ORIGINAL ARTICLE

The effect of cassava starch and modified cassava starch on the setting time of alginate impression: a laboratory experiment

Aria Fransiska[1*]
Vinny Puti Belia[1]
Reni Nofika[2]
Nelvi Yohana[3]
Sri Ramayanti[4]

[1]Department of Dental Materials, Faculty of Dentistry, Universitas Andalas, Padang, Indonesia
[2]Department of Conservative Dentistry, Andalas University, Padang, Indonesia
[3]Department of Orthodontia, Faculty of Dentistry, Andalas University, Padang, Indonesia
[4]Department of Pedodontia, Faculty of Dentistry, Andalas University, Padang, Indonesia

* Correspondence:
aria.fransiska@dent.unand.ac.id

Received: 18 November 2024
Revised: 10 January 2025
Accepted: 20 March 2025
Published: 31 March 2025
DOI: 10.24198/pjd.vol37no1.59194

p-ISSN 1979-0201
e-ISSN 2549-6212

Citation:
Fransiska, A. Belia, V.P. Nofika, R. Yohana, N. Ramayanti, S. The effect of cassava starch and modified cassava starch on setting time of alginate impression. Padj J Dent, March. 2025; 37(1): 18-24.

ABSTRACT

Introduction: Alginate is the most commonly used impression material in dentistry for creating accurate impressions of soft and hard tissues in the oral cavity. Its properties can be modified by adding starch, as both alginate and starch contain polysaccharides. This modification affects not only alginate's dimensional stability but also its setting time. This study aimed to analyze cassava starch and modifies cassava starch on the setting time of alginate. **Method:** This experimental laboratory study measured the setting time of pure alginate, alginate with 40% cassava starch, and alginate with 40% modified cassava. Analyze data using Anova and Post Hoc LSD Test. **Results:** The fastest setting time was observed in pure alginate (89±2,23 seconds), followed by alginate with 40% modified cassava starch (150±3,01 seconds), and alginate with 40% cassava starch exhibited the longest setting time (211±3,57 seconds). A one-way ANOVA test showed significant differences between the setting times of pure alginate, alginate with 40% cassava starch, and alginate with 40% modified cassava starch. The post hoc LSD test showed that there were significant differences in each treatment group. **Conclusion:** The addition of cassava starch and modified cassava starch affects the setting time of alginate. Pure alginate sets the fastest, followed by alginate with modified cassava starch, while alginate with cassava starch has the longest setting time. The addition of both natural and modified starch has a significant effect on the setting time of alginate with different effects between the two.

KEYWORDS

Alginate, modification, cassava starch, modified cassava starch, setting time

INTRODUCTION

Alginate is the most commonly used impression material in dentistry due to its low price, ease of use, and fast setting time.[1] It belongs to a group of irreversible hydrocolloid impression materials and is widely utilized for producing study and working models. Alginate offers several advantages, such as water-bonding, good elastic recovery, and modifiability.[2]

However, alginates also have some notable disadvantages, particularly their inferior dimensional stability compared to elastomeric impression materials. Alginate is susceptible to dimensional changes through imbibition and syneresis if exposed to open air for more than 12 minutes. These changes can compromise the accuracy of the impression and reduce the reproduction of fine details.[1,3] Comprising approximately 85% water, alginate is particularly vulnerable to distortion, affecting its dimensional stability.[4] Imbibition (humidity absorption) and syneresis (humidity

loss) are primary factors contributing to these dimensional changes. Alginate in contact with water undergoes imbibition, resulting in volume expansion, while alginate exposed to air experiences syneresis, leading to volume reduction.[5,67]

Alginate impression materials can be modified by adding starch to alginate powder before the mixing process. This modification is based on the polysaccharide content shared by both alginate and starch.[8] Alginate is a polysaccharide-type carbohydrate composed of alginic acid polymer chains,[9,10] while starch is a polysaccharide consisting of amylose and amylopectin polymer chains.[11,12] The amylopectin content in starch induces partial hydrolysis of alginate through cross-linking with the carboxyl groups of alginate. Amylose, on the other hand, has the ability to form faster hydrogen bonds with water, thus affecting the development and absorption of water in starch granules.[13,14]

