

A Comparative Study of Physical Properties of Gypsums Manufactured in India

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Abstract Gypsum products are one of the most widely used materials in dentistry. The wide use of plaster of paris motivated a number of manufacturers to introduce different brands of the profession but their physical and mechanical properties were still questionable. The aim of this study was to access, compare and evaluate the physical properties of different brands of laboratory gypsum available in Indian dental market. Seven brands namely Calspar, Rajhans, Elephant, Horse, Lion, Johnson and Shree Niwas Chemicals were selected for the comparison of their particle size, consistency and setting time. The obtained data were tabulated and compared with Indian, Australian and US standard specification. Statistical analysis for comparative study was done. It was found that none of the brands were up to mark. The present study shall be able to provide some beneficial information regarding their quality control and guide the manufacturers for improving the standardization of their products so that most suitable type of material may be available to the profession.

Keywords Consistency · Size · Setting time · Gypsum

Introduction

Gypsum is a type of stone that is mined from earth. It is usually white to yellowish milky in color and is found in a compact mass in nature. Colour may be gray, red or brown due to presence of some foreign materials like as clay, iron oxide or oxides of other materials. Its different varieties have been use for centuries for making decorative arts and objects. Since biblical times gypsum materials have also been used as building materials. It is believed that early sculptors may have made plaster casts of different objects [1]. After suitable manufacturing processes, gypsum may be made into various types of products, such as plaster of paris, dental stone and investment materials. The term plaster of paris was given to this product because it was abstained by burning the gypsum mineral from the deposits near Paris, France. Deposits of gypsum, however, are found in many countries [2]. Gypsum chemically known as calcium sulphate dihydrate. After calcinations it is converted into calcium sulphate hemihydrate. This hemihydrate form of gypsum is fine powder rather than hard rock. By different calcinations method beta-hemihydrates and alpha-hemihydrates can be found. Beta-hemihydrates are more popularly known as plaster of paris.

In the present investigation an attempt has therefore, been made to test the physical properties of seven dental laboratory gypsum manufactured in India. Seven brands are Calspar (Dental Products of India, Mumbai, India) Rajhans (Aruna Plaster Udyog, Haridwar, India), Elephant (Gypstona Industries, Haridwar, India), Horse Universal Plaster Industries, Howrah, India), Johnson (Johnsons & Johnsons, Mumbai, India), Lion (Snowwhite Industries, Rishikesh, India) and SNC (Shree Niwas Chemicals, Ambala, India).

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Materials and Methods

Seven brands of indigenously produced dental laboratory gypsum were included in this study to standardize the products in accordance with the Indian standard specification for dental laboratory gypsum, March 1972, Australian standard No. T-5: 1951 for dental laboratory gypsum and US federal specification No. SS-P-446 for gypsum, Dental type-I (Model). The tests were carried in a room having temperature 37 °C and relative humidity between 50 %.

Mixing Technique

Australian standard No. T-5: 1951 on dental laboratory plaster was followed, for mixing the plaster. The mixing technique is as follows: a flexible rubber bowl and a rounded blade metal spatula were used. Plaster was sprinkled into water in a rubber bowl in 15 s avoiding the entrapment of air. During the next 15 s the bowl was jarred to facilitate wetting and escape of entrapped air. The plaster and water were then spatulated at the rate of 3 times per second using a circular stirring motion for 30 s. The plaster mix was then ready for testing.

Methods

Determination of Particle Size

Indian specification for dental laboratory plaster IS: 6555-1972 was followed.

Apparatus: Metal sieves 150 and 600 μ m sizes (IS: 460-1962).

Procedure

One hundred grams of plaster was placed on a 600 μ m IS sieve and shaken through on to a 150 μ m IS Sieve. The material was then washed through the sieve by agitating in a vessel containing denatured spirit. The residue was washed with a stream of spirit till the washings were clear. The sieve was dried at room temperature. When the residue was dry, the sieve was shaken gently for 1 min to remove the fine particles adhering to the sieve. The residue remaining in the sieve was weighed and reported as the percentage retained.

Test for Consistency

The plaster was mixed at 0.45, 0.50 and 0.55 water powder ratios. The plaster mix was then noted for consistency by touch and classified as thick, creamy, thin and thinner.

Determination of Setting Time

Apparatus:

- (a) Vicat needle apparatus (IS: 5513-1976)
- (b) Metal ring mould
- (c) Glass plate

Procedure

All the tests were carried out in triplicate. The metal ring mould was placed on a flat glass plate and filled with plaster mixed in a particular water powder ratio. The needle tip was lowered carefully on to the horizontal surface of plaster and allowed to rest there on under its own mass. This was repeated at frequent intervals. The plaster was deemed to have developed its initial set when the needle failed to leave a perceptible circular indentation on the surface of the specimen. A fresh area was selected for each indentation and the needle kept clean. The time from the moment of first contact of plaster with water was recorded to the nearest 1/2 min. The setting time was reported as the mean of three determinations.

