Comparative evaluation of compressive strength and color stability of zirconomer and ceram-x against various children's health drinks: An in vitro study

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Abstract

Children eat & drink food that contains food additives which may stain not only tooth structures but also stains the restorative materials. As esthetic is one of the prime concerns for both parents and children nowadays, long-term color stability, as well as compressive strength to withstand masticatory forces, are of the utmost importance throughout the functional lifetime of restorative materials, study intends to evaluate and compare the effects of various children's health drinks on the color stability and compressive strength of Zirconomer and Ceram-x. A total of 60 specimens were made with each restorative material, Zirconomer, and Ceram-x. Fifteen were immersed in distilled water as a control and remaining (n=45) as experimental. The experimental specimens were randomly divided into three groups based on media of immersion (n=15 each). Group 1 was immersed in Soya milk, Group 2 was immersed in Milo, and Group 3 was immersed in Horlicks.

The specimens were subjected to 1, 5, and 10 times immersion per day lasting for 5 min distributed evenly over a 12 hours period, for 15 days. The color changes (ΔE values) were measured using a spectrophotometer. All were then subjected to Universal Testing Machine analysis.The compressive strength and color stability of Ceram-x were found to be significantly more than that of Zirconomer ($P < 0.05$).

Conclusion: Ceram-x showed more resistance to color change than Zirconomer with all the tested media and immersion regimes. Ceram-x also appears to be better than Zirconomer when compressive strength is considered. The Ceram-x showed more resistance and stability to any color change compared to Zirconomer in all different immersion media & regimes but Ceram –x had better compressive strength than Zirconomer.

Experimental article (J Int Dent Med Res 2021; 14(1): 33-38)
Keywords: Colour stability,Compressive strength, Ceram-x, Nanocomposites, Zirconomer.
Received date: 03 September 2020 **Accept date:** 14 October 2020

Introduction

The basic objective of dental restorative material is to replace the functional, biological, and esthetic properties of the tooth structure.[1] The color, shape, and surface texture of the teeth are very important in giving a beautiful smile. The demand by parents and children toward a natural appearance led to research for the development of materials that simulate natural teeth.[2] color stability and the mechanical property of esthetic materials like glass ionomer cement and composite resin may be hampered due to the presence of oral microflora, saliva and the frequent intake of food, thus leading to the constant evolution of restorative materials and techniques making possible to achieve optimal esthetics with increased strength.[2,3] Glass ionomer cement (GIC) and composites are the most commonly used restorative materials used in dentistry throughout the years due to its unique

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high fluoride releasing property of glass ionomer to prevent and arrest tooth destruction and superior esthetic appearance of composite resins. GIC lack to achieve sufficient hardness, resistance to fracture, and shows a low abrasion resistance. So, newer conventional glass ionomer cement was developed gradually with better mechanical properties with the inclusion of Zirconia fillers which reinforces the structural integrity of restoration and imparts superior mechanical properties in posterior load-bearing areas Zirconomer a new class of posterior restorative glass ionomer that comprises the strength and durability of amalgam are evolved. this is the era of nanotechnology, which is being used colossally to produce restorative materials with better adhesion, mechanical and esthetics properties, the recent improvement is the Ceram x, the nanocomposite that is radiopaque, light-curable restorative material which is used for the restoration of both primary and permanent teeth.[4] Several studies have shown that glass ionomer cement and composite resins are susceptible to color alteration when exposed to various beverages. The frequently used health drinks can notably affect the properties of glass ionomer cement and composite resins. [2, 5, 6] Hence, the present in vitro study was undertaken to evaluate and compare the compressive strength and color stability of Zirconomer and Ceram x against different kinds of children's health drinks.

