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The Influence of Chemical Activation on Tooth Bleaching Using 10% Carbamide Peroxide

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Clinical Relevance

If a chemical agent were able to accelerate the effects of bleaching agents on tooth structure, one could reduce treatment time or diminish the daily time spent on the bleaching procedures.

SUMMARY

The aim of this study was to assess the influence of manganese gluconate, a chemical activator of bleaching agents, at a concentration of 0.01% on the efficiency of a 10% carbamide peroxide-based bleaching agent. Forty bovine incisors were immersed in a 25% instant coffee solution for seven days and randomly divided into two groups. Group 1 was the control group and consisted of 10% carbamide peroxide-based bleaching gel only. Group 2 consisted of 10% carbamide peroxide-based bleaching gel and 0.01% manganese gluconate. Three readings of color were taken using the Vita Easyshade spectrophotometer: the initial reading, a reading at seven days, and a reading at 14 days. Total color variation was calculated by ΔE*Lab. Data were submitted to the statistical *t*-test (5%), which showed that after seven days group 2 had a significant increase in the degree of tooth bleaching compared with group 1. The mean values (±SD) were 16.33

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(±3.95) for group 1 and 19.29 (±4.97) for group 2. However, the results for group 1 and group 2 were similar after 14 days. Adding 0.01% manganese gluconate to 10% carbamide peroxide bleaching gel increased the degree of tooth bleaching after a seven-day treatment and did not influence the resulting shade after 14 days.

INTRODUCTION

Bleaching offers a conservative, simplified, and economical alternative for changing the color of teeth.[1] The two main forms of dental bleaching are in-office bleaching and at-home bleaching. If correctly administered, both bleaching techniques are safe and efficient.[2-4] As high concentrations of hydrogen peroxide are generally used in in-office bleaching, one advantage is faster results. Another advantage of in-office bleaching is that the professional has complete control over the application process.[5]

The at-home bleaching technique, in which lower concentrations of carbamide peroxide or hydrogen peroxide are used, has the advantages of being self-administered by the patient, requiring a shorter clinical time in the dentist's chair and a lower cost.[6] However, its greatest disadvantage is the longer time required to obtain the desired results.

In 2000, Viscio and others[7] considered that the future technology for bleached teeth could involve the use of chemical activators to improve the performance of bleaching gels. Thus, the incorporation of chemical agents into bleaching agents is one of the options that is currently being tested.[8-14] If a chemical agent can accelerate the decomposition reaction of hydrogen peroxide/bleaching agents on tooth structure, one could reduce in-office treatment time or diminish the daily time spent on the bleaching procedure at home.

Thus, because of the popularity and high acceptance of the at-home bleaching technique by patients, and with the intention of accelerating the bleaching results, this current study sought to analyze the influence of a chemical activator, manganese gluconate, at a concentration of 0.01%, on 10% carbamide peroxide-based bleaching gel within the scope of self-administration. The null hypothesis tested was that adding the chemical agent would not influence the effects of the bleaching agents on tooth structure.

MATERIALS AND METHODS

Forty extracted bovine incisors were used in this study. The tooth crowns were worn transversally with a plaster cutting appliance, under water cooling, at 11 mm from the cement-enamel junction. The roots were sectioned with a flexible diamond steel disk with a distance of 2 mm from the cement-enamel junction. With the help of a carborundum disk driven by a low-speed micromotor, the teeth were sectioned longitudinally to expose the dentin. The lingual half was removed and discarded, and the labial half was used for the study.

The labial surfaces of the specimens were submitted to prophylaxis with a jet of water and bicarbonate of soda, using the Prophy Jet appliance (Kondortech – São Carlos, SP, Brazil). The teeth were immersed in an ultrasound bath for 20 minutes. The dentin surfaces were etched with 37% phosphoric acid in gel for 15 seconds. The specimens were then washed with an air/water jet for 30 seconds to expose the dentin tubules. For pigmentation, the teeth were immersed in 200 mL of a recently prepared 25% instant coffee solution (Nescafé, Nestlé, Araras, SP, Brazil) and kept in a bacteriologic oven for seven days at a temperature of 37°C (Figure 1).

