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METHODS OF NOTATION OF THAI MURAL PAINTING COLOURS BY CIE AND MUNSELL SYSTEMS*

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ABSTRACT

A search for the Thai names of colours used in mural painting has resulted in the identification and systematic compilation of some 209 colour names. Fifty colour patches commonly used in mural painting were produced using traditional pigment powder. The correctness of produced colour patches was ascertained by two well-known artists of the Fine Arts Department, Ministry of Education. Two well-known methods, the Munsell and the CIE systems, were used to specify the characteristics of the fifty Thai traditional colours.

For the Munsell system, a glossy edition of the Book of Colour was used. For each patch, two adjacent Munsell constant-hue chips were selected, between which the hue of the specimen lay. The value, chroma and hue were estimated by interpolation or extrapolation of the chip designations, using a 6500 K light source and an illuminance at the surface of 1900 lux.

For the CIE system, the chromaticity coordinates (x,y) and luminance (Y) of the fifty colour patches were measured by an ICS (MicroMatch) spectrophotometer using Illuminant D_{65}.

The notation of Thai mural painting colours by the CIE and Munsell systems and the accompanying publication of fifty colour patches will be helpful in establishing common standards for Thai traditional colours for future and preservation work.

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INTRODUCTION

Few colours were in use when pyramids were built some 5000 years ago,[1] so the Egyptians frequently made use of the traid - yellow, red and blue - often outlining these colours with black. Until the 1860s, the few hundred dyes and pigments in common use were largely derived from molluscs, insects and plants, such as those used in Renaissance times. Then, with escalating speed, commercial dyes and pigments were produced from petroleum products during the twentieth century. By 1980s, the number of discovered colours[2] had reached an astonishing total of 3,000,000, some 9,000 of which have now been marketed.

This increase in the number of colours has created a need for colour identification and nomenclature. One of the oldest collections is that of Antonius Thylesius,[3] published in Latin *(Libellus de coloribus)* in Paris in 1529, which separately named and described 125 colours. Then, a remarkable and unique method of colour identification and nomenclature was devised in 1776 by Moses Harris,[3] where some 72 colours were described in terms that are still recognized today. Other important publications[3] on colour identification and nomenclature are listed, as follows: Werner's *Nomenclature of Colours,* Edinburgh, 1814; Gaspard Gregoire's *Table de Couleurs,* Paris, 1820; D.R. Hay's *A Nomenclature of Colours,* London, 1846; Robert Ridgway's *Colour Standards and Colour Nomenclature,* Washington, 1912; Albert H. Munsell's *Munsell Colour System,* Maryland, 1915; Kenneth L. Kelly's *Colour : Universal Language and Dictionary of Names,* Washington, 1976; and ASTM's *Standard Method for Computing the Colours of Objects by Using the CIE System,*[4] Pennsylvania, 1985. Some of these systems for colour nomenclature can be used as references. However, there are still no systematic colour standards in Thailand.

Tempera is used in traditional Thai mural painting (Plate 1), and is a mixture of pigment powder (Plate 2) and a binder such as glue or arabic gum. Each resulting mixture has a different common name, such as chat (bright red), muang (violet), lueang rong (gamboge). The knowledge used to describe the characteristics of these colours is transferred from art teacher to student from generation to generation. In the past, there have been no publications quantitatively describing the characteristics of Thai traditional colours together with their colour patches, so that knowledge of these colours existed only in the memory of experienced artists. Many attempts have been made to describe colours but trade names of colours are often non-descript and absurd. The artist's colour vocabulary[5] is limited to his profession, while scientific explanations[6] are unintelligible to artists and laymen. Some foreigners, such as Prof. Silpha Bhirasi[7] and Prof. R. Nikolas,[8] have tried to compare some Thai colour names to common English colour names. However, the English common names of colours are themselves not uniform and this only creates further confusion for users. For example, a colour name in a given country may change from one century to another according to the prevailing fashion[9] and a given colour name can notate different colours in different countries.

These difficulties and inconsistencies of colour names came to light particularly during the restoration of the Temple of the Emerald Buddha for the Rattanakosin (Bangkok) Bicentennial celebrations in 1982. The traditional Thai colours on the temple murals were not readily identifiable.