Alginate modification with the addition of starch affects not only the dimensional stability but also the setting time of the alginate.[15] Setting time refers to the duration from when alginate is mixed with water until it loses its attachment and hardens.[16] Setting time is an important parameter for determining whether or not the mold is well formed. Before setting, alginate flows to replicate the anatomy of the oral cavity. After setting, the flowability of the alginate ceases, and it solidifies, forming a detailed mold of the oral cavity.[15] According to the ADA (American Dental Association) specification No. 18, alginate setting times are divided into fast-setting (1-2 minutes) and normal-setting (3-4.5 minutes) types.[16]

Cassava (Manihot esculenta) is the highest starch-producing plant, with a starch content ranging from approximately 73.3–84.9%. Cassava starch is recognized by the FAO (Food Agricultural Organization) as a consumable material and is widely used in the food and beverage industry.[17–19] The amylose and amylopectin content in cassava starch contributes to its sticky properties and its ability to transition from hydroxyl to hydrogel when in contact with water.[20,21]

In practice, cassava starch can be divided into natural cassava starch and modified cassava starch.[22] Modified cassava starch is starch that has undergone a series of modified processes to produce starch with better characteristics than natural starch.[23,24] One of the modification processes of starch is by fermentation using lactic acid bacteria that results in characteristic changes such as viscosity value, gelation ability, ease of dissolution, and rehydration power in starch.[2225,26]

Febriani (2012) stated that adding starch to alginate impression materials resulted in improved dimensional stability compared to pure alginate impression after 30 minutes of exposure at room temperature.[18] Belia et al. (2023) investigated the effects of adding 40% cassava starch and 40% modified cassava starch to alginate. Their findings indicated that alginate with 40% modified starch exhibited the least dimensional change, followed by alginate with 40% cassava starch, while pure alginate showed the greatest dimensional change.[27]

Although several studies have examined the influence of starch addition on the dimensional stability of alginate, no prior research has specifically investigated how cassava starch and modified cassava starch affect the setting time of alginate impression materials. Understanding this relationship is essential because the setting time directly determines the working characteristics and clinical usability of alginate-based impressions.

The novelty of this study lies in its experimental evaluation of the effect of both natural and modified cassava starch on the setting time of alginate impression materials, an aspect not previously explored. By comparing the performance of pure alginate, alginate with cassava starch, and alginate with modified cassava starch, this study provides new insight into how starch modification influences alginate polymerization behavior and gelation dynamics. Therefore, this study aimed to analyze cassava starch and modifies cassava starch on the setting time of alginate.

METHODS

This experimental laboratory study employed a post-test-only control group design. The study was conducted in the Skills Laboratory of the Faculty of Dentistry at Andalas University. The study included three sample groups: pure alginate as the control group, alginate with a 40% addition of cassava starch, and alginate with a 40% addition of modified cassava starch as the treatment groups. The materials used were Hygedent alginate (*Hygedent Inc.*, China), Pak Tani Gunung cassava starch (P.T. Budi *Starch and Sweetener* TBK, Indonesia), and Mocafine modified cassava starch (P.T. Rumah Mocaf Indonesia, Indonesia).

(a) (b)

Picture 1. (a) acrylic plate (b) *impression tool (tray)*[2829]

This study was conducted by mixing alginate powder with pure starch powder before stirring. Samples were prepared using an acrylic plate with a diameter of 5 mm and a height of 20 cm and an impression tool made of stainless-steel material with a diameter of 48 mm and a height of 23 mm (Picture 1). A total of 30 samples were prepared, divided equally among the three treatment groups. Setting times were measured using a stopwatch, and the data were subsequently analyzed using one-way ANOVA followed by the Post Hoc LSD test.