After staining, the enamel surfaces were polished with a diamond polishing paste using felt disks. With the purpose of delimiting the color reading area,[15] a circular adhesive label 9 mm in diameter was adhered to the center of the buccal surface (Figure 2). The entire buccal and other surfaces were coated

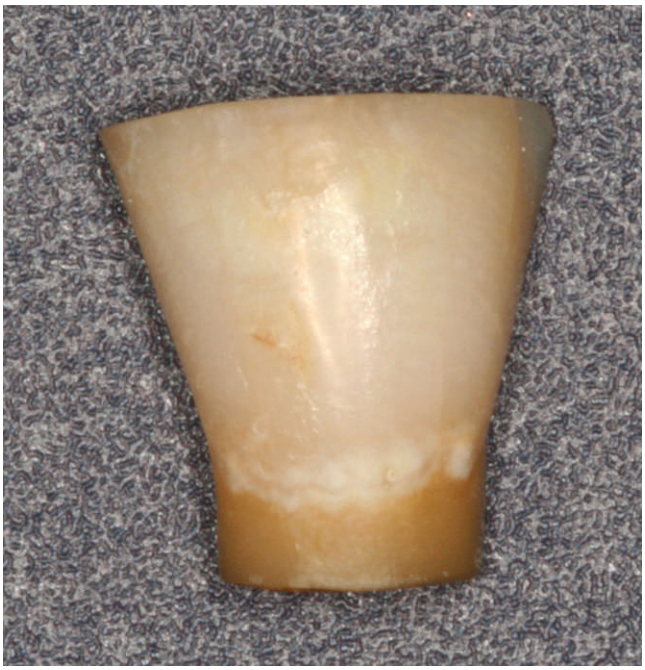


Figure 1. *Tooth after staining.*

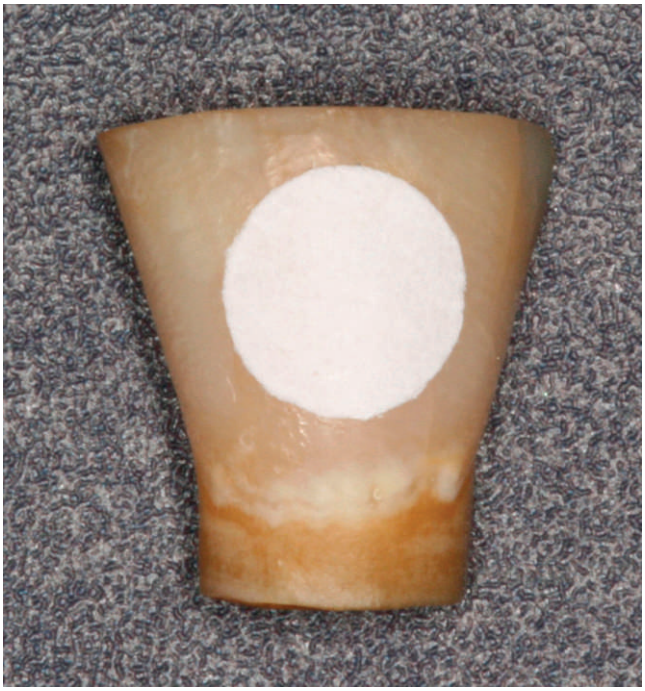


Figure 2. *Adhesive tape adhered to the buccal surface of the tooth.*

with colorless nail varnish (Colorama, São Paulo, SP, Brazil; Figure 3). After the nail varnish dried, the label was removed, exposing a dental enamel window 9 mm in diameter (Figure 4). The other purpose of varnishing the specimen was to prevent

Figure 3. *Tooth sealing with two coats of nail varnish.*

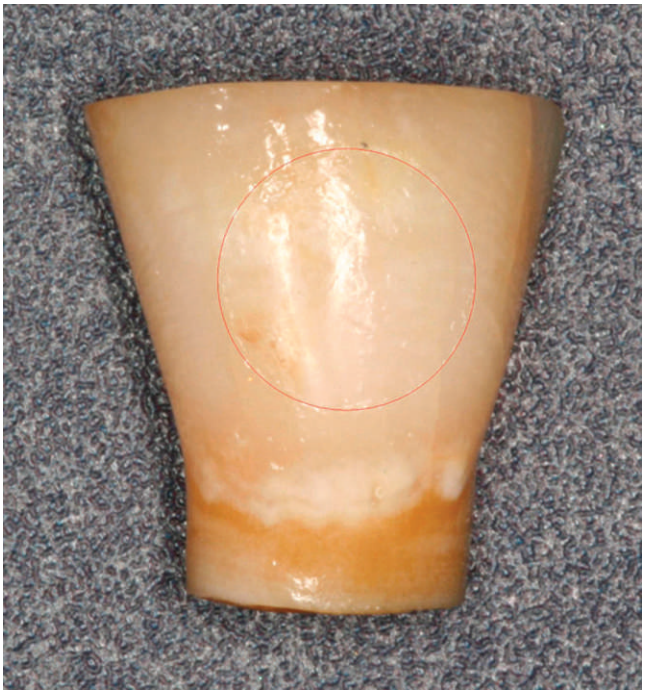


Figure 4. *Final result of the surface varnishing. The red circle delimits the area not varnished.*

