1990s, based on a statistical theory, an application of the theory of VC dimension and structural risk minimization principle, with the aid of optimization methods [12,13] such as a machine learning algorithm. It has unique advantages in solving small samples, nonlinear and high dimensional pattern recognition problems [14]. But its performance by

Table 5. Grade F by prediction and evaluation of jadeite-jade green color

Predicted Level F	16# Pe=84.6 G=50	9# Pe=79.0 G=50	22# Pe=77.8 G=50	10# Pe=92.1 G=50	49# Pe=85.6 G=50	60# Pe=89.3 G=50	20# Pe=88.4 G=50	27# Pe=91.1 G=60	262# Pe=93.0 G=50
Known Level F	273# Pe=86.2 G=40	42# Pe=83.3 G=40	265# Pe=71.5 G=40	13# Pe=73.6 G=40	14# Pe=74.5 G=30	12# Pe=80.5 G=40	59# Pe=78.8 G=40	55# Pe=89.2 G=30	4# Pe=85.9 G=30
Predicted Level F	49# Pe=85.6 G=50	198# Pe=19.4 G=10	236# Pe=14.9 G=10	192# Pe=18.7 G=10	230# Pe=18.3 G=10	159# Pe=18.1 G=10	6# Pe=18.4 G=10	102# Pe=17.0 G=10	
Known Level F	261# Pe=85.1 G=40	158# Pe=25.4 G=20	167# Pe=25.2 G=20	160# Pe=20.0 G=10	210# Pe=20.4 G=10	181# Pe=22.3 G=10	89# Pe=25.8 G=10	122# Pe=26.9 G=10	

Table 6. Level G by prediction and evaluation of jadeite-jade green color

Known level F	82# Pe=16.9 G=20	247# Pe=17.2 G=20	154# Pe=18.5 G=20
Measured Level F	127# Pe=41.1 G=20	67# Pe=30.4 G=20	145# Pe=26.4 G=8

the error penalty parameter *c* and its greater influence on the form of kernel function and its parameters, applied to many kinds of classification was not good enough, so the classification accuracy should be improved [15,16].

The model trained by SVM is verified by the test set samples, its accuracy is 86.21%, and can be used to do prediction [17], and the unasserted levels are listed in Table 4. There are 35 pieces of unasserted samples. 19 of them with Pe∈(65, 100) and G∈(50, 100) are graded as level F, while among the rest, 16 with Pe∈(10, 20), G∈(10, 20) , 9 pieces are graded as level G and 7 pieces are graded as level F. The quality of jadeite-jade green rapidly decreased with reduced lightness, so good quality jadeite-jade usually has a fancy intense color, which corresponds to the experimental prediction. Only the prediction of Ch5-V2 is a little higher than what it should be at level F even below.

Compared with computer color simulation, the results of level F and G of color grade predicted by SVM are listed in Tables 5 and 6. Predicted 9 pieces of F samples and 6 pieces of G samples did not match the corresponding color close to already known levels of the samples. Although SVM prediction is possible, this proves that the existing green jadeite-jade grading system has obvious flaws.

CONCLUSIONS

When the color temperature of the light source gradually increases, stone color turns little by little to blue. Compared with the CIE standard light source D_{65}, the lightness of jadeite-jade green greatly decreased under CWF and A, which can obviously present visual difference. Taking into account light source and samples, D_{65} is more suitable as the light source for jadeite-jade green compared with the sources CWF and A.

As an independent colorimetric parameter, lightness is relatively in accordance with the visual effect of jadeite-jade green, e.g., the optimal color of jadeite-jade green is not the standard green of color science, but a little deep and dark.

There are 3 problems in the current jadeite grading systems: 1. Some good-quality green jadeite-jade, as “Fu-Rong” jadeite-jade, could not be included in the grading system, because its green and yellowish green is with the main wavelength more than 550nm; the second is green under naked eye but with relative low excitement purity (Pe<10), it always has the typical color of “Jin-Si” jadeite-jade. 2. For all color parameters considered separately, the weight of their contribution to the color is not comprehensively taken into account. As a result, some good-quality green samples under naked eye are out of the grading system. 3. There are 35 samples predicted by SVM, 17 and 3 pieces of them predicted as level F and G, respectively, that are matched with already known levels, so they can be involved in the jadeite grading system; but the other 9 and 6 pieces of them are predicted as level F and G, respectively, that are unmatched with already known levels, so there are obviously some disadvantages in the current system.

Gem quality evaluation of green [18] is a complex system. Gem colors will be simultaneously determined by the lighting source, observation conditions (including the background) and its own conditions. So the first factor is the light source effect [19,20]. The second factor is the impact on the visual lightness of the green color under neutral background, and if possible, all psychological factors such as color constancy should be considered. Because of the dependency of hue and chroma, the relative independent lightness should be first considered when the object color is taken into account [21], and then the weights of their respective contributions to the color appearance should be comprehended to make an operable color grading system of jadeite-jade.

Based on the combination of theory and practice, CIE 1976 L*a*b* uniform color space is recommended as measuring system, and Munsell color system is recommended as object matching system.