The objectives of the present study are firstly, to produce traditional Thai colour patches through photography and printing to assist future restoration work and secondly, to preserve Thai colours by quantification of their characteristics by two established methods for describing colour, namely the Munsell and the CIE* methods.

MATERIAL AND METHODS

The Munsell colour notation[10] was chosen not only because it can be readily understood by artists and the public but also because it describes colours with great accuracy. This notation is the most widely used system of colour identification today, both in the United States and abroad. Munsell colour notation is a system of letters or numbers or both, whereby the colour of any opaque object may be specified in terms of *hue* (the name of the colour), *value* (the lightness of the colour) and *chroma* (the strength of the colour). Five principal hues are written using their initials: R for red, Y for yellow, G for green, B for blue and P for purple. The intermediate hues between principal hues are YR, GY, BG, PB and PR respectively. The daylight reflectance of a specimen is expressed on a value scale, extending from 0 for ideal black to 10 for ideal white. The departure of a colour from a gray having the same Munsell value is expressed on a chroma scale, extending from 0 to about 20 for the strongest coloured specimens producible. The arrangement of hue, value and chroma scales is shown on Plate 3.

There are approximately 1,490 Munsell notations exemplified in the current glossy finish collection of Munsell standard papers. The Munsell colour notation of a specimen was obtained by visual comparison with the Munsell hue, value and chroma scale of the Munsell Book of Colour.[11] Specimens were viewed by the author and rechecked by two artists. The specimen was placed on a neutral background (middle gray), and illuminated with 6500 K Standard light sources in a Daylight Colour Matching Booth of ASTM designation D 1729-82.[12] A glossy edition of the Munsell Book of Colour was used. Two adjacent Munsell constant-hue chips were selected between which the hue of the specimen lay. Each one was placed on each side of the specimen and the chips were covered with a gray mask,so that the specimen and only one chip could be seen. A mask was moved from chip to chip in order to find the chip that most closely matched the specimen. The value, chroma, and hue were estimated by interpolation or extrapolation of the chip designations.

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* Commission Internationale de l'Eclairage. The English version, ICI, (International Commision on Illumination) is not widely used.

The chips between which the value of the specimen lay were found. The value of the specimen was estimated to the nearest tenth of a one-value-step interval between adjacent values. The estimated value was recorded in front of the slanting lines; for example, 4/X. The mask was moved so as to present successive colours of the same Munsell hue and value but of different chroma, and by interpolation or extrapolation, the Munsell chroma of the colour was determined. The estimated chroma was recorded behind the slanting line; for example, 4/8. Although all Munsell chips of the same chroma notation were intended to yield colour perceptions having the same saturation, a slightly different estimate of chroma may be obtained by comparing the colour specimen with the chips of the next value. In these cases, the estimated chromas were averaged.

The specimen's hue was estimated by interpolation between chips of the nearest Munsell value and chroma in the selected hue chips. The nearest fifth of the 2.5-hue step between adjacent hue chips was estimated. The estimated hue was recorded in front of the value and chroma estimate, and separated from it by a space; for example, 10R 4/8. If the value and chroma of the specimen did not correspond closely to those of any chip, the interpolation of hue with the next closest pair of chips was repeated and the average was recorded.

CIE COLOUR NOTATION

The CIE colour system is a method which uses lightness or luminance, Y, and chromaticity coordinates, x,y, to specify the characteristics of a colour object. Traditional Thai painting colours were also specified by the CIE system. The CIE colour system[13] was chosen because it can correlate visual descriptions with instrumental measurements of colours and facilitates communication between artists and laymen on the one hand, and scientists and technologists on the other.

An ICS (MicroMatch) spectrophotometer was used for measuring the luminance and the chromaticity coordinates. A ten-degree observer angle and D_{65} illuminant were chosen for the measurements.

