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Research Article

The Effect of Cassava Starch and Modified Cassava Starch on Dimension Stability of Alginate Impression

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Abstract

Alginate is the most common impression material in dentistry. Alginate is a water-based material and thus has a lack of dimensional stability due to imbibition and syneresis. Dimensional changes in alginate can cause the impression to be less accurate. Dimensional changes can be resolved by modifying alginate, one of which is by adding cassava starch and modified cassava starch. This study aims to determine the effect of adding cassava starch and modified cassava starch on changes in the stability of alginate impression. This research was conducted in an experimental laboratory with a post-test-only control group design and 30 samples. The research was conducted by observing dimensional changes of pure alginate, alginate with 40% cassava starch, and alginate with 40% modified cassava starch at 0 minutes and 30 minutes of impression filling. The smallest dimensional change occurs in alginate with the addition of modified cassava starch 40%; as a result of 0.342% followed by alginate with the addition of natural cassava starch 40%; as a result of 0.592% and pure alginate with the largest dimensional change of as a result 0.85%. The One Way Anova test showed significant differences from the dimensional changes of pure alginate, alginate with 40% cassava starch, and alginate with 40% modified cassava starch. Alginate with the addition of 40% modified cassava starch is more stable than alginate with the addition of 40% cassava starch and pure alginate.

Keywords: alginate; cassava starch; dimensional stability; modified cassava starch

INTRODUCTION

Impression materials are used in dentistry to produce accurate impressions of hard and soft tissue of the oral cavity.[1] Alginate is one of the most common impression materials used in dentistry because it is easy to use, relatively inexpensive, and has a fast setting time.[2] Alginate has many advantages, such as the ability to bind to water, elastic recovery ability, and modification, making it the ultimate choice in dental practice.[3]

Alginate has many advantages. However, there are still some disadvantages, such as less accurate detail reproduction when compared to elastomer and the poor dimension of stability where distortion occurs at storage times of more than 12 minutes. Longer storage will cause dimensional changes in alginate.[2,4] Several factors cause dimensional changes, that is, the process of imbibition and syneresis.[5]

The syneresis of alginate can cause shrinkage, while the imbibition process causes alginate to increase in volume when it comes into contact with water.[6] The alginate impression should be cast immediately after finishing the impression process.[7] Alginate impressions left open at room temperature for 30 minutes will change stability dimensions, and a reprint is

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required. The longer the impression is left, the greater the distortion can occur.[1]

The alginate can be modified by adding starch to the alginate powder before manipulation.[8] The background for alginate modification with starch is the polysaccharides in both materials.[9] Alginate is composed of alginic acids that include carbohydrates of the polysaccharide type.[10] Starch is a polysaccharide compound consisting of a bond between monosaccharides and oxygen. Amylose and amylopectin are the two main polymers that compose starch's essential ingredients.[8] Amylopectin in starch leads to crosslinking with alginate carboxyl groups, causing partial hydrolysis. Amylose levels in starch affect the development and absorption of water in starch granules because amylose can form faster hydrogen bonds.[11]

The highest starch-producing plant is the cassava (*Manihot esculenta*), with a starch content of around 73.3–84.9%. People in food and beverage manufacturing widely use it because it is easy to find, economically affordable, and has qualified FAO (Food Agricultural Organization) as a human consumable material.[12,13] The starch contains amylopectin and amylose compounds and has sticky properties. It has basic properties such as alginate impression, which can change from hydrosol to hydrogel when mixed with water.[14] The cassava starchs are divided into natural and modified cassava starch for its utilization.[15] Modified starch is a food update to address the shortage of natural starch, but it is still rarely known in general and rarely used in daily life, thus expanding information related to the use of modified starch.[16] Modified cassava starch is a starch that has undergone a modified process by fermentation using lactic acid bacteria to produce better physical and chemical characteristics than natural starch.[17] The cassava starch fermentation technique modification process changes features such as viscosity value, gelation ability, solubility, and rehydration power.[15]

MATERIALS AND METHODS

This study is a laboratory experiment with a post-test-only control group design. The samples used were alginate (Hygedent, China), natural cassava starch (Pak Tani Gunung, P.T Budi Starch and Sweetener TBK, Indonesia), and modified cassava starch (Mocafine, P.T Rumah Mocaf Indonesia, Indonesia). Samples were obtained by impression using a tube-shaped master model made of stainless steel material 28 mm in diameter and 18 mm in height and an impression device made of stainless steel material 48 mm in diameter and 23 mm in height.[18] The number of samples in this study was 30, divided into six treatment groups.