the artificial saliva and bleaching gels from penetrating the dentinal tubules during the storage and bleaching periods and interfering with the color.

Specimens were individually stored in test tubes sealed with cotton wads. Specimens were soaked in distilled water to provide an environment of high relative humidity, and then kept in an oven at 37°C.

The color of the labial faces of the teeth was measured using the Vita Easyshade spectrophotometer (Vita Zahnfabrik, Bad Säckingen, Germany; Figure 5). Three separate readings were taken in the area with a diameter of 9 mm: an initial measurement, a measurement after seven days, and a measurement after 14 days.

For each specimen, means were calculated for the values of L*, a*, and b*. The L* value defines the lightness of the color, and a* and b* define the chromatic characteristics of the color, with a* referring to the red-green axis and b* referring to the yellow-blue axis.

Specimens were divided into two groups, each group containing 20 teeth, and received the following treatments:

- Group 1: 10% carbamide peroxide-based gel application (control group).

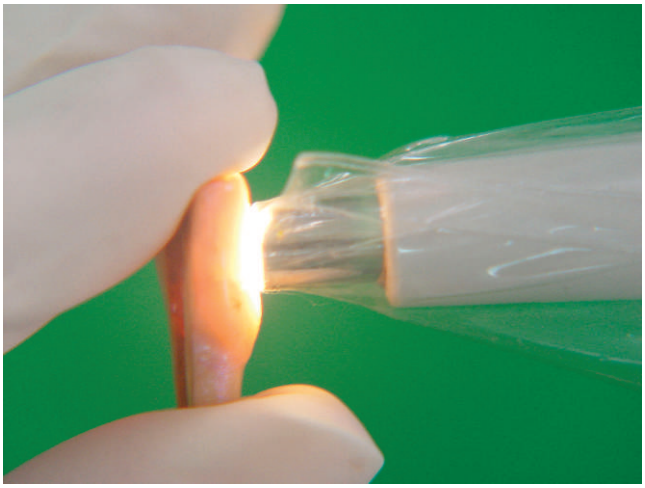


Figure 5. *Color measurement. The Easyshade pointer was positioned at an angle 90° to the buccal surface of the tooth.*

- Group 2: 10% carbamide peroxide gel application with the addition of 0.01% manganese gluconate.

Gels used in group 2 were kept in separate compartments of a double syringe, with a self-mixing tip, which ensured the application of equal amounts in each specimen.

The application of bleaching gels was done on the demarcated labial areas of the tooth crowns for eight hours daily[16] (Figure 6). During the nonbleaching intervals, the teeth were washed under running water to completely remove the bleaching agents and then stored in distilled water at 37°C.

The values of the changes of L* (ΔL), a*(Δa), and b*(Δb) were calculated (Figure 7) from the color measurements taken at baseline and after each time interval. The total change in color, or the variation in perception of color, of each tooth was calculated and designated by Delta E (ΔE), which refers to the color difference between time periods. This parameter was calculated according to the following formula:

$$\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$$

Data were submitted to the statistical *t*-test at a 5% level of significance.

RESULTS

The results showed a larger degree of tooth bleaching in group 2, in which the 10% carbamide peroxide gel was activated with 0.01% manganese gluconate. Application of the *t*-test (Table 1) showed a significant difference after seven days, but no significant difference after 14 days.