RESULTS AND DISCUSSION

At least 209 Thai colour names were identified from four Thai dictionaries of arts,[14] two Thai encyclopedias of arts,[15] seven textbooks,[16] seven volumes of archival correspondence[17] and one journal.[18] These names were arranged in Thai alphabetical order. A glossary of Thai colour names was thus compiled for the first time. The Thai names were then romanized using the system prescribed by the Royal Institute,[19] as shown in Table 1. It was noted that many English common names used to describe the characteristics of Thai traditional colours were not uniform and created confusion for users.

Fifty colour patches commonly used in Thai mural painting were produced from traditional pigment powder by Mr. Amorn Sripochanart, a well-known artist of the Fine Arts Department, Ministry of Education. A Daylight Colour Matching Booth,

designed by the author, was constructed in accordance with ASTM designation[11]: D 1729-82. CIE Illuminant D_{65} was used and illuminance at the viewing plane was 1900 lux. The grayness of booth walls was equal to the grayness of a Munsell chip no.7. A Minolta colour temperature meter was used to check the correctness of the colour temperature of light emitted from the light source D_{65} and a luxmeter was used to measure the illuminance at the surface of colour patches. The correctness of produced colour patches was checked by another well-known artist of the Fine Arts Department, Mr. Pinij Suvarnapunya, under 6500 K standard light source of the Daylight Colour Matching Booth.

The fifty colour patches produced from traditional pigment powder were specified in terms of the Munsell and the CIE colour notation systems, according to the methods described above. The results of these analyses are shown in Table 2.

Finally, the fifty colour patches were carefully reproduced on glossy coated papers by means of offset printing. Tone and colour reproduction of the reproduced colour patches were strictly controlled by means of densitometry and matched with the original colour patches under the 6500 K standard light source in the Daylight Colour Matching Booth. Satisfactory results were obtained as shown on Plates 4 and 5.

The Munsell and CIE systems, used here for the specification of Thai mural painting colours, are methods that are easily comprehensible to the general public. These methods describe colours with great accuracy and enable visual descriptions of colours to be correlated with instrumental measurements. This will serve to make the attributes of such colours more comprehensible to artists and laymen. In addition, the characterization and photographic reproduction of some 50 traditional Thai colours will help establish common standards for future restoration work, and help preserve a disappearing facet of the Thai national heritage. However, for a more complete standardization of the Thai traditional colours, a national committee should be formed to represent the three major ministries concerned : the Ministry of University Affairs, the Ministry of Education and the Ministry of Industry.

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Colour plates illustrating the study on Methods of Notation of Thai Mural Painting Colours by the CIE and Munsell Systems

Plate 1
A traditional Thai mural, an episode from the Ramakian, the Thai version of the Ramayana.

Plate 2
A complete range of primary pigment powder.