Table 1. Chemical Composition per 100 g of Cassava Starch and Modified Cassava starch (Directorate of the Ministry of Nutrition, 2017)

Composition	Cassava Starch	Modified Cassava Starch
Amylose	17%	21.04%-29.2%
Amylopectin	83%	79.6-78.8%
Starch	88,2	85.0
Protein	1.1	1.2
Fiber	0.9	6.0
Residue	1.1	1.3
Fat	0.5	0.6
Water	9.1	11.9

The setting time was measured from the moment alginate was mixed with water until gelation occurred, characterized by the loss of alginate adhesion to the acrylic plate. The mixture was prepared using a water-to-powder (W/P) ratio of 4 grams of starch, 6 grams of alginate and 22 ml of water as prescribed by the manufacturer of the product. The setting time was measured by inserting the tip of the acrylic plate into the mold for two seconds and then quickly removing it. The tip of the acrylic plate was then checked for alginate residue using a tissue.

Picture 2. Setting Time Measurement Process

The setting time measurements were performed by a single operator to minimize variability (Picture 2). Checks were conducted at 5-second time intervals until no alginate residue remained on the acrylic plate. The measurement result data obtained were subsequently analyzed using statistical tests.

RESULTS

The results of the research demonstrated that pure alginate exhibited the fastest mean setting time (89.10 seconds), followed by alginate with 40% modified cassava starch (150.00 seconds) and alginate with 40% cassava starch, which showed the longest mean setting time (211.10 seconds).

Table 2. One-Way ANOVA of Alginate Setting Time

Groups	n	Mean (s)	sd	P-Value
100% Pure Alginate	10	89.10	2.23	0.000
Alginate with the addition of 40% cassava starch	10	211.10	3.57	
Alginate with the addition of 40% modified cassava starch	10	150.00	3.01	

Based on Table 2, the one-way ANOVA test revealed a p-value <0.05, indicating statistically significant differences in setting time among the treatment groups. To further analyze the differences between specific groups, a Post Hoc LSD test was conducted.

Table 3. Post Hoc LSD Test of Alginate Setting Time

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

*= significant differences (p<0.05)

DISCUSSION

Alginate, a hydrocolloid impression material, is known for its relatively fast setting time. Based on setting time, alginate is categorized into two types: Type I (fast set), with a setting time of 1-2 minutes, and Type II (normal set), with a setting time of 2-4.5 minutes.[16,30] This variation in setting time provides dentists the option of adjusting the type of alginate used according to the operator's workability. Setting time in alginate can be modulated by regulating water temperature, adding accelerators or retarders, changing the ratio of water to powder, and modifying the material by adding other substances.[12]

According to ANSI/ADA Standards No. 18, the minimum setting time of alginate should be within 15 seconds of the manufacturer's specified working time, with an average setting time of approximately 3-4.5 minutes for normal-setting alginate.[31] The results of this study showed that the setting times for all groups fell within the range specified by ANSI/ADA Standards No. 18. The setting time was calculated using a stopwatch and recorded.[16] The study revealed the fastest setting time in pure alginate with an average of 89.1 seconds, followed by alginate with modified cassava starch with an average of 150 seconds, and the longest setting time in alginate with

cassava starch with an average of 211.1 seconds. These findings suggest that the addition of starch powder to alginate leads to a longer hardening time compared to pure alginate.

Alginate with the addition of starch has a longer setting time because the addition of starch to alginate causes the proportion of alginate powder to decrease, resulting in gel formation being longer.[32,33] Alginate has calcium chloride content as a reactor for gel formation when it encounters water.[18] When starch is added to alginate, calcium ions preferentially react with the starch, and the hydroxyl groups in starch interact more readily with water due to their hydrophilic nature.[32] This would inhibit the cross-link process of hydrogel formation in alginate, which causes a longer setting time than pure alginate.[15,18]

This finding is consistent with the research by Utami et al. (2022), which reported prolonged setting times with the addition of rice flour to alginate while remaining within ANSI/ADA specification standards. Pure alginate undergoes a pure gelation reaction resulting in a faster setting time, while alginate and starch addition has a longer setting time because polysaccharide components in the starch slow down the gelation reaction in the alginate, resulting in a longer setting time.[32]

Table 2 shows the average setting time of pure alginate, alginate with the addition of cassava starch, and alginate with the addition of modified cassava starch. Alginate with the addition of modified cassava starch exhibited a faster setting time than alginate with the addition of cassava starch. This difference can be attributed to the distinct physical and chemical properties of cassava starch and modified cassava starch. Cassava starch contains 17% amylose and 83% amylopectin, while modified cassava starch contains 21.04-29.2% amylose and 79.6-78.8% amylopectin.[34,35] The process of modifying cassava starch by fermenting it with lactic acid bacteria increases the amylose content compared to unmodified cassava starch.[36]