REFERENCES

1. Bureau of Technical Supervision of the Quality of Yunnan Province. DB53/T 102-2002 Local Standard in Yunnan Province-Jadeite Jewelry Grading. *Beijing: Standards Press of China*, 2002-11-1.
2. Bureau of Technical Supervision of the Quality of Yunnan Province. DB53/T 302-2009 Local Standard in Yunnan Province-Jadeite Jewelry Quality Grade Evaluation. *Beijing: Standards Press of China*, 2010-3-1.
3. GB/T 23885-2009, Jadeite Grading, China National Bureau of Technical Supervision. Chinese National Standards. *Beijing: Standards Press of China*, 2009-6-1.
4. E. C. Fuchs, K. Gatterer. *Central European Journal of Chemistry*, **6**(4), 497 (2008).
5. H. Xu, M. R. Luo, B. Rigg. Evaluating the Quality of Daylight Simulators Using Metameric Samples. *9th Congress of the International Colour Association*, **4421**, 697-700 (2002).
6. S. H. Kim, Y. K. Lee, B. S. Lim, S. H. Rhee, H. C. Yang. *Dental Materials*, **23**(3):374-379(2007).
7. Z. J. Li, R. S. Berns. *Color Research and Application*, **32**(4), 293 (2007).
8. M. E. L. Leow, W. K. M. Ng, B. P. Pereira, A. K. Kour, R. W. H. Pro *Prosthetics and Orthotics International*, **23(**2), 174 (1999).
9. L. D. Carstensen. *Color Research and Application*, **20**(2), 131 (1995).
10. D. C. Rich, J. Jalijali, *Color Research and Application*, **20**(1), 29 (1995).
11. M. Melgosa, E. Hita, *Optik (Jena)*, **107**, 5 (1997).
12. R. Li, Y. E. Shiwei, Z. Z. Shi, *Acta Electronica Sinica*, **30(**5), 745 (2002).
13. B. Gou, X. W. Huang, SVM *Journal of Data Acquisition & Processing*, **21**(3), 334 (2006).
14. Z. W. Xing, H. Zhang, Machine. *Computer Technology and Development*, **22**(6), 247 (2012).
15. G. H. Feng, *Computer Engineering and Applications*, **47**(3), 123 (2011).
16. X. X. Niu, K. H. Yang, *Information Technology*, **11**, 19 (2006).
17. Q. Y. Zhang, X. L. Feng, H. L. Long, J. J. Suo, D. D. Zhang, L. Z. Xu, L. Xu, *Acta Chimica Sinica*, **70**(8),989 (2012).
18. Y. Guo, X. Li, H. M. Du, H. J. Sun, Green Color Appreciation of Gemstones Based on CIE 1976

L*a*b*. *2011 International Conference on Multimedia and Signal Processing,* Guilin, Guangxi China, May 14-15, 2011, *DOI:*10.1109/CMSP.47.2011
19. H. Wang, Y. Guo, Y. Zhang, *Key Engineering Materials*, **492**, 374 (2011).
20. Y. Guo, J. Zhang, T. Mo. A*dvanced Materials Research*, **177**, 620 (2010).
21. H. M. Du, Y. Guo. Optical influence of different standard illuminants on green nephrite's color From Manasi. *Proceedings of Conference 7844 Semiconductor Lasers, Solid State Lighting & Applications*, **7844**,784411 (2010).

СИСТЕМА ЗА ОЦЕНКА НА ЗЕЛЕНИЯ ЦВЯТ НА ЖАДЕИТ-НЕФРИТ НА ОСНОВАТА НА ТРИ КОЛОРИМЕТРИЧНИ ПАРАМЕТРА НА CIE СТАНДАРТНИ СВЕТЛИННИ ИЗТОЧНИЦИ D_{65}, CWF И A

Гуо Инг*

Училище по гемология, Университет по геонауки, пекин, Китай

Потъпила на 1. юни 2016; Приета на 25. май 2017

(Резюме)

Изследвани са промените в цвета при облъчване с различни светлинни източници, като е оценено влиянието на факторите светлост, оттенък и хрома поотделно и заедно. В резултат е създадена система за оценка на цвета, основаваща се на външния вид. Изследван е цветът на 277 образци от зелен жадеит-нефрит с помощта на спектрометър Color i5 на основата на еднородното цветово пространство CIE 1976 L*a*b* и системата на Munsell за цветово съвпадение. Резултатите показват, че стандартният CIE светлинен източник D_{65} е по-подходящ за оценка на зеления цвят на жадеит-нефрит в сравнение със стандартните източници CWF и A. След последователно използване на източниците D_{65} и A, цветът показва лек жълт нюанс. Когато източникът се сменя от D_{65} на CWF, светлостта на жадеит-нефритовия зелен цвят рязко намалява. Светлостта на зеления цвят на образците от жадеит-нефрит е в областта (5.64-61.96), като по-голямата част е със средна до висока светлост (30-60). Показано е,че оптималният цвят на жадеит-нефрита е дълбок и тъмен. Помощният векторен инструмент предсказва, че 20 от 35 некласифицирани кабошони от жадеит-нефрит би трябвало да са на съответното ниво от системата за оценка на зеления цвят. Имайки пред вид комбинацията от теория и практика е направен изводът, че системата за оценка на зеления цвят на жадеит-нефрита трябва да се одновава на еднородното цветово пространство CIE 1976 L*a*b* в съчетание с цветовата система на Munsell за физично сравняване на цвета.