Materials and methods

The present in vitro study has been carried out in the Faculty of Dentistry SEGi University Kota Damansara, in collaboration with Research and Developmental Lab, MARA University of Technology (UiTM, Malaysia), and was approved by the institutional Ethical Committee. Standard specimens of 120 disc-shaped specimens were prepared by using polyvinyl chloride (PVC) mold with a 6 mm inner diameter and 4 mm thickness. Out of the total 120 samples, 60 samples were prepared with Zirconomer (Shofu Dental Corporation, Japan) and the others with Ceram-x (Dentsply, India). The samples were filled with Zirconomer as specified by the manufacturer instructions in a ratio of 3.6:1 at room temperature (23°C) and also with Ceram-x, which is available as a single component. The molds were filled with materials by using cement carrier. Mylar strips were covered over them pressed against two glass slabs on either side of the PVC mold with constant hand pressure and materials were allowed to set. Chemically activated Zirconomer was allowed to set completely, and the Ceram-x was light-cured according to the recommended exposure time of 20 s with an LED light of output 600 mW/cm2.

Immersion of Samples in solutions:

After the preparation of samples, the samples were stored in distilled water for 24 hours at 37°C for rehydration. Before immersing the samples into the solutions, baseline values were evaluated by using spectrophotometer, with the CIELAB scale L*, a* and b*. The experimental specimens were randomly divided into three groups based on media of immersion (n=15 each). Group 1 was immersed in Soya milk, Group 2 was immersed in Milo, and Group 3 was immersed in Horlicks. (Table :1)

The specimens of each restorative material were immersed into airtight plastic container containing 25 ml of the test solutions to 1, 5, and 10 times lasting for 5 minutes every day.

Brand name	Manufacturing company	Ingredients	Suspected staining agent
Soya milk	ACE Canning Corporation Sdn. Bhd.	Soya bean extract, water, cane sugar, salt, Acidity Regulator 500	Nil
Milo	Nestlé Products Sdn. Bhd.	Malt extract, skimmed milk powder, maltodextrin, sugar, cocoa, palm oil minerals, vitamins, vanillin	Cocoa powder
Horlicks	GlaxoSmithKline Consumer Healthcare Sdn. Bhd.	Wheat flour, malted barley, dried whey, sugar, vegetable fat, milk solids, vitamins, minerals, salt, traces of soya beans	Nil
Distilled water was used as control group			

Table 1. Test solutions used.

Following the immersion, the rest of the day, the samples were stored in distilled water at room temperature until further use. This whole procedure was carried out for 15 days.

Color stability and Compressive strength Evaluation:

The samples were collected and analyzed for change in color using a spectrophotometer. Values were recorded in International commission on illumination (CIE) \ CIE L*a*b* which is an approximately uniform color space for lightness namely white/black (L), red/green (a), and yellow/blue (b) and color change was calculated from the mean ΔL*, Δa* and Δb* values for each specimen with the following formula.

Equation: ΔE* = (ΔL*)2 + (Δa*)2 + (Δb*)2½

All the specimens were then transferred to the Universal Testing Machine individually and subjected to load cell of 20 kN, at a crosshead speed of 1 mm/s at an angle of 90° to restoration until visible or audible evidence of failure was observed. For all the study samples, the compressive strength was calculated in megapascals (MPa) using the formula:

CS = Load/πr2 (Where CS = compressive strength; load is expressed in Newton (N); π = 3.14l; r = half the diameter of mould).

Statistical Analysis

All statistical analysis was performed using the statistical software SPSS for Windows, version 22. The color changes observed among the groups were compared using a one-way ANOVA test. Intergroup comparison was conducted using an independent sample t-test. The compressive strength among the groups was compared using the Kruskal-Wallis test. For all the tests, the level of significance chosen was $P < 0.05$.