This study was conducted to determine the effect of adding 40% cassava starch and 40% modified cassava starch on the dimensional changes in alginate. This study examined the difference between the alginate cast at 0 minutes filling time and 30 minutes filling time concerning the control and treatment groups. The data were obtained by measuring the diameter of the gypsum model at 0 minutes of filling time and 30 minutes of filling time using the digital caliper. The data were analyzed using the One Way Anova test and continued with the Post Hoc LSD test.

RESULT

The results of measuring the diameter of the gypsum model at 0 minutes filling time and 30 minutes filling time in the entire treatment group showed a difference. It proved that after 30 minutes of mold filling delay, a dimension change occurred in each treatment group. The result of measuring the average dimensional change of gypsum model results from the casting of pure alginate, alginate with 40% cassava starch, and alginate with the addition of 40% modified cassava starch can be calculated by looking for a measurement difference at 30 minutes filling time minus the measurement at 0 minutes filling time shown in Table 1.

Table 1. Dimensional change percentage result

Groups	Gypsum model diameter (mm) $\bar{x} \pm s$		Average dimensional change	Dimensional change (%)
	0-minute filling time	30-minute filling time		
100% Pure Alginate	27.978 ± 0.008	28.216 ± 0.018	0.238	0.850
Alginate with the addition of 40% cassava starch	27.996 ± 0.015	28.162 ± 0.013	0.166	0.592
Alginate with the addition of 40% modified cassava starch	28.002 ± 0.008	28.098 ± 0.008	0.096	0.342

The dimensional changes were calculated by looking at the difference between the average diameter of the gypsum model at 30-minute filling time and the average diameter of the gypsum model at 0-minute filling time. The results showed that the largest change occurred in the pure alginate group with a result of 0.850%, followed by alginate with an addition of 40% cassava starch with a result of 0.592%, and the smallest change in alginate with an addition of 40% modified cassava starch with result 0.342%.

Table 2. One Way Anova of alginate castings diameter at 0 minute filling time

Groups	n	Mean (mm)	sd	P-Value
100% Pure Alginate	5	27.978	0.008	0.013
Alginate with the addition of 40% cassava starch	5	27.996	0.015	
Alginate with the addition of 40% modified cassava starch	5	28.002	0.008	

Table 3. One Way Anova of alginate castings diameter at 30-minute filling time

Groups	n	Mean (mm)	sd	P-Value
100% Pure Alginate	5	28.216	0.018	0.001
Alginate with the addition of 40% cassava starch	5	28.162	0.013	
Alginate with the addition of 40% modified cassava starch	5	28.098	0.008	

Table 2 showed a value of $p < 0.05$, indicating a significant difference in each treatment at a filling time of 0 minutes. Table 3 also showed the significant difference of each treatment at a filling time of 30 minutes. To identify the significance of differences from one group to another, a Post Hoc LSD test was conducted.

Table 4. Post Hoc LSD Test of alginate castings diameter at 0 minute filling time

Groups	Alginate with the addition of 40% cassava starch	Alginate with the addition of 40% modified cassava starch
100% Pure Alginate	0.025*	0.005*
Alginate with the addition of 40% cassava starch		0.410
Alginate with the addition of 40% modified cassava starch		

Table 5. Post Hoc LSD Test of alginate castings diameter at 0 minute filling time

Groups	Alginate with the addition of 40% cassava starch	Alginate with the addition of 40% modified cassava starch
100% Pure Alginate	0.001*	0.001*
Alginate with the addition of 40% cassava starch		0.001*
Alginate with the addition of 40% modified cassava starch		

Table 4 shows Post Hoc LSD results at 0 minutes of filling time. It can be inferred that there is a significant difference ($p<0.05$) between pure alginate and alginate with 40% cassava starch and 40% modified cassava starch, as well as between alginate with 40% cassava starch and alginate with 40% modified cassava starch. An insignificant difference ($p<0.05$) occurs between the addition of 40% cassava starch and 40% modified cassava starch. Post Hoc LSD results at 30-minute filling time in Table 5 can be inferred that there are significant differences in dimensional stability between all treatment groups at 30 minutes filling time.

