Concentrations of Potassium, Sodium, Magnesium, Calcium, Copper, Zinc, Manganese and Iron in Black and Gray Hairs in Taiwan

Tsai Yung-Yueh,[a] Wang Chin-Thin,*[,b,1] Chang Wei-Tun,[c] Wang Ren-Tse,[d] and Huang Chin-Wang[a]

[a]*Department of Chemistry, Chun Yuan Christian University, Taoyuan, Taiwan,* [b]*Mackay College of Nursing, No. 92, Sheng Ching Road, Peitou, Taipei, Taiwan,* [c]*Department of Forensic Science, Central Police University, Taoyuan, Taiwan, and* [d]*Ta Jen Pharmaceutical College, Pingtung, Taiwan*

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An investigation of the metal concentrations of potassium, sodium, calcium, magnesium, copper, zinc, manganese and iron in the black and gray hairs of the same person in Taiwan was performed using atomic absorption spectroscopy (AAS). The flame modus of AAS was employed to determine the concentrations of trace and mineral elements. The results of trace element and mineral element concentration determinations were evaluated by statistical analysis using the t-test for comparison of significant differences between black and gray hairs of the same person in the same region of the head. Our findings revealed that the concentrations of potassium, sodium, calcium, magnesium, copper, zinc, manganese and iron in gray hairs were lower than those in black hairs. Concentrations of manganese, copper, magnesium, calcium and sodium showed significant differences between the two kinds of hairs ($p<0.05$). On the contrary, no significant differences were noted in zinc, iron, and potassium ($p>0.05$). Our experiment gives direct evidence to suggest that reduction of hair trace element and mineral element concentrations may be one of the factors associated with hair graying or aging. Manganese, copper, magnesium, calcium and sodium obviously have greater effects on the hair color and aging.

*To whom correspondence should be addressed: Mackay College of Nursing, No. 92, Sheng Ching Road, Peitou, Taipei, Taiwan.
[1]Present address: 1F, No. 1, Alley. 61, Lane. 114, Sec. 7, Chung Shan N. Road, Taipei, Taiwan, R.O.C. Tel.: +886-2-28748998; Fax: +886-2-28740682; E-mail: wgt9599@ms16.hinet.net

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INTRODUCTION

In addition to lipids, pigments and trace elements, proteins mainly compose 65 to 95% of human hair. Most of these trace elements do not exist in hair alone, but bind with proteins or fatty acids.[1] It is well known that people from different races or territories have different hair colors (*e.g.* blond, red, brown, black, *etc.*). This difference is predominantly caused by different amino acid composition and different melanosome content of the melanin in hair.[2] In the past decades, the phenomenon of color changes related to trace or mineral elements in hair has been a subject of study. Numerous reports on the relationship between the gray-hair of youths and the gray hairs of the elderly, and pigment loss or reduction of eumelanin concentration[3] have been described. Surprisingly few studies have so far been made of the changes of trace element and mineral element concentrations in hair from the same person.

In this paper, we are concerned with whether a change of trace element and mineral element concentration is a factor, which is related to hair color, especially in the case of gray haired young people.[1,4] Results derived from samples collected in Taiwan were made and compared with those of previous studies.

MATERIALS AND METHODS

Materials —— Reagents used for digestion procedures and the deionized distilled water (18MΩ) were purchased from E. Merck. Standard solutions (1000 ppm in H_2O) of potassium, sodium, magnesium, calcium, copper, zinc, manganese and iron were obtained from E. Merck. The standard human hairs used as the base for the determination of precision and accuracy were National Institute for Environmental Studies No. 5 human hair which was purchased from the National Institute for Environmental Studies, Japan. The containers were made of inert materials such as quartz, Teflon and polypropylene. All containers were first immersed in 8 N HNO_3 for 24 h, and then rinsed under deionized distilled water, and dried at ambient temperature before using.

Hairs Sampling and Cleaning —— Two batches of black and gray hair samples were collected from the nape section of each healthy person. The age of thirty-five males who provided samples of black and gray hairs were from 22 to 54 years old. Hairs were cut near the scalp area with thin-blade stainless steel scissors. Average length of hair samples ranged from 1.0 to 3.0 cm. Hair samples was accurately weighed to 2.0000 ± 0.2000 g.

Hair samples then were placed inside poly ethylene bags after cutting, and stored in a controlled environment of temperature (25℃) and humidity (65% RH). The procedure for sample cleaning described, later was in our earlier report.[5] Samples were immersed in a 65 ml mixture of *n*-hexane–ethyl alcohol–acetone (4 : 2 : 1 v/v) two times. Each immersion lasted 1.5 hrs. Afterwards, samples were rinsed under deionized distilled water four times, and then immersed in 65 ml acetone for 15 mins. Hairs were finally given a final rinse under deionized distilled water three times, and then were filtered with paper and dried at ambient temperature. Black and gray hairs were separately sealed for the digestion procedure.