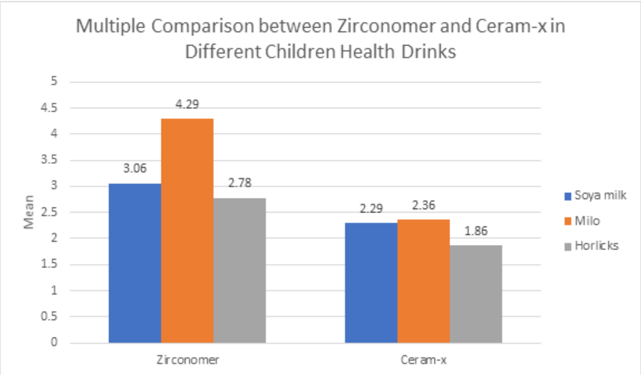
Results

The results have depicted that in all the immersion media used; distilled water, soy milk, Milo, and Horlicks, Zirconomer samples have shown higher color change and lesser compressive strength compared to samples of Ceram-x at P<0.001. However, insignificant differences were found between Group 1 (Soya milk), 2 (Milo), and 3 (Horlicks) at P>0.05. Between all three different media, the immersion of samples in Milo drinks (Group 2) appears to undergo the most color change, while not much difference of color change can be noticed between immersion in soya milk (Group 1) and Horlicks (Group 3). (Table:2 & Graph:1)

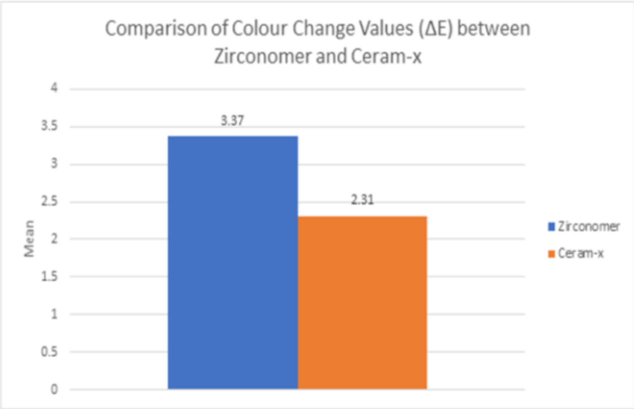
All color change was recorded in (ΔE) value. This is because the (ΔE) values play a lot of role in proving the acceptability of a restorative material clinically. In all three immersion media, Zirconomer samples have shown more color change compared to Ceram-x. Ceram-x samples appear to be more stable to any color change even after the immersion regime in different media. (Graph:2)

Variables	Zirconomer		Ceram -x		P values
	Mean	SD	Mean	SD	
Distilled water	-	-	-	-	-
Soy Milk	3.06	1.13	2.29	2.17	0.065*
Milo	4.29	2.21	2.36	2.33	0.003**
Horlicks	2.78	1.38	1.85	1.32	0.033**
Total	3.37	1.18	2.31	1.99	0.000***

Table 2. Colour change values for both the materials in different immersion solutions. * P > 0.05 is insignificant; ** P < 0.05 is statistically significant; *** P < 0.001 is highly significant; SD: Standard deviation.



Graph 1. Comparison between the materials in children's health drinks.



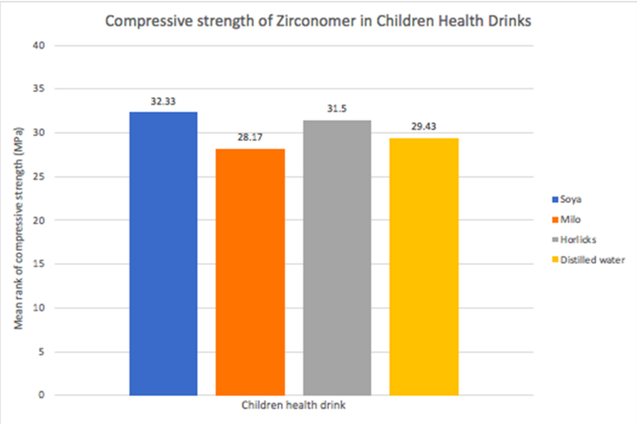
Graph 2. Colour change values between the materials.