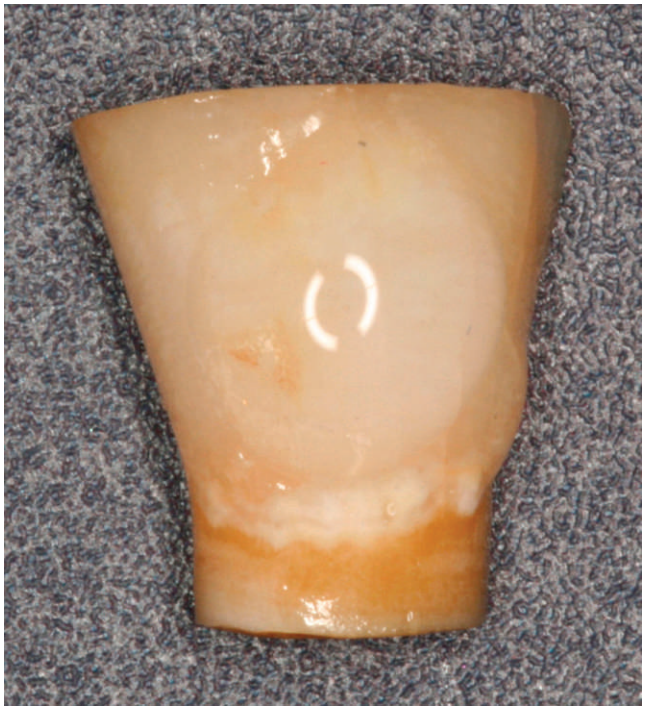


Figure 6. *Application of carbamide peroxide-based gel.*

Graph 1 shows a box-plot with reference to the Delta E (ΔE) data by time of treatment with 10% carbamide peroxide gel.

DISCUSSION

This study used the VITA Easyshade Spectrophotometer based on previous studies that confirmed its accuracy and reliability in determining tooth color.[17] Decomposition of hydrogen peroxide may be accelerated by chemical activators associated with, or used separately from, bleaching gels.[8-13,18] The chemical activator manganese gluconate was used in this study based on previous studies[11,12] that reported its efficiency in intensifying in-office dental bleaching. A study done by Travassos and others[13] tested the ability of various types of chemical catalyzing agents to intensify bleaching results when added to 35% hydrogen peroxide gel. The agents were ferric chloride, ferrous sulfate, manganese gluconate, manganese chloride, and mulberry root extract. Those authors found that manganese gluconate exhibited the highest means for shade perception variation, representing an increase in the process's efficiency to the order of 55.21%.[13] Gaffar and Fakhry-Smith[11] studied the efficiency of a bleaching gel containing 35% hydrogen peroxide, which was