Hair Digestion[5] —— A hair sample was weighed (0.3000 ± 0.1000 g), and then was placed inside a 250 ml microwave analyzer bottle. 10 ml of nitric acid was added and was then followed by microwave heating (CEM–MD2000 microwave digester) using less than 30% power for 5 min. Then, 10 ml distilled water was added followed by 40% power heating for 25 min and 0% power heating for 10 min. Finally, 2 ml H_2O_2 was added and followed by 65% power heating for 5 min. After the heating procedures, bottles were taken out under normal pressure and temperature. All digested solutions were diluted to specific volumes with deionized distilled water for Atomic absorption spectroscopy (AAS) determination.

AAS Analysis —— With some minor variations in AAS conditions, the instrumentation and procedures (Hitachi Z-8200 Atomic Absorption Spectrophotometer coupled with Flame Atomizer) were as used in our earlier study.[5–9] The external standard method was used for the quantitative determination of metal elements in hairs. A series of standard solutions containing the following concentrations of potassium, sodium, magnesium, calcium, copper, zinc, manganese and iron ions were prepared using deionized distilled water and stock solutions (1000 ppm): 0.00, 0.10, 0.20, 0.40, 1.00, 2.00 and 4.00 μg/ml. To obtain accurate quantitative data, the regression coefficient of the standard calibration curve for each element was greater than 0.9998.

Statistical Analysis —— The statistical graphic package (Statgraphic) was used to complete the computation of various statistical data. The evaluation of significant difference between two means of each metal concentration in black and gray samples was conducted by *t*-test statistical analysis. It was reported as significant difference where the "*p*" value is less than 0.01 of the average concentration. If "*p*" value was greater than 0.05, it indicated no significant difference in black and gray hairs. Values were expressed as average concentration ± S. D.

RESULTS AND DISCUSSION

Accuracy and Precision Evaluation

Due to the diversity and complexity of hair samples, it is necessary to evaluate the accuracy and precision of the analytical protocol. The recovery and coefficient variations (*CV*%) of standard hairs were used for thus purpose. Results revealed that recovery % of potassium, sodium, magnesium, calcium, copper, zinc, manganese and iron was from 98.2% to 103.1%. Simultaneously, the precision of *CV*% of potassium, sodium, magnesium, calcium, copper, zinc, manganese and iron were in the range 4.1% to 8.5%. The results were well matched with the biological standard reference material of NIES. No. 5 human hair *CV*% from 4.1% to 8.8%.

Comparisons of Hair Samples

Table 1 shows that concentrations of potassium, sodium, calcium, magnesium, copper, zinc, manganese and iron in gray hairs were lower than those in black hairs for males. From these results, hair color appears to be related to the trace element and mineral element concentrations, as mentioned above. When the concentrations of metal elements were lower, the color of hair becomes grayer. Concentrations of manganese, copper, magnesium, calcium and sodium showed significant differences between black and gray hair. Viewed in this light, the change of hair color resulted from greater interaction with manganese, copper, magnesium, calcium and sodium elements in hair. However, no significant differences were indicated in zinc, iron, and potassium content.[4]

Table 1. Comparison Trace Element and Mineral Element Concentrations in Black and Gray Hair from the Same Person

	Concentration black hair (n=35) (μg/g)	Concentration gray hair (n=35) (μg/g)	Deviation between black hair and gray hair (%)	Distribution range black hair (μg/g)	Distribution range gray hair (μg/g)	p value of t-test
Potassium	179.7±109.0	163.4± 93.5	− 9.1	500.0 − 43.4	500.0 −36.8	$p>0.05$
Sodium	419.0±233.0	332.0±237.0	−20.7	1150.0 −135.0	1250.0 −53.7	$0.01<p<0.05$
Calcium	581.0±404.0	447.0±327.0	−23.1	1436.0 −112.0	1201.0 −12.5	$0.01<p<0.05$
Magnesium	138.1± 64.0	94.6± 63.5	−31.5	272.0 − 29.6	266.0 −23.4	$p<0.01$
Copper	3.4± 2.1	2.3± 1.6	−32.4	8.9 − 0.6	6.2 − 0.2	$p<0.01$
Zinc	27.7± 19.6	22.4± 14.2	−19.1	92.0 − 3.5	61.0 − 3.7	$p>0.05$
Manganese	6.7± 4.1	3.2± 2.3	−52.2	19.1 − 1.2	13.1 − 0.5	$p<0.01$
Iron	28.3± 16.1	23.3± 15.6	−17.7	94.0 − 7.5	84.0 − 2.7	$p>0.05$

Each value is the mean±S.D.

CONCLUSION

The findings of this study revealed that the concentrations of potassium, sodium, calcium, magnesium, copper, zinc, manganese and iron metal elements in gray hairs are lower than in black hairs. Significant differences ($p<0.01$) were noted with manganese, copper and magnesium, followed by calcium and sodium, which were less significant ($0.01<p<0.05$). While zinc, iron and potassium showed no significant differences ($p>0.05$) between black and gray hairs.

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