All the samples of both the materials underwent a compressive strength evaluation using a Universal Testing Machine. All the values were recorded in MPa (Megapascal Pressure Unit). (Table:3)

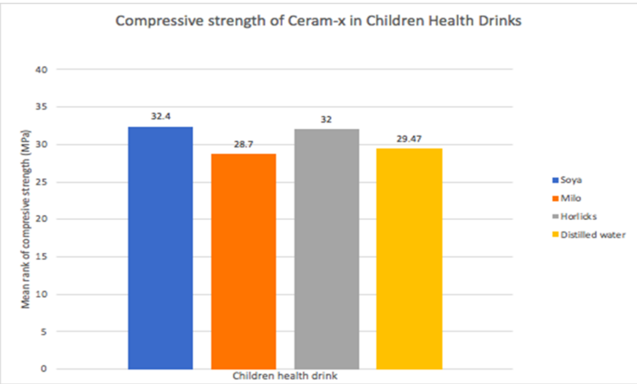
Variables	Mean rank of compressive strength (MPa)	
	Zirconomer	Ceram-x
Distilled water	29.47	29.43
Soya milk	32.33	32.40
Milo	28.70	28.17
Horlicks	31.50	29.43

Table 3. Mean rank of compressive strength (MPa).

Between all three different media and control groups, no significant difference was found when compressive strength is compared. The contents and composition of the drinks play very little role in influencing the compressive strength of the restorative materials without any offending agent. (Graph:3&4)

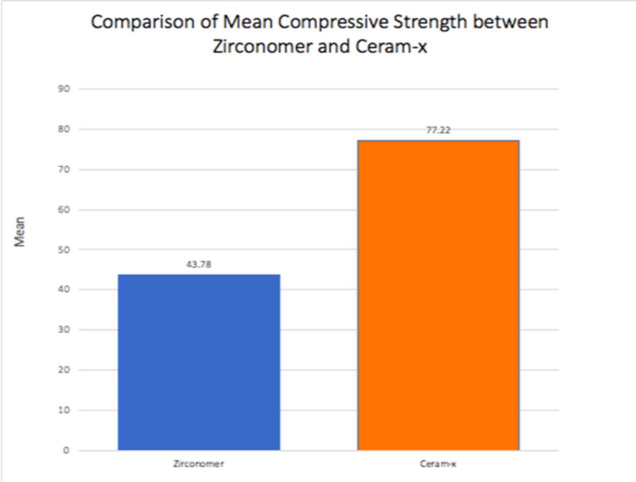


Graph 3. Compressive strength of Zirconomer in Health drinks.



Graph 4. Compressive strength of Ceram-x in Health drinks.

However, when all 60 samples of each material are tested respectively and the mean compressive strength is calculated, Ceram-x samples show better compressive strength distinctly compared to Zirconomer samples. (Graph:5)



Graph 5. Mean Compressive strength of the materials.

Discussion

Composite resin is widely used as a restorative material, and they are expected to retain the color and stability as the quality of these composite resin restorations have been improved.[8] Discoloration of these composite restorations may occur due to different circumsentences, intrinsic, or extrinsic. The intrinsic sugars are naturally integrated into the cellular structures of food and the extrinsic sugars are the one which occurs as free molecules or Which are added to the food like added sugars especially during manufacture.[9,10]

The composition and size of the filler particles of these resins which affect the surface smoothness and the vulnerability for extrinsic staining and Studies have shown that most of the water absorbs by resin-based materials are during the first week of restoration. and if the resin composite can absorb water, it can also absorb other fluids like tea and coffee and other beverages.[11,12] Studies exist in the literature regarding the staining effects of beverages on tooth-colored restorations, as the oral environment is exposed to a variety of media every day and many of them may stain or change the surfaces of dental restorations.[13,14]

Obviously, saliva is an important enhancing of the environment for the dissolution of dental erosion by diluting and buffering extrinsic acids it also provides the source of glycoproteins which coats as the protective acquired pellicle on the tooth surface, saliva provides the lesser protection from erosion when acidic beverage consumption is more.[15] An ideal restorative material should exhibit color stability in addition to other properties like strength and biocompatibility, although it's virtual, not possible to have all expected properties Thus, the present study aimed to assess for color stability & comprehensive strength of zirconomer and ceram-x against Soya milk, Milo, Horlicks probably the popular children's health drinks in Malaysia. Soy beverages, also known as soy, or wrongly as soy milk, these are water extracts of whole soybeans. Their composition may vary according to the variety and growth conditions, which affects the composition of the soy extract, these Soy beverages are water extracts are frequently encouraged as a healthy alternative to bovine milk. Soy beverages have a higher potential acidogenicity than bovine milk beverages.[16,17]