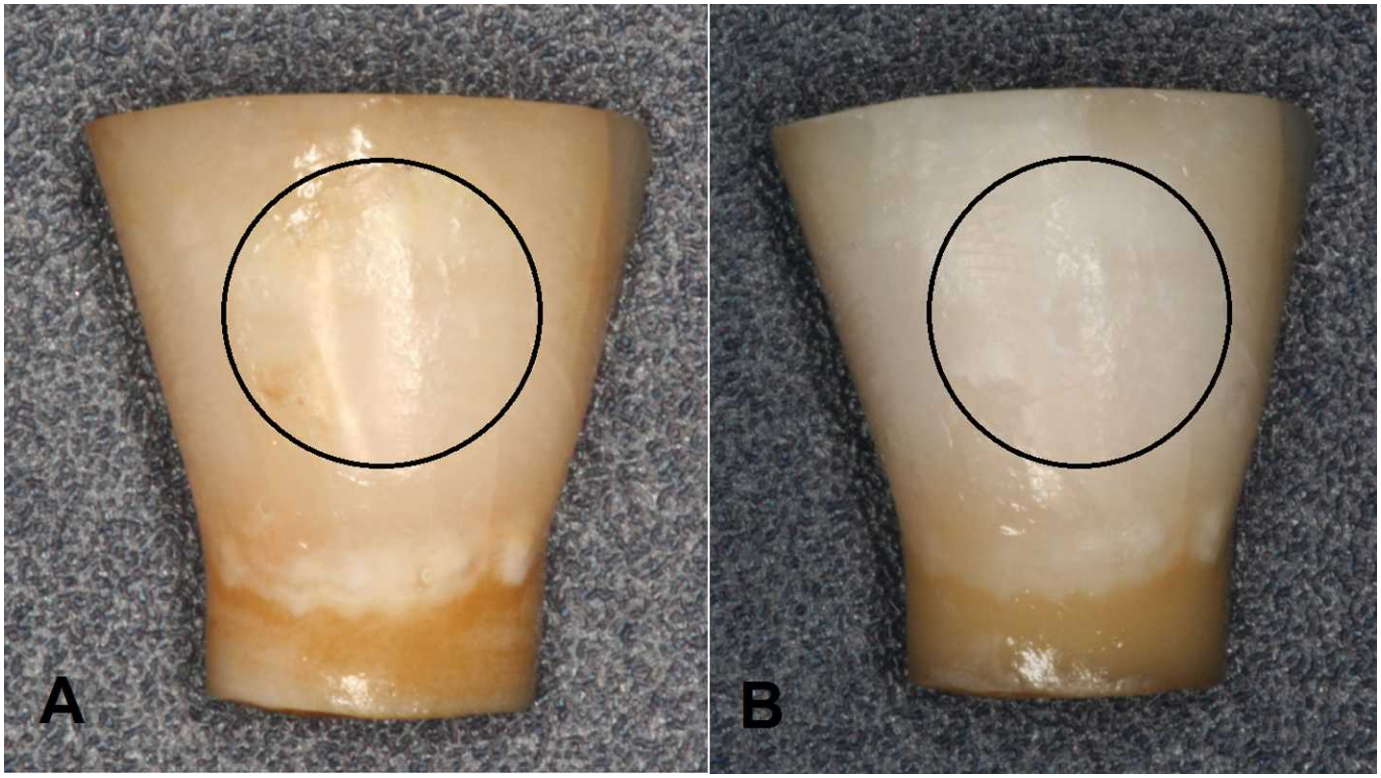


Figure 7. *Illustration of bleaching treatment at baseline and after 14-day treatment. (A): Before bleaching treatment (baseline). (B): After bleaching treatment (14 days).*

mixed with manganese gluconate. The results indicated that the presence of the chemical activator increased the efficacy of hydrogen peroxide by 1.5 to 8 times.

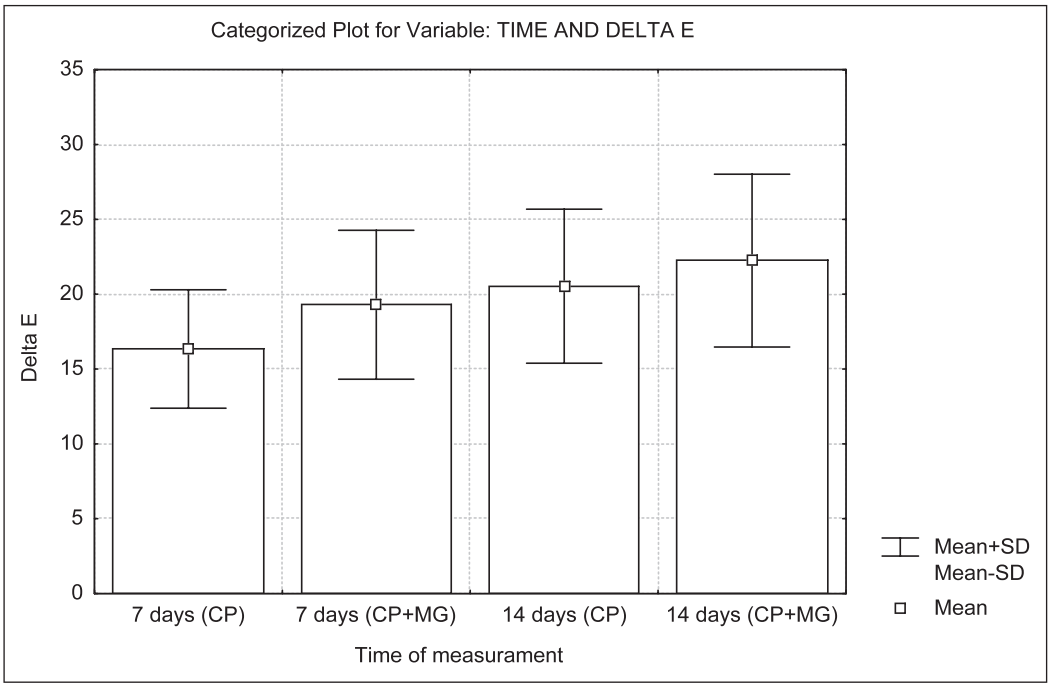
Manganese gluconate is a vitamin used as a dietary supplement and as a nutrient. Manganese is necessary for a variety of metabolic functions, including those involved in skeletal system development, energy metabolism, activation of certain enzymes, nervous system function, immunological system function, and reproductive hormone function. It is also an antioxidant that protects cells from damage due to free radicals. The estimated safe and adequate daily dietary intake levels for adolescents and adults ranges from 2 to 5 mg/day. For infants and children up to age 10 years, the levels range from 0.3 to 2 mg/day. Manganese, an essential element for humans and the fourth most widely used metal in the world, is a neurotoxic substance. But just as in the case of any chemical substance, the dose makes the poison; manganese toxicity has primarily been observed in occupational settings where there is a potential for chronic exposure to high levels or after the accidental ingestion of large quantities.[19]