DISCUSSION

The result demonstrated dimensional changes in filling time of 0 minutes and filling time 30 minutes after the alginate setting. The dimensional changes were calculated by subtracting the diameter of the gypsum model at 30 minutes filling time from the diameter of the gypsum model at 0 minutes filling time in the entire control group and treatment group. The study results obtained values of the average diameter of the gypsum group with a filling time of 0 minutes were 27.992 mm, and the average diameter of the gypsum group with a filling time of 30 minutes was 28.158 mm. It suggests a change in the dimensions of alginate impression materials due to the syneresis process after being left for 30 minutes in the open air. The syneresis of alginate is due to differences in osmotic pressure and elasticity of the alginate matrix gel. Osmotic pressure changes are related to thermodynamics, in which water moves from one pressure to another. The polymer chain inside the gel will increase osmotic pressure so that the gel loses its conformational ability, which causes the polymer present in the gel to push water out of the gel. It will cause the polymer to stretch and create an elastic reaction to shrink the gel back to its former state. The process of discharging water from the gel causes the gel to dilute and cause a difference in gel size.[19] Dimensional changes are particularly vulnerable due to the alginate-sensitive gel structure that changes the conditions that change the amount of water in the gel.[20] The dimensional change is caused by the absorption of the liquid, resulting in swelling or imbibition, and the removal of the liquid by the gel, resulting in shrinkage or syneresis.[21] The process of syneresis and imbibition is also influenced by external factors: external pressure, water vapor absorption, mechanical disturbance of the gel, time, and temperature.[22]

Alginate with the addition of a 40% modified cassava starch has the smallest percentage of dimensional change with a value of 0.342%. Alginate, adding cassava starch 40%, has a dimensional change percentage of 0.592%, and pure alginate has the highest dimensional change percentage of 0.85%. The results showed that the alginate with 40% cassava starch addition and 40% modified cassava starch addition has fewer changes than pure alginate. The crosslinking of starch with alginate causes the gel to be more stable and more resistant to syneresis. The levels of amylose and amylopectin in starch influence the gel formation process in starch. Once mixed with water, gelatinization occurs where amylose and amylopectin in the starch absorb and retain water. The gel produced by adding cassava starch and water is viscous and does not readily release water due to amylose and amylopectin compounds in starch. This is what is used to mix cassava starch with alginate.[12,23] All treatment groups still produce dimensional changes that have not passed the ADA dimension change standard No.19, which is that the linear dimensional change of irreversible hydrocolloid impression material must not exceed 1.0%.[24,25]

The smallest percentage of dimensional change is found in alginate with the addition of 40% modified cassava starch. It indicates that alginate with the addition of modified cassava starch results in a more stable mold than alginate with the addition of 40% cassava starch and pure alginate. In alginate with the addition of a 40% modified cassava starch, a minimal syneresis process results in the least dimensional change compared to other groups. Cassava starch has physical and chemical properties that differ from modified cassava starch.[26]

Cassava starch has 17% amylose and 83% amylopectin, while modified cassava starch has 21.04%–29.2% amylose and 79.6–78.8% amylopectin.[27] This is because modified cassava starch has gone through a series of fermentation processes using lactic acid bacteria that break the amylopectin chain into amylo, so the modified cassava starch has more amylose than cassava starch.[28] The fermentation process also produces enzymes that cause changes in the characteristics of modified cassava starch, such as gelation ability, increased viscosity, solubility, and rehydration power in starch.[29] The fermentation of modified cassava starch also breaks starch granules from crystalline to porous. It causes modified cassava starch to bind more water because water will enter the material and be trapped inside the porous.[29,30]

At 0 minutes of filling, there was an insignificant difference in gypsum diameter with 40% cassava starch and 40% modified cassava starch due to the gelatinization process and the filling immediately after the impression material had not been set up and thus did not occur changes due to the syneresis process. Modified cassava starch has more amylose content than cassava starch. It causes the retrograde process and crystallinity of modified cassava starch better than cassava starch and produces more resistant starch. Thus, at 30 minutes, there was a significant difference in the diameter of the gypsum alginate model by adding 40% cassava starch and 40% modified cassava starch because the modified cassava starch gel was more stable and more resistant to syneresis after being left at room temperature than a cassava starch gel.

CONCLUSION

In conclusion, there were dimensional changes in the stability of pure alginate, alginate with 40% cassava starch, and alginate with 40% modified cassava starch at 0 minutes and 30 minutes of mold filling. Alginate with the addition of 40% modified cassava starch was more stable than alginate with the addition of 40% cassava starch and pure alginate. Alginate with the addition of 40% modified cassava starch underwent the smallest dimensional change with 0.342%, followed by alginate with the addition of 40% cassava starch with 0.592%, and the largest dimensional change was found in pure alginate with 0.85%.

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