Milo is a chocolate and malt powder which is mixed with hot water and milk, Milo in powder form have milk, malt, cocoa, sugar, the recommended preparation of Milo is to add five teaspoons of Milo powder in 200ml of hot water then the serving contains only 6 % of sugar.[18]Horlicks is a malted milk hot drink, which is marketed as a nutritional supplement, The ingredients include wheat flour, malt extract, malted barley, milk solids, sugar, minerals, salt, vitamins, protein isolate. The formulation can vary in different countries. Horlicks remains popular in Malaysia and Singapore.[19] To check the restoration discoloration, visual or instrumental techniques can be used, but the use of instrumental methods are preferred ones, like spectrophotometers and colorimeters to quantify tooth color that could potentially abolish the subjective aspects. Individuals for assessment of the color, currently, spectrophotometer and colorimeters have been advised to measure discoloration of restorations using the CIE Lab system.[20-23]

Along with the restorative materials, the denture base materials made up of acrylic resins also showed the discoloration and staining after exposed to different beverages containing artificial coloring agents.[24,25]

An ideal restorative material should exhibit color stability in addition to other properties like strength and biocompatibility, although its virtually, not possible to have all expected properties. Thus, the present study aimed to assess for color stability & comprehensive strength of zirconomer and ceram-x against Soya milk, Milo, Horlicks probably the popular children's health drinks in Malaysia. We didn't find any study in the literature search that was conducted using these three drinks which motivated us to do the present pilot study. Any color change (ΔE) in the range of 3.3 to 3.7 and above is considered to be clinically perceptible.[26,27] The present study shows that (ΔE) value in Zirconomer was more than 3.3 which is clinically perceptible, hence clinically unacceptable, whereas Ceram-x shows (ΔE) value of less than 3.3 which is clinically acceptable. Composition and the relative amount of resin and filler content present, greatly influence the stainability of a material. Materials with relatively lower filler content have shown to have poor color stability.[28] Ceram-x contains 62% volume of fillers including glass fillers (~1 micrometer), nanofillers (~10nm), and organically modified ceramic nanoparticles (2nm to 3nm). Zirconomer with the addition of zirconia (0.01-3.5 micrometer) filler particles exhibits lower filler content, thus poorer color stability. Zirconia is also used for aesthetic prosthesis fabrication to resist high loading, but because of its low surface energy and wettability, it is not a favourable material for bonding to the resin cements compared to ceramics. Ceram x shows more value of compressive strength than Zirconomer, as the lesser dimension of the particles and an increased filler load attained in Ceram x, without increasing their viscosity, which increases its mechanical property such as compressive strength.[4,27,29,30,31]

Although the present in vitro study evaluated both colour stabity & compressive strength with quite a good number of samples, it is recommended to conduct further in vivo studies with larger number of samples. However, care must be taken regarding the overall handling of these restorative materials while using them with proper finishing, that could help in retaining better colour stability.

Conclusions

Although many newer materials are introduced with better properties, they may not reach all the expectation of the dentist & patient.

This may be due to our complex oral microbiome which varies individually & also variations in our lifestyle & food habits. However, based on the results obtained from the present study, the following conclusions can be made a) Ceram-x shows more resistance and stability to color change when compared to Zirconomer in all different immersion media & regimes b) Ceram – x also had better compressive strength when compared to Zirconomer.

Acknowledgements

We would like to thank Assoc. Prof. Datuk. Dr. Khairiyah Binti Abd Muttalib, Former Dean Faculty of Dentistry, SEGi University for her guidance & Professor Dato' Dr. Mohamed Ibrahim Abu Hassan, Dean Faculty of Dentistry, Universiti Teknologi MARA for his support & providing the access to the laboratory.

Declaration of Interest

The authors report no conflict of interest.

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