

COMPOSITION ANALYSIS OF CALCIUM AND SULFUR ON GYPSUM AT THE PUGER DISTRICT JEMBER REGENCY AS AN ALTERNATIVE GYPSUM DENTAL MATERIAL

(ANALISIS KIMIA KANDUNGAN KALSIUM DAN SULFUR PADA GIPSUM DI KAWASAN PUGER KABUPATEN JEMBER SEBAGAI ALTERNATIF GIPSUM DI BIDANG KEDOKTERAN GIGI)

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Abstract

Gypsum is a material used in medical dentistry, as dental casting material, dental model, base for dental model and investment material. The gypsum used in medical dentistry is Hydrated Calcium Sulfate ($\text{CaSO}_4 - 2\text{H}_2\text{O}$). Puger district at Jember regency is well-known as a mining area that produces abundant amount of gypsum. This research was aimed to analyze the calcium and sulfur composition of the gypsum from Puger district as an alternative material in dental practice. The total samples were 48, and divided into four groups. The first group contained of gypsum mined from low level land. The second group was the gypsum mined from middle level land, and the third group was the gypsum mined from upper level land. While the fourth group was the gypsum commonly used in dentistry. Calcium composition was analyzed using *Atomic Absorption Spectrophotometer* (AAS) with wavelength of 285 nm, while sulfur composition analyzed using spectrophotometer 21 D with 432 nm wavelength. The result showed that compositions of calcium and sulfur of the gypsum groups was significantly different ($p < 0.05$). In conclusion, Gypsum at Puger district has adequate calcium (Ca) and sulfur (S) composition to be used as an alternative gypsum in medical dentistry.

Key words: gypsum, calcium, sulfur

INTRODUCTION

Gypsum is one of the very important materials used extensively in industry, construction, ceramic and medical dentistry. Gypsum could be processed and developed, using technology and engineering in its process,¹ to be a product with high competitiveness. Gypsum is a mining material which has a solid mineral composition with grey, red or brown colors. The colors may be due to the mineral contents such as ferric oxide, anhydrate, carbohydrate, clay and many other oxides².

The word of gypsum is derived from a Greek word which means chalk or plaster. As gypsum from the quarries of the Montmartre district of Paris has long furnished burnt gypsum used for various purposes, this material has been called plaster of Paris.³ Gypsum is one of the dental materials mostly used due to the easiness of changing its properties by adding different chemical components. According to ANSI/ADA Specification n°25, there

are three important types of gypsum product: plaster or plaster of Paris (type II), dental stone (type III) and high strength stone (type IV). The main difference among them is on the type of the crystals obtained from the dehydration of the gypsum mineral ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$). The alteration on the type of the crystal forms will influence the mechanical strength, the surface resistance and even the setting expansion. Then, the choice of the gypsum type must be made according to the desired application.^{4,5}

Commonly, gypsum is divided in to two types: the soft gypsum (Plaster of Paris) or β -hemihydrates and the solid gypsum (dental stone) or α -hemihydrates. Gypsum in medical dentistry used for casting material, dental model, based for dental model and investing material on the metal casting processing for dental conservation.^{2,6,7}

Mining industries in southern part of the Jember regency produce gypsum abundantly, especially in the Puger district. However, until nowadays they process and produce gypsum with very simple ways

to fulfill industry and construction needs only, and not for medical dentistry. The gypsum used in medical dentistry is a mineral which has composition of calcium, sulfur and oxygen added with two molecules of water. These minerals are commonly called as Calcium Sulfate Dehydrated ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ or gypsum).^{7,8}

The data about the gypsum chemical composition for gypsum mined at the Puger district are still obscured especially in relation to its use in the medical dentistry. We conducted a research in order to understand whether *calcium sulfate dehydrated* is main component for gypsum from Puger district. The research was conducted using chemical examination on *calcium sulfate dehydrated* on limestone.

Calcium in the main chemical component in chemical periodic schedule symbolized with Ca and has atomic number of 20, the fifth abundant component in the earth's crust and mostly found in the soil system is limestone and gypsum. Calcium oxide or limestone is mostly used in chemical process by heating and mixing with water. Sulfur is chemical component in chemical periodic schedule (S) and has atomic number of 16. Sulfur, in chunks, is resulted from anaerobic bacterial process in sulfate minerale specially gypsum. Therefore, gypsum composed of calcium (Ca) and sulfur (S) as a main chemical composition and added with water.⁹ This research aimed at analyzing the calcium and sulfur compositions of Puger gypsum and the result expected to be useful as medical dentistry alternative materials, in accordance with the standard criterion of gypsum in dentistry materials.