Table 3 shows Post Hoc LSD test results on pure alginate, alginate with the addition of cassava starch, and alginate with the addition of modified cassava starch. There is a significant difference ($p<0.05$) in the setting time of each treatment group. The addition of 40% cassava starch and 40% modified cassava starch resulted in significant changes compared to pure alginate. There is a significant difference between setting time alginate with 40% cassava starch and alginate with 40% modified cassava starch. The addition of both natural and modified starch has a significant effect on the setting time of alginate with different effects between the two.

Belia et al. (2024) conducted a study on the effect of adding cassava starch and modified cassava starch on the dimensional stability of alginate. Their study found that alginate with modified cassava starch exhibited the least dimensional change, followed by alginate with cassava starch, and finally pure alginate. The modified starch causes changes in the characteristics of starch in the form of gelation ability, increased viscosity, ease of dissolution, and rehydration of starch. The fermentation process also causes the breakdown of starch granules so that modified starch can bind more water than natural starch.[27]

The limitation of this study is that the study only measures the alginate setting time by adding cassava starch and modified cassava starch using acrylic plates with 5-second time intervals. The water powder ratio used in this study is a pure w/p ratio alginate that affects not only setting time but also other physicochemical properties of alginate.

CONCLUSION

The addition of 40% natural cassava starch and 40% modified cassava starch significantly affects the setting time of alginate. Alginate with the addition of cassava starch exhibited the longest setting time (211 seconds), followed by alginate with modified cassava starch (150 seconds), while pure alginate demonstrated the fastest setting time (89 seconds). Implication of this study can be applied in dentistry,

namely in dental materials, by adding modified cassava starch to alginate before printing.

Acknowledgement: This work was supported by the Research Fund of the Faculty of Dentistry, Andalas University.

Author Contributions: Conceptualization, F.A. and B.V.P; methodology, F.A. and B.V.P; software, F.A. and B.V.P. ; validation, F.A., B.V.P., N.R., Y.N. and R.S. ; formal analysis, F.A. and B.V.P.; investigation, B.V.P.; resources, F.A., B.V.P., N.R., Y.N. and R.S. ; data curation, F.A. and B.V.P.; writing original draft preparation, F.A. and B.V.P.; writing review and editing, F.A.; visualization, B.V.P.; supervision, F.A.; project administration, F.A.; funding acquisition, F.A. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the Research Fund of the Faculty of Dentistry, Andalas University.

Institutional Review Board Statement: Not Applicable

Informed Consent Statement: Not Applicable

Data Availability Statement:
https://drive.google.com/file/d/1TZ0hB6spERD2rxFILRMMEdjqaOOY5xCu/view?usp=sharing

Conflicts of Interest: The authors declare no conflict of interest, and the funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