Results

The present investigation covered seven brands of dental laboratory plasters which were tested for their particle size, consistency and setting time. The data so obtained has been tabulated and compared with the US federal specification No. SS-P-446 for plaster of paris, Dental type-I (Model), Australian standard specification No. T-5: 1951 and Indian Standard specification IS: 6555-1972.

Particle Size

Table 1 shows that the residual powder retained on the 150 μ m sieve for all the brands except the Elephant was within 5 % or less as specified by the Indian as well as Australian standard specifications. The Elephant brand retained the maximum particles (7.1 %). Statistical analysis also shows that 't' value for Elephant brand is 2.214 which is significant at 5 % level of significance. The Johnson brand retained the minimum (1.0 %). The Calspar and the Horse brands retained only 2.5 and 3.2 % respectively where as the SNC brands retained 4.7 %, Lion 4.2 % and Rajhans 4.1 % respectively.

In the absence of recommended water powder ratio by the respective manufacturers the tests for consistency, setting time, compressive strength and setting expansion were done at three different water powder ratio, i.e. 0.45, 0.50 and 0.55. The room temperature varies between 35

Table 1 Showing residual powder particles retained on 150 µm IS-Sieve

S. No.	Brand	Retained particles in percentage	't' value	P value
1	Calspar	2.5	0.810	>0.05
2	Rajhans	4.1	1.397	>0.05
3	Elephant	7.1	2.214*	<0.05
4	Horse	3.2	1.088	>0.05
5	Lion	4.2	1.429	>0.05
6	Johnson	1.0	–	–
7	SNC	4.7	1.582	>0.05

Indian standards specification 5 % or less

Australian standards specification not more than 5 %

* Significant at 5 % level of significance

and 45 °C and the relative humidity between 50 and 60 % approximately.

Table 2 shows the consistency of the various brands of plaster at three different water powder ratios of 0.45, 0.50 and 0.55. It may be observed that four out of seven brands of plasters exhibited a creamy consistency at 0.45 water powder ratios, namely Calspar, Elephant, Lion and SNC brands. The remaining three brands namely Rajhans, Horse and Johnson brands produced a creamy consistency at the water powder ratio ranging from 0.50 to 0.55. It might the

Table 2 Showing consistency of different brands at different W/P ratio

S. No.	Brand	W/P ratio	Consistency
1	Calspar	0.45	Creamy
		0.50	Thin
		0.55	Thin
2	Rajhans	0.45	Thick
		0.50	Creamy
		0.55	Creamy
3	Horse	0.45	Thick
		0.50	Creamy
		0.55	Creamy
4	Elephant	0.45	Creamy
		0.50	Thin
		0.55	Thinner
5	Johnson	0.45	Thick
		0.50	Creamy
		0.55	Creamy
6	Lion	0.45	Creamy
		0.50	Thin
		0.55	Thinner
7	SNC	0.45	Creamy
		0.50	Thin
		0.55	Thin

further observed that the three brands produced a thick consistency at 0.45 W/P ratio.

Setting Time

Table 3 shows the setting time for various types of plasters at the three different water powder ratios of 0.45, 0.50 and 0.55. It may be observed from the above table that the setting time for all the products increased with the increase in water powder ratio. Moreover, the setting times for all the brands and at all the three water powder ratios were within the specified limits of 5–20 min. Statistical analysis shows that Johnson brand is superior to all other brands with respect to setting time at different water powder ratios and 't' value for all other brands at different water powder ratios are highly significant.

Discussion

Seven brands of dental laboratory plaster were taken in this study to evaluate some of their physical properties such as particle size, consistency and setting time. The tests were carried out on the basis of Indian and Australian Standard Specification for dental laboratory plaster and the US federal specification for plaster of Paris, Dental type-I (Model).

On analyzing Table 1, it was observed that all the brands had the size of particles well within the specified limit of specification except that of Elephant brand which showed coarser size of the particles. The specification suggests that the particle size shall be such that no material is retained on 600 µm IS sieve and not more than 5 % is retained on 150 µm IS sieve. In case of the Elephant brand 7.1 % particles remained on sieving which was beyond the specified limit of 5 % or less. Thus, on the basis of residual powder particles the Elephant brand appeared to be less satisfactory. Further, it was obvious from the table that Johnson brand had the finest size of particles as the percentage retained on 150 µm IS sieve was only one percent. Skinner et al. [3] reported that the finer the particle size the hemihydrates, the faster the mix will harden, particularly if the product has been ground during manufacture [3].