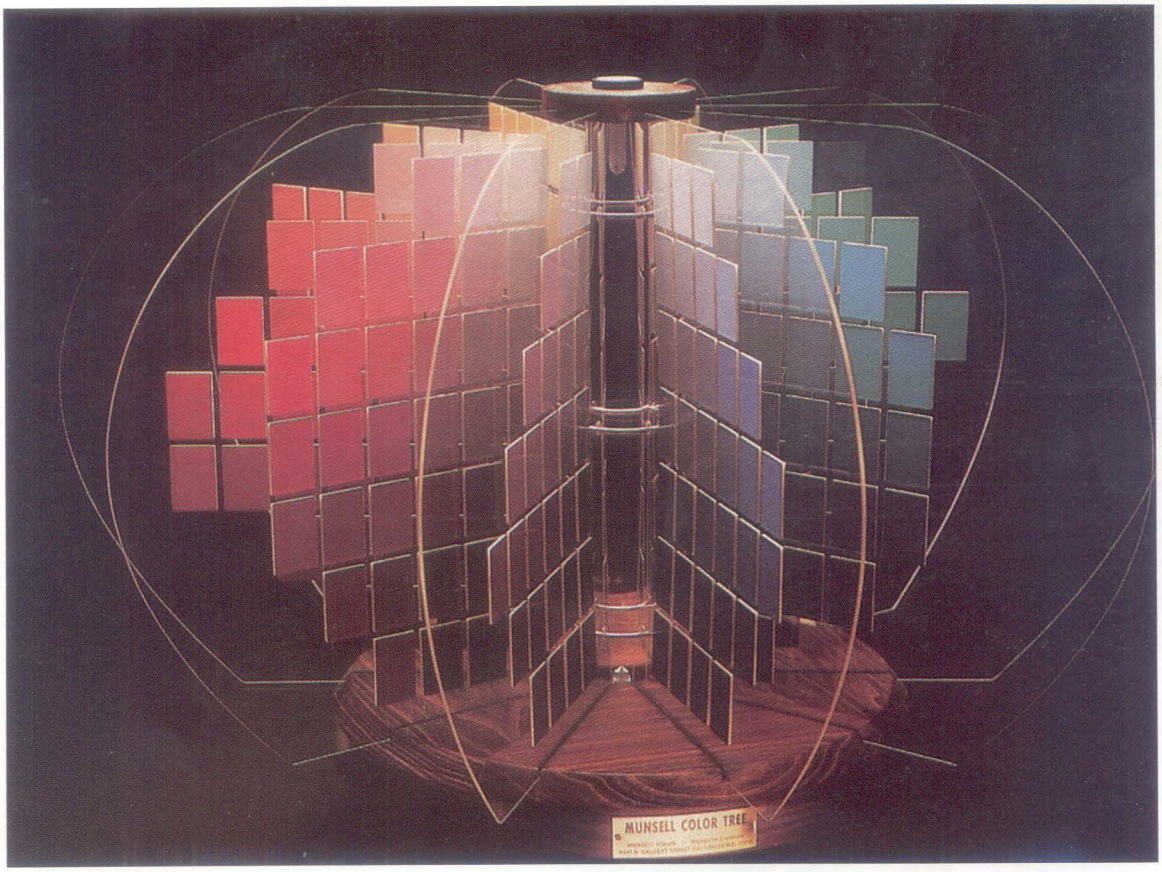

Plate 3 A Photograph of the Munsell Colour Tree or Solid manufactured by Munsell Colour, Macbeth, a division of Kollmorgen, Baltimore, USA. Munsell Colour Notation arranges all colours relative to each other in colour space. All perceptible colours are located by means of their hue, value, and chroma. HUE is the quality of a colour that distinguishes red, yellow, blue, etc. In the Munsell Colour Tree, hues are arranged around the circumference of a circle. VALUE is the lightness of a colour, and on the Tree, colours vary from dark at the bottom to light at the top. CHROMA is the purity or intensity of a colour and increases outward horizontally from the center of the Tree.

N 9.25 / 84.2% R 1.1 Khaufun ขาว (ฝุ่น)	10R 5/4 2.1 Hoangdinklang หงดินกลาง	5PB 3/4 3.1 Mokhramkae มอครามแก่	7.5PB 3/6 4.1 Kroammatha ขาบ (กรมท่า)	2.5BG 3/2 5.1 Khiaukhap เขียวขาบ
7.5R 4/12 1.2 Daengchat แดงชาด (ไต่เซ็ง)	2.5YR 5/6 2.2 Hoangdinkae หงดินแก่	5PB 6/4 3.2 Mokhramklang มอครามกลาง	7.5PB 3/4 4.2 Mekkhram เมฆคราม	10GY 3/4 5.2 Khiaubaikhae เขียวแก่ เขียวใบแค
10R 4/12 1.3 Daengchat แดงชาด (ย่งกิด)	5R 5/10 2.3 Hoangchat หงชาด	5PB 7/4 3.3 Mokhramon มอครามอ่อน	2.5P 5/8 4.3 Dokphaktoap ดอกผักตบชวา	2.5G 4/4 5.3 Khiausamo เขียวสมอ
5Y 8/14 1.4 Lueangroang เหลืองรง	10R 7/8 2.4 Hoangsen หงเสน	N 4.5/ 15.6% R 3.4 Momuek มอหมึก	2.5RP 4/4 4.4 Doktabaek ดอกตะแบก	2.5G 5/6 5.4 Khiautangchae เขียวตั้งแช
7.5PB 2/10 1.5 Khram คราม	2.5YR 6/12 2.5 Hoangsabat หงสบาท	N 6.75/ 39.5% R 3.5 Momuekon มอหมึกอ่อน	10RP 3/4 4.5 Muangchat ม่วงชาด	10BG 5/2 5.5 Namlai น้ำไหล

Plate 4 Colour patches with Thai names and Munsell colour notations.