MATERIALS AND METHODS

The research was an experimental laboratory with posttest only control group design. The research located at Dental Technology Material Laboratory, Faculty of Dentistry Jember University and Laboratory of Agronomy at Dept of Agronomy Study Program, Faculty of Agriculture Jember University. The total samples used were 48, divided into 4 groups based on the gypsum mining location to each group consisted of six samples as follows: Group 1; gypsum from low level and mining location. Group 2 was gypsum from the middle level land (central Puger). For the group 3, gypsum mined from the upper level land surface. The last was Group 4;

commercial dental gypsum.

The research constituted as follows: first phase preparation; gypsum rock taken from three different location levels of mining i.e. at Puger, low, middle and high land surfaces were pounded and sieved. Gypsum for medical dentistry was processed similarly.

The analysis of calcium composition was performed by filling 0,25 gram gypsum material in to Erlenmeyer glass, added with 10 ml concentrated HNO_3 and 5 ml concentrated HClO_4 . The mixture boiled until 300°C for ± 2 hours until we obtained a clear fluid, and prepared to be cooled. After cooling, added with 100 ml, aquadistilled and took 1 ml with pipette to dilute it 10 times and added with 9 ml aqua-distillate. After that, we made a standard series for Ca 1000 ppm each with concentrations of 0, 25, 50, 100, 150, 200, 250 ppm Ca. After having been examined with Atomic Absorption Spectrophotometer (AAS) with the wavelength of 285 nm, using formula as follows :

$$\text{Ca} = \frac{\frac{100 \text{ ml}}{0,25} \times 10 \times \frac{\text{ppm std}}{\text{abs std}} \times \text{abs sample}}{10.000}$$

To analyze the amount of sulfur composition, 0,25 gram gypsum was filled in to Erlenmeyer glass, then 10 ml concentrated HNO_3 and 5 ml concentrated HClO_4 was added and heated until 300°C for ± 2 hours until we obtained a clear liquid and cooled. After cooling, add with 100 ml aquadistillate and took 1 ml with pipette and diluted it 10 times and added with 9 ml aquadistillate. After that, made a standard series for Ca 1000 ppm each with concentrations 5, 10, 20, 30, 40, 50, 100ppm S, examined with Spectrophotometer 21 D with has wavelength of 432 nm, furthermore using this formula :

$$\text{S} = \frac{\frac{100 \text{ ml}}{0,25} \times 10 \times \frac{\text{ppm std}}{\text{abs std}} \times \text{abs contoh}}{10.000}$$

Data analysis was using ANOVA with the degree of significance 5%, followed with Least Significant Difference (LSD) test to understand the difference

on each treatment.

RESULTS

Calcium content in the commercial dental gypsum was 6.56, from highland Puger was 11.56, from middle level land Puger 16.07 and from low level land Puger was 17.49. It is clearly shown that the calcium composition mean from Puger higher than commercial dental gypsum. The highest calcium content was from low level land Puger (Table 1).

Table 1. The mean of calcium content of Gypsum mined from high, middle and low land Puger

Group	N	Caesium	Content SD
Commercial dental gypsum	6	6,56	0,014
Highland Puger gypsum	6	11,56	0,026
Middleland Puger gypsum	6	16,07	0,018
Lowland Puger gypsum	6	17,49	0,008

Before continuing the test for calcium content from some mining locations, data were treated with Kolmogorov Smirnov test to know normal distribution. The result of test showed that ($p > 0.05$) the overall data had a normal distribution. The result of Lavene test showed that significant was of 0.617 ($p > 0.05$), meant data was homoge.

There was significant difference on the calcium composition in each gypsum mining location, i.e.: commercial dental gypsum, high, middle, and from low land Puger ($p < 0,05$) (Table 2).

Table 2. Result of LSD test for calcium composition on Commercial dental gypsum, gypsum high, middle and low land Puger.

Group	Gypsum from low land Puger	Gypsum from middle land Puger	Gypsum from Highland Puger	Commercial dental gypsum
Commercial Dental Gypsum	*	*	*	-
Highland Puger Gypsum	*	*	-	
Middleland Puger Gypsum	*	-		
Lowland Puger Gypsum	-			

* = significant difference

The rates of sulfur content in commercial dental gypsum was 28.36. While the content for highland Puger gypsum 2.66 ; gypsum from middle land Puger 0.99 and gypsum from low level land Puger

1.66. Therefore, the composition of gypsum for dentistry was commonly higher than the means of gypsum mined at the Puger district, while the lowest content was gypsum from the middle level land Puger (Table 3).