Table 1: *ΔE Values (Mean and Standard Deviation) and Results of* t *Test Obtained After Seven and 14 Days of Treatment*

	Group	Mean ± SD	*t*-Value	*p*-Value
After Seven days	1	16.33 (± 3.95)	–2.07	0.04*
	2	19.29 (± 4.97)		
After 14 days	1	20.53 (± 5.14)	–0.98	0.33
	2	22.24 (± 5.77)		

* *Significant difference (*$p<0.05$*).*

However, lower doses for brief periods (maximum time of 14 days), as in the case of using a concentration of 0.01% manganese gluconate chemical activator for at-home bleaching agents, has an exposure level of manganese that is safe for all age groups. Furthermore, studies show that the low gastrointestinal absorption and the rapid elimination of manganese limits the toxicity of manganese after the ingestion of high doses.[20]



Graph 1. *Box-Plot with reference to the Delta E (ΔE) data by time of treatment with 10% carbamide peroxide gel. Legends: CP – Carbamide Peroxide; MG – Manganese Gluconate; SD – Standard Deviation.*

Furthermore, the bleaching agent is used externally on the surface of the enamel in small portions, and ingestion of the bleaching solution is minimal or does not occur. One syringe (3.5 g) of 10% carbamide peroxide gel with 0.01% manganese gluconate yields 116 mg of hydrogen peroxide and 0.35 mg of manganese gluconate. One syringe is used for seven applications of home bleaching agent and, thus, each dose of manganese gluconate drops to 0.05 mg/day. Therefore, 0.01% manganese gluconate is considered safe when used in at-home bleaching agents. However, it is important to keep syringes with this bleaching agent out of the reach of children, who might ingest the whole bleaching agent of one syringe, to prevent any possible accident.

In the search for a better bleaching result, manganese gluconate was previously shown to be efficient as an accelerator of the decomposition reaction of hydrogen peroxide in a whitening dentifrice. However, studies on chemical activation are limited to their association with hydrogen peroxide.[21] Therefore, because of the widespread use of carbamide peroxide-based bleaching gels in at-home tooth bleaching techniques, a bleaching agent associated with manganese gluconate was developed for this study in an attempt to increase bleaching efficiency by accelerating the bleaching agent decomposition.

A great advantage of associating chemical substances with at-home bleaching agents is the reduction of the total or daily time necessary for bleaching, which would provide the patient with faster results and more comfort, as the bleaching tray would be used for a shorter time. In addition, manganese gluconate does not alter the taste of the bleaching gel. The present study showed that carbamide peroxide activation by manganese gluconate provided significant results in terms of greater bleaching efficiency compared with the control group after only seven days, but after 14 days the results were similar. Therefore, the null hypothesis tested was rejected only for the seven-day treatment.

A previous study showed that whitening was initially faster with the use of more concentrated bleaching agents.[22] However, with the increase in treatment time, the results were equivalent, as occurred in this study when the chemical agent was added to the bleaching agent.

In addition to manganese gluconate, other chemical substances have been investigated to activate bleaching agents in an endeavor to increase the bleaching efficiency of these agents. This would allow faster results to be obtained by reducing the bleaching treatment time. Among the chemical compounds investigated were manganese chloride, manganese citrate,[11,23] ferrous sulfate,[24] sodium

carbonate (or bicarbonate),[24] catalase,[8,22] and mulberry root extract.[14]

The association of chemical compounds with bleaching agents represents a wide field of investigation in the area of tooth bleaching. This study should be regarded as preliminary, and future research should focus on determining the most effective substances and the ideal concentrations that would render the best clinical results. Moreover, one should investigate the safety of these chemical activators in terms of adverse effects, tooth sensitivity, effects on soft tissue, and interaction with dental tissues.

CONCLUSION

Adding 0.01% manganese gluconate to 10% carbamide peroxide bleaching gel increased the degree of tooth bleaching after a seven-day treatment and did not influence the resulting shade after 14 days.

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