REFERENCES

1. Krishnaa PK. Evaluation of Dimensional Stability of Different Solvents for Alginate. Biosci Biotechnol Res Commun. 2020;13(8):555-558. http://dx.doi.org/10.21786/bbrc/13.8/196
2. Alaghari S, Velagala S, Alla RK, AV R. Advances in alginate impression materials: a review. Int J of Dent Materials. 2019;01(02):55-59. https://doi.org/10.37983/IJDM.2019.1203
3. Kulkarni MM, Thombare RU. Dimensional changes of alginate dental impression materials-an invitro study. J of Clinical and Diagnostic Research. 2015;9(8). https://doi.org/10.7860/JCDR/2015/13627.6407
4. Astuti NKA, Sumantri S, Nasir IA. The Effect of 25% Belt Leaves and 0.2% Chlorhexidine as Disinfectant Materials on The Dimensional Stability of Alginate Molds. Interdental J Kedokteran Gigi (IJKG). 2021;17(2):103-109. https://doi.org/10.46862/interdental.v17i2.2937
5. Madhavan S, Abirami. A review on hydrocolloids-agar and alginate. J of Pharmaceutical Sciences and Research. 2015;7(10).
6. Octarina, Raharja J. The effect of seal bag storage on dimensional stability of alginate impression material. Scientific Dental Journal. 2018;2(3):93. https://doi.org/10.26912/sdj.v2i3.3097
7. Santoso EDL, Widodo TT, Baehaqi Moh. Pengaruh Lama Perendaman Cetakan Alginat Di Dalam Larutan Desinfektan Glutaraldehid 2% Terhadap Stabilitas Dimensi. ODONTO Dent J. 2014;1(2). https://doi.org/10.30659/odj.1.2.35-39
8. Anas R, Syam S, Purnomo H. Increased dimensional stability of alginate impression by addition cassava starch and sago starch. Makassar Dent J. 2020;9(3):196-198. https://doi.org/10.35856/mdj.v9i3.353
9. Murdiyanto D, Faizah A, Khalifa M. Potensi Penambahan Pati Jagung, Ubi Kayu, Beras Ketan dan Sagu pada Alginat Terhadap Perubahan Dimensi. Prosiding 14th Urecol: Seri Kesehatan. 2021;14.
10. Wang J, Liu S, Huang J, Ren K, Zhu Y, Yang S. Alginate: Microbial production, functionalization, and biomedical applications. Int J Biol Macromol. 2023;242. https://doi.org/10.1016/j.ijbiomac.2023.125048
11. Akbar F, Anita Z, Harahap H. Pengaruh Waktu Simpan Film Plastik Biodegradasi dari Pati Kulit Singkong Terhadap Sifat Mekanikalnya. J Teknik Kimia USU. 2013;2(2). https://doi.org/10.32734/jtk.v2i2.1431
12. Bertoft E. Understanding starch structure: Recent progress. Agronomy. 2017;7(3). https://doi.org/10.3390/agronomy7030056
13. Ikbal M, Habibie Mude A, Baiq Gadisha S, Putra Pradana A, Ilmu Material Teknologi Kedokteran Gigi D. Pengaruh penambahan pati beras ketan putih. Makassar Dent J. 2019;8(2). https://doi.org/10.35856/mdj.v8i2.281
14. Lozano-Vazquez G, Alvarez-Ramirez J, et al. Characterization of Corn Starch-Calcium Alginate Xerogels by Microscopy, Thermal, XRD, and FTIR Analyses.. 2021;73(7-8). https://doi.org/10.1002/star.202000282
15. Yustri Anita L, Agustiono P. The Effect Of Arrowroot Starch (Marantha Arundiceae L) Into Alginate Towards Alginate Impression Setting Time. 2012;1(2). https://doi.org/10.18196/di.v1i2.523
16. Anusavice KJ, Shen C, Rawls HR. Phillips' Science of Dental Materials. 12th edn. Saunders Company; 2013; 171-172
17. Raolika YD, Wowor VNS, Siagian K V. Pengaruh Penambahan Pati Ubi Kayu (Manihot Utilisima) dalam Berbagai Konsentrasi Terhadap Stabilitas Dimensi Bahan Cetak Alginat. J Ilmiah Farmasi. 2016;5(3). https://doi.org/10.35799/pha.5.2016.12949
18. Febriani M. Pengaruh Penambahan Pati Ubi Kayu Pada Bahan Cetak Alginat Terhadap Stabilitas Dimensi. IDJ. 2012;1(1). https://doi.org/10.18196/di.v1i1.507
19. Sánchez T, Salcedo E, Ceballos H, et al. Screening of starch quality traits in cassava (Manihot esculenta Crantz). 2009;61(1). https://doi.org/10.1002/star.200800058
20. Zulkarnain M, Singh JK a/p H. Pengaruh penambahan pati ubi kayu pada bahan cetak alginat terhadap stabilitas dimenisi model gigi tiruan. JMKG. 2018;3(2).
21. Shittu TA, Alimi BA, Wahab B, et al. Cassava Flour and Starch: Processing Technology and Utilization. In: Tropical Roots and Tubers: Production, Processing and Technology; 2016. https://doi.org/10.1002/9781118992739.ch10a