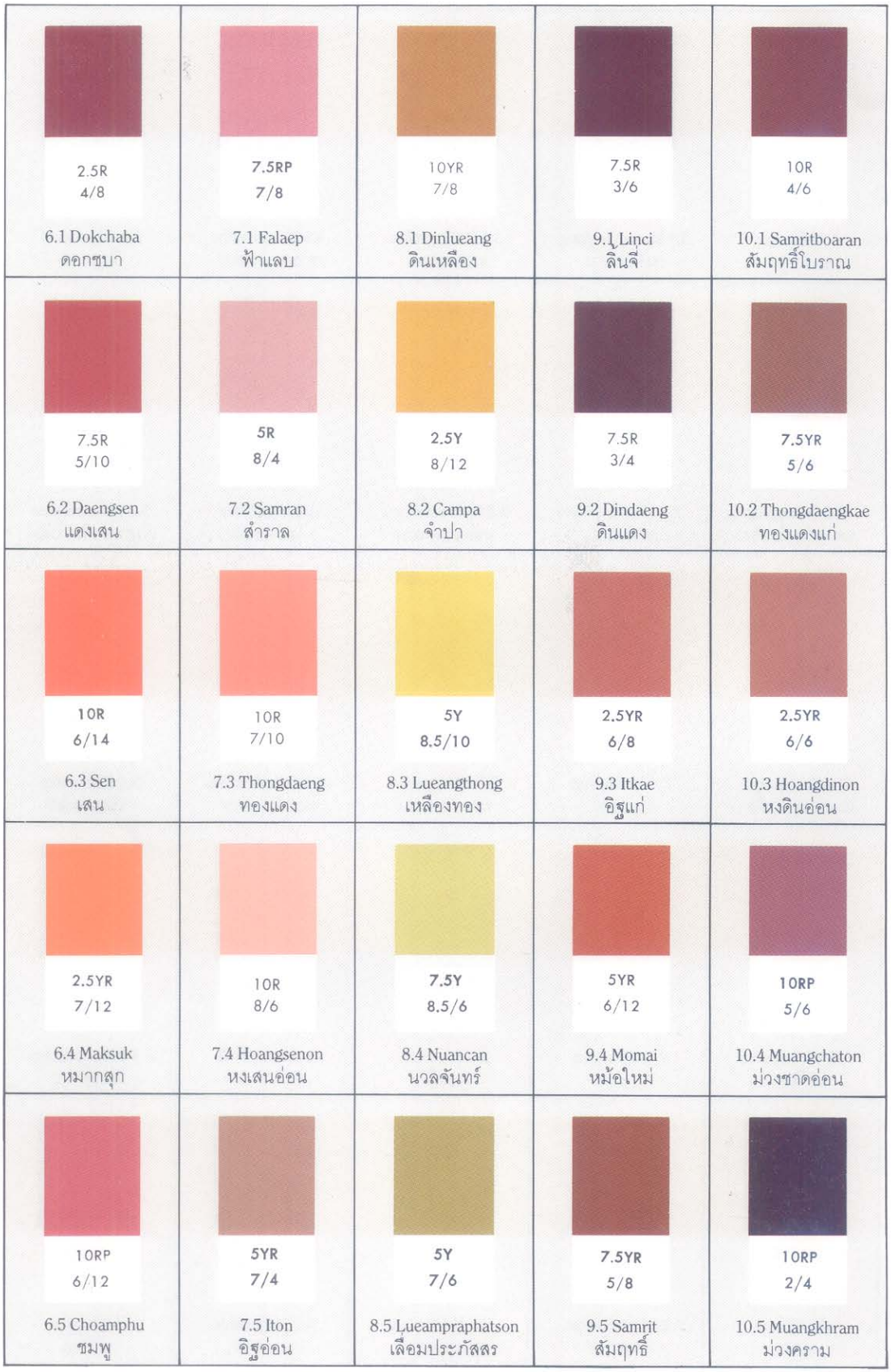

Plate 5 Colour patches with Thai colour names and Munsell colour notations.