Table 2 demonstrated the consistency of different brands at various water powder ratios. The three brands namely Johnson, Horse and Rajhans produced a thick consistency at 0.45 water power ratio which might be attributed to the rate of setting reaction which was found to be faster as evident from their minimum setting time values of 7.3, 8.2 and 9.4 min respectively. These three brands showed creamy consistency at 0.50 and 0.55 water powder ratios. Anderson [4] reported that the limiting factor in the consistency of a plaster is that it must be workable [4]. The

Table 3 Showing setting time of different brands at 0.45, 0.50 and 0.55 W/P ratios

S. No.	Brand	W/P ratio	Mean setting time in minutes	Standard deviation	't' value	P value
1	Calspar	0.45	9.4	0.705	4.000**	<0.01
		0.50	11.0	0.316	11.180**	<0.01
		0.55	12.8	0.432	7.746**	<0.01
2	Rajhans	0.45	9.5	0.707	4.000**	<0.01
		0.50	10.2	0.341	8.944**	<0.01
		0.55	11.0	0.318	3.873**	<0.01
3	Elephant	0.45	15.0	0.548	16.771**	<0.01
		0.50	15.6	0.316	31.304**	<0.01
		0.55	17.6	0.617	16.000**	<0.01
4	Horse	0.45	8.2	0.327	2.582*	<0.01
		0.50	9.5	0.772	0.444*	<0.01
		0.55	10.5	0.583	1.963*	<0.01
5	Johnson	0.45	7.5	0.707	–	–
		0.50	8.5	0.316	–	–
		0.55	9.8	0.745	–	–
6	Lion	0.45	11.0	0.316	9.036**	<0.01
		0.50	12.5	0.347	17.888**	<0.01
		0.55	14.5	0.949	8.452**	<0.01
7	SNC	0.45	9.4	0.675	4.000**	<0.01
		0.50	11.3	0.617	7.746**	<0.01
		0.55	13.0	0.707	7.000**	<0.01

Indian standards specification 5–20 min

Australian standards specification 5–20 min

US federal specification 10 ± 3 min

* Significant at 5 % level of significance; ** significant at 1 % level of significance

Lion and the Elephant brands produced creamy, thin and thinner consistencies where as SNC and Calspar brands gave creamy and thin consistencies at 0.45, 0.50 and 0.55 water powder ratios.

It is evident from Table 3 that all the brands of plaster showed a definite tendency of increase in setting time as the water power ratio increased. Thus making it clear that setting time is directly proportional to water powder ration and this finding was in conformity to the results of Ware and McLaverly [7], Hollenbeck and Smith [5], Skinner and Phillips [3], and Overburger [6], who also supported this statement.

Conclusion

The present investigation is to evaluate the physical properties of some brands of dental laboratory plasters manufactured in India. In these study seven brands namely Calspar, Rajhans, Elephant, Horse, Johnson, SNC and Lion brands were tested for particle size, consistency, setting time, compressive strength and linear expansion on setting. The data so obtained have been compared with the Indian

and Australian standards specification for dental laboratory plaster and US federal specification for plaster of Paris, Dental type-I (Model).

On the basis of findings discussed the following conclusions have been drawn:

1. All the brands tested except the Elephant brand of the dental laboratory plaster showed particle size within the specification's value of 5 % or less. The Elephant brand showed 7.1 % particles retained on the 150 μ m IS sieve and hence is coarser than other brands. The Calspar, Horse, Rajhans, Lion and SNC brands retained 2.5, 3.2, 4.1, 4.2 and 4.7 % respectively. The Johnson brand had the finest particles as the particles retained on the sieve were only 1 % and is the most preferred brand.
2. Three brands namely the Horse, Johnson and Rajhans produced thicker consistency at 0.45 water powder ratio whereas the other four brands namely Calspar, Lion, SNC and Elephant exhibited a creamy consistency at this ratio. However, the first three brands produced a creamy consistency between 0.50 and 0.55 water powder ratio.

3. The setting time for all the brands and all the three water powder ratios of 0.45, 0.50 and 0.55 was within the specified limit of 5–20 min. The Johnson brand exhibited minimum setting time values of 7.3, 8.5 and 9.8 min and the Elephant brand exhibited setting time values of 15, 15.6 and 17.6 min at 0.45, 0.50 and 0.55 water powder ratios respectively. Moreover, the setting time for all the brands increased with the increase in water powder ratio.

Lastly, it could be concluded that the manufacturers must improve the quality of dental laboratory plaster so that most suitable type of material may be available to the profession.

Conflict of interest We state that no conflict of interest, if any is involved in this study.

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