Table 3. The mean of sulfur composition on commercial dental gypsum, high, middle and low land Puger

Group	N	Sulfur	Composition SD
CommercialDental Gypsum	6	28,36	0,02280
Highland Puger Gypsum	6	2,66	0,02280
Gypsum from middle land Puger	6	0,99	0,01414
Gypsum from lowland Puger	6	1,66	0,01265

DISCUSSION

Gypsum used on this experiment was gypsum from the Puger district area, since the material was very abundant and never used in medical dentistry. The main chemical composition for gypsum on dentistry was calcium, sulfur and water. These compositions mixed together to be calcium sulfate dehydrated ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$).⁷⁻⁹

Gypsum from Puger had higher calcium (Ca) content than commercial dental gypsum this showed that the calcium content on the earth soil was the fifth most abundant and calcium on the earth surface was commonly in the form limestone and gypsum. Gypsum from Puger District has sulfur (S) content, even in very small amount compared to commercial dental gypsum. It indicates that the sulfur content is in the chunks resulted from anaerobe bacterial process in mineral sulfate especially gypsum. Sulfur content in gypsum (calcium sulfate) is commonly from active volcanoes, since the volcano in Puger District is no longer active then its sulfur content is ver low.¹⁰

The result showed significant differences on the amount of calcium content between the commercial dental gypsum and the gypsum from Puger District ($p < 0,05$). It had also significant differences between the commercial dental gypsum and the gypsum from Puger District ($p < 0,05$). It indicates that the gypsum from Puger District is natural mineral content and has not been cultivated through some processes as in the commercial dental gypsum, therefore, its contents is also different and ready to use medical dentistry.

Subsequently, it was conducted *Least Significant Difference* (LSD) test and resulted some significant differences in the calcium content from each

gypsum group ; commercial dental gypsum, high land gypsum, middle land gypsum, and low land gypsum. There were also some significant differences in sulfur content from those groups. These differences may be affected by some factors including heath, rain, water content, evaporation and gypsum storage.

Department of soiland water conservation said that the sample of limestone was better kept in humid area (90% RH) and temperature 18°C. The best sample keeping was the condition of intact sample with water content similar with the field condition. If conditions were dry, it was suggested to pour with enough water one day before mined. Ca and S contents in gypsum from the high land had the most similar content to commercial dental gypsum, therefore ,it was advisable that the sample collection for the subsequent process was only from the high land level.

Commercial dental gypsum, commonly made by gypsum factory used as comparator. After analyzing it showed the rate of calcium content on Puger gypsum was higher than commercial dental gypsum. While the sulfur content on Puger gypsum less than sulfur of commercial dental gypsum. If gypsum from Puger is used in commercial dental gypsum, it certainly must beprocessed before used so its calcium and sulfur content tends to be similar with commercial dental gypsum.

The result of the research is a beginning step to know the main chemical content of Ca and S situated in Puger District as the forming agent of *Calcium Sulfate Dehydrated* for alternative dental gypsum. To form *Calcium Sulfate Dehydrated* still needs further research to process gypsum from Puger District into dental gypsum, through calcinations process from limestone (CaCO_3) by heating in 900 °C for 1 hour to form CaO dan CO_2 .¹¹ Furthermore, hydratation process is conducted by adding water to form $\text{Ca}(\text{OH})_2$, and neutralized using H_2SO_4 15 % to form $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$.^{12,13}

Gypsum was a mineral Hydrated Calcium Sulfate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) formed with surface water and sulfate ion from oxide sulfide on gravel and root system and interaction with calcium from limestone or from limestone clay. These materials are very useful for industry, construction and medical. The calcium and sulfur mixture to make gypsum or mineral Hydrated Calcium Sulfate treated to be CaO

and SO_3 with CaO with concentrations: 30.98%, SO_3 : 42.62-%; H_2O : 13.01% and the others as addition. The mineral and stone treated as agromineral commonly precipitate and have economic meaning, such as sulfur, sulfate (gypsum), limestone as calcium carrier.

It can be concluded that gypsum from the Puger district had calcium content (Ca) and Sulfur (S) and the gypsum from Puger could be used as alternative medical dentistry material.

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