TABLE 1 Glossary of Thai Colour Names

Two hundred and nine Thai colour names were identified and arranged in Thai alphabetical order and Thai names were then romanized as follows;

1. Kroammatha, Krak, Kalahoam, Klang, Kaki, Kanton, Kampu Kampuasura, Kura, Kulap, Chiwha, Choamphu.
2. Khap, Khau, Khaukrabang, Khausai, Khauklipbua, Khaunuan, Khaupun, Khauphong, Khaufun, Khaumau, Khiau, Khiauklang, Khiaukantong, Khiaukanmali, Khiaukae, Khiaukhap, Khiaukhaika, Khiaukhram, Khiaukhramon, Khiaukhramkae, Khiautongchae, Khiautaphun, Khiauthae, Khiaunuan, Khiaubaikhae, Khiaubaimai, Khiau poan Dam, Khiaufarang, Khiaumuet, Khiaumahatthai, Khiausoat, Khiausamo, Khiaumoan, Khiauhin, Khiau oam Dam, Khiauon, Khaimak.
3. Khram, Khramkae, Khramon, Khruemfon, Khwaiphueak.
4. Ngoen
5. Can, Can, Canon, Campa.
6. Chapphannarangsi
7. Choamphu, Chiwha, Chat, Chatcosae, Chattaicheng, Chatyoangkit, Chaton, Chataimui.
8. Dokchaba, Doktabaek, Dokbuaroai, Dokphaktoap, Dindaeng, Dindaengkae, Dindaengtat, Dindaengthet, Dindaengon, Dintat, Dinlueang, Daeng, Daengkae, Daengkhem, Daengchat, Daengdokchaba, Daeng dang Dokkamut, Daengtat, Daengthapthim, Daengmani, Daengyo, Daenglinci, Daenglueatnoak, Daengsoat, Daengsen, Daengsenkae, Daengsenon, Daengon, Dam, Damthan, Damnamrak, Dammuet, Dammuek.
9. Takuatat, Tuntun.
10. Thong, Thongdaeng, Thongdaengkae, Thau.
11. Noakphirap, Noapphakau, Nuan, Nuancan, Nuanthau, Nuea, Dingdaeng Namngoen, Namngoenkae, Namngoenon, Namtan, Namthale, Namrak, Namlai, Nammak.
12. Buaroai, Banyen, Baikhae, Baimai, Bencaroang.
13. Plueakmangkhut
14. Phankhau, Phankhram, Phandaeng, Phandam.
15. Fat, Fun.
16. Phlai, Phlainau.
17. Fa, Falaep.
18. Muang, Muangkae, Muangkhram, Muangkhramon, Muangchat, Muangchatkae, Muangdoktabaek, Muangon, Mahatlek, Mahatthai, Mokhram, Mokhramkae, Mokhramklang, Mokhramon, Momuet, Momek, Momuek, Momuekon, Mek, Mekkhramon, Mekmo, Metmaprang, Mun.
19. Yen, Yottangon.
20. Roang, Ron.
21. Linci, Lukcan, Lukwa, Lueamlueang, Lueampraphatson, Lueatnoak, Lueatmu.

22. Samo, Soam, Samrit, Samritboaran, Sanimthongdaeng, Sen, Senon, Senkae, Saet, Samran.
23. Hoang, Hoangchat, Hoangdin, Hoangdintat, Hoangdinklang, Hoangdinon, Hoangsabat, Hoangsen, Hoangsenon, Momai, Mok, Maksuk, Lek, Lueang, Lueangklang, Lueangkae, Lueangcampa, Lueangthong, Lueangthau, Lueangroang, Lueangsoat, Lueangon.
24. It, Itkae, Iton.