22. Noerwijati K. Upaya Modifikasi Pati Ubi Kayu Melalui Pemuliaan Tanaman. Buletin Palawija. 2015;13(1). https://dx.doi.org/10.21082/bul%20palawija.v13n1.2015.p92-100
23. Diniyah N, Subagio A, Nur R, et al. Sifat Fisikokimia dan Fungsional Pati dari Mocaf (Modified Cassava Flour) Varietas Kaspro dan Cimanggu. Jurnal Penelitian Pascapanen Pertanian. 2018;15(2):80-90. https://doi.org/10.21082/jpasca.v15n2.2018.80-90
24. Akpa J, Dagde KK, Gunorubon J, Kekpugile K. Modification of Cassava Starch for Industrial Uses. Int J of Engineering and Technology. 2012;2(6).
25. Apriliani, A. L. & Mulyadi, A. H. (2022). Analysis of Characteristics of Mocaf (Modified Cassava Flour) with Variations of Fermentation Time and Bread Yeast Concentration (Saccharomyces cerevisiae). Research in Chemical Engineering (RiCE), 1(2), 59–63. https://doi.org/10.30595/rice.v1i2.26
26. Diniyah N, Subagio A, Nur Lutfian Sari R, Gita Vindy P, Ainur Rofiah A. Effect of Fermentation Time and Cassava Varieties on Water Content and the Yield of Starch from Modified Cassava Flour (MOCAF). Indonesian J of Pharmaceutical Science and Technology. 2018;5(2). https://doi.org/10.24198/ijpst.v5i3.15094
27. Belia VP, Fransiska A, Suprianto K. The Effect of Cassava Starch and Modified Cassava Starch on Dimension Stability of Alginate Impression. Insisiva Dent J: Majalah Kedokteran Gigi Insisiva. 2024;13(1):16-22. https://doi.org/10.18196/di.v13i1.20797
28. Nurliyani RP, Fajrin FN, Fransiska A. Pengaruh Konsentrasi Larutan Natrium Hipoklorit Terhadap Stabilitas Dimensi Cetakan Alginat. Vol 10.; 2022. https://doi.org/10.25077/adj.v10i2.219
29. Fransiska A, Nurliyani RP, Nofika R. Effect of Spraying Time of Sodium Hypochlorite Solution on the Dimensional Stability of Alginate. J of International Dent and Medical Research. 2024;17(1).
30. Pratiwi D, Handayaningrum CP. Pengaruh Kondisi Penyimpanan Terhadap Setting Time Bahan Cetak Alginat. J Ked Gigi Terpadu. 2019;1(1). https://doi.org/10.25105/jkgt.v1i1.5140
31. Sakaguchi RL, Ferracane JL, Powers JM. Craig's Restorative Dental Materials. Vol 9th edn.; 2019; 233-237
32. Utami SS, Asfirizal V, Munir M. Pengaruh Penambahan Tepung Beras (Oryza Sativa L.) Terhadap Setting Time Bahan Cetak Alginat. Mulawarman Dental J. 2022;2(1). http://dx.doi.org/10.30872/mul.%20dent.%20j.v2i1.5339
33. Zafeiri I, Beri A, Linter B, Norton I. Mechanical properties of starch-filled alginate gel particles. Carbohydr Polym. 2021;255. https://doi.org/10.1016/j.carbpol.2020.117373
34. Risti Y, Rahayuni A. Pengaruh Penambahan Telur Terhadap Kadar Protein, Serat, Tingkat Kekenyalan dan Penerimaan Mie Basah Bebas Gluten Berbahan Baku Tepung Komposit. (Tepung Komposit : Tepung Mocaf, Tapioka dan Maizena). J of Nutrition College. 2013;2(4). https://doi.org/10.14710/jnc.v2i4.3833
35. Mustafa A. Analisis Proses Pembuatan Pati Ubi Kayu (Tapioka) Berbasis Neraca Massa. AGROINTEK. 2016;9(2). https://doi.org/10.21107/agrointek.v9i2.2143
36. Edam M. Aplikasi Bakteri Asam Laktat Untuk Memodifikasi Tepung Singkong Secara Fermentasi. J Penelitian Teknologi Industri. 2017;9(1). https://doi.org/10.33749/jpti.v9i1.3205