TABLE 2 Notation of Thai Mural Painting Colours by CIE And Munsell Systems

Thai colour names	Colour notation			
	Munsell system	CIE System		
		Y	x	y
Nuancan	7.5Y 8.5/6	86.42	.3795	.4007
Lueangthong	5Y 8.5/10	77.97	.4328	.4386
Lueangroang	5Y 8/14	78.73	.4234	.4534
Khiaunuan	2.5G 6/4	33.48	.3171	.3767
Khiautangchae	2.5G 5/6	23.62	.2965	.4240
Khiaukae	10GY 3/4	9.50	.3177	.3999
Khiauklang	10GY 4/4	13.99	.3481	.4330
Namlai	10BG 5/2	24.42	.2782	.3378
Khram	7.5PB 2/10	4.31	.1902	.1759
Khap	7.5PB 3/6	8.46	.2443	.2536
Mokhramkae	5PB 3/4	9.33	.2691	.2854
Mokhramklang	5PB 6/4	35.94	.2721	.2976
Mokhramon	5PB 7/4	52.89	.2837	.3063
Mekkhram	5PB 3/4	10.04	.2491	.2601
Khiaukhap	2.5PG 3/2	5.90	.2866	.3662
Dammuek	N*2.75/5.5%R**	6.32	.3294	.3432
Dammuet	N*2.25/3.8%R**	5.33	.3154	.3294
Momuek	N*2.5/4.6%R**	19.54	.3082	.3261
Momuekon	N*6.75/39.5%R**	39.01	.3056	.3247
Khiausamo	2.5G 4/4	13.54	.3085	.3962
Dokphaktoap	2.5P 5/8	19.44	.2864	.2656
Doktabaek	2.5RP 4/4	17.99	.3375	.2936
Buaroai	5PR 5/6	25.48	.3682	.3058
Dinlueang	10YR 7/8	39.62	.4481	.4125
Momai	5YR 6/12	31.90	.5177	.3955
Itkae	2.5YR 6/8	28.23	.4503	.3687
Iton	5YR 7/4	47.19	.3867	.3622
Khiau poan dam	10GY 2/2	5.52	.3136	.3488
Lueampraphatson	5Y 7/6	57.40	.3935	.4120
Khaukrabang	N*9.5/90.0%R**	101.42	.3140	.3312
Dokchaba	2.5R 4/8	11.42	.4928	.3273
Daengchat (Yoangkit)	10R 4/12	16.89	.5095	.3432
Daengchat (Taicheng)	7.5R 4/12	16.39	.5159	.3345
Hoangchat	5R 5/10	21.10	.4832	.3196
Choamphu	10RP 6/12	30.13	.4316	.3012
Falaep	7.5RP 7/8	51.72	.3666	.3095

Thai colour names	Colour notation Munsell system	CIE System		
		Y	x	y
Sen	10R 6/14	37.30	.5454	.3770
Hoangsen	10R 7/8	51.17	.4342	.3538
Hoangsenon	10R 8/6	70.95	.3770	.3469
Daengsen	7.5R 5/10	26.09	.4876	.3435
Hoangsabat	2.5YR 6/12	39.88	.5256	.4012
Dindaeng	7.5R 3/4	10.49	.4292	.3456
Hoangdinkae	2.5YR 5/6	23.10	.4514	.3642
Hoangdinklang	10R 5/4	22.92	.3966	.3403
Hoangdinon	2.5YR 6/6	34.14	.4117	.3655
Muangchat	10RP 3/4	11.06	.3841	.3134
Muangkhram	10RP 2/4	7.29	.3577	.3062
Thongdaeng	10R 7/8	56.21	.4319	.3590
Samrit	7.5YR 5/8	23.67	.4715	.3946
Namrak	2.5Y 3/2	8.71	.3606	.3641
Samritboran	10R 4/6	12.32	.4528	.3603
Thongdaengkae	7.5YR 5/6	28.44	.4496	.3869
Samran (Khwaiphueak)	5R 8/4	60.70	.3657	.3314
Muangchaton	10RP 5/6	23.34	.3772	.3141
Campa	2.5Y 8/12	66.52	.4433	.4210
Maksuk	2.5YR 7/12	45.15	.5044	.3841
Linci	7.5R 3/6	8.01	.4514	.3423

* Neutral Colour (A neutral colour is grey)

** Reflectance of light in percent