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THE CHARACTERIZATION OF TOMATO JUICE PATCH AS DENTAL BLEACHING WITH HPMC-PVP COMBINATION POLYMER BASE

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Abstract - Natural dental bleaching has been used as an alternative to avoid the risk of irritation due to the application of dental bleaching made from peroxide groups. Tomato has known to have good potency in teeth whitening. Dental bleaching also has various dosage forms and the patch is one of the most-preferable dosage forms because of its convenience when it is applied. In this research, a tomato (*Solanum lycopersicum* L.) juice patch has been established as a natural dental bleaching product. The objective of this research was to characterize the tomato juice patch with Hydroxypropylmethylcellulose (HPMC) and Polyvinylpyrrolidone (PVP) combination polymeric-base. Patches were formulated in three formulas by varying the tomato juice concentration into 55%; 60%; and 65% (w/w). Patches were prepared with the solvent casting method. Patch characterization has shown the results that all formulas have thicknesses in the range 100-300 μm; pH in range 4-5; folding endurance >300 times; and can be attached to teeth specimens for more than 3 hours.

INTRODUCTION

In-office bleaching, take-home bleaching or OTC teeth whitening products are the options available today for teeth whitening treatments. Home bleaching is one of the most important and popular ways of teeth whitening. The bleaching material can be hydrogen peroxide, carbamide peroxide or non-hydrogen peroxide systems which contain sodium chloride, oxygen and sodium fluoride (Meizarini, 2005). In Indonesia, variations in teeth whitening products are still less varied such as toothpaste and mouthwash. Now, there are also several variations of new products that have not been popularly used in Indonesia, e.g. teeth whitening pen, radiation technology, instant tooth whitening gels, and teeth whitening patch.

A patch is a dosage form which consists of one or more layers or polymer films containing drugs and/or other excipients. Patches can contain a layer of mucoadhesive polymers that bind to the oral mucosa, gingiva or teeth to control drug release to the oral mucosa, oral cavity or both (Shravan, 2012).

As a teeth whitener, wet and dry type teeth whitening patches have been developed. The wet type patch is a hydrogel formulation or in the form of an active gel formulation applied to an adhesive layer or immersing an adhesive layer into a solution containing the active ingredient. Wet type patches have weak adhesive strength and stickiness of the patch causes the gel to stick to the user's hand before application (Chang *et al.,* 2002). Dry patches are made in a dry form to provide solutions to these weaknesses. Dry-type patches have stronger adhesive strength against teeth and are able to withstand the teeth during hydration so they can stick longer and provide a better whitening effect with less active substance concentrations (Kim *et al.,* 2010).

In this study, the hydrophilic glass polymer PVP was used as a polymer base because of its compatibility with peroxide and its ability to provide strong adhesion properties to teeth (Kim *et al.,* 2010). PVP was combined with HPMC as a film-forming agent because films made by HPMC polymers have characteristics that are resistant to folding more than 300 times and can be attached to teeth specimens for more than 7 hours (Fitriyah, 2013). HPMC is also more resistant to dissolution compared to Na CMC so it is expected to maintain

the film shape when applied to the teeth and hydrated by saliva (Wardhana, 2013). The film layer was then coated with a backing layer to form a patch. According to Kim (2010), the backing must consist of water-insoluble and impermeable polymers to prevent sticking to the gums or tongue or prevent patches from removing teeth from saliva. Backing Tegaderm was chosen because it is impermeable and water-insoluble so it can resist the diffusion of active substances into saliva (Wardhana, 2013).

Tomatoes contain hydrogen peroxide and peroxidase enzymes. Hydrogen peroxide diffuses via enamel to the dentinal tubules and serves as a strong oxidizing agent that can produce highly reactive free radicals. These compounds can damage dye molecules so that the color becomes neutral and causes a whitening effect. Peroxidase can increase the speed of hydrogen peroxide in reducing color (Pratiwi, SA., 2009).

Lumuhu *et al.*, (2016) has researched the differences in the effectiveness of both tomato and apple juices as natural ingredients for teeth whitening by immersing dental specimens in 100% juice. The results showed that tomato juice and apple juice can whiten teeth. Moreover, tomato juice is more effective compared to apple juice as a teeth whitening agent. These facts underlie the authors to conduct further research and choose tomatoes as natural teeth whitening agent which is formulated in a teeth whitening patch.

Based on the description above, this research aims to observe the characteristics of the tomato juice patch as a product for dental bleaching. Patch was a dry type teeth whitening patch consisting of two layers. The main layer was a polymer matrix of HPMC and PVP combination, containing the active substance and Tegaderm backing layer. 100% Tomato juice (*Solanum lycopersicum* L.) was used as an active substance and formulated in various concentrations.

MATERIALS AND METHODS

Methods

In this study formulation and characterization of teeth whitening patches based on HPMC and PVP polymers have been carried out, and contain tomato juice as the active ingredient. The patch sampling method used is a simple random sampling method for each batch of production. Some analyses of the characteristics of the patch were carried out, including; viscosity measurement of film-forming liquid using rotational viscometer; organoleptic, microscopic and macroscopic evaluation of films; physical evaluation includes the weight and thickness of the film; patch surface pH using the pH indicator; swelling index of patch; moisture content using the gravimetric method; folding resistance; and patch in-vitro residence time.

Preparation of Artificial Saliva Using AFNOR's Method

The artificial saliva used in this research was prepared according to AFNOR's recipe whose composition is detailed as in Table 1.

Table 1. The Formula of Artificial Saliva with AFNOR's Method

Ingredients	Gram / Liter
Na_2HPO_4	0.26
KSCN	0.33
NaCl	6.00
KH_2PO_4	0.20
KCl	1.20
$NaHCO_3$	1.50
HCl	Adjust pH 6.8
Aquadest	Ad 1 Liter

Film-Forming Liquids Preparation

Every 100 grams of formula contains the components as shown in Table 2. The material was weighed accurately then HPMC was dissolved in a portion of aquadest until dissolved (M1) and PVP was dissolved in a portion of aquadest until dissolved (M2). M2 was then mixed into M1 while stirring until homogeneous and glycerin was added. The tomato juice was then put into the solution and stirred until it is homogeneous.

Table 2. The Formula of Tomato Juice Patch

Ingredients	Formula (gram)		
	F1	F2	F3
Tomato juice	16.5	18.0	19.5
HPMC	2.1	2.1	2.1
PVP	0.9	0.9	0.9
Gliserin	1.5	1.5	1.5
Aquadest ad	30.0	30.0	30.0

Evaluation of The Film-Forming Liquids Viscosity

Tests carried out using HAAKE 6R viscometer using the R7 spindle with a rotational speed of 1.5 and

gradually increased to 5 rpm at room temperature.

Patch Preparation

The film-forming liquids was poured into the mold and dried in the oven (40°C, 18h). After a film layer has been formed, Tegaderm™ was coated on the surface of the film to produce a patch.

Physical Evaluation of The Patch

Organoleptic color, odor and texture were observed. Measurement of sample weight was done by weighing 10 patches with a size of 6 x 1.5 cm^2 randomly then the average mass was measured and the standard deviation was calculated. The film thickness was measured by a digital micrometer at 5 points on each patch and the average thickness was calculated in micrometers (μm).

Measurement of Surface pH

2 × 1 cm^2 patches were immersed in 1 mL of aquadest (pH 7) for 1 hour at room temperature then the surface pH was measured using the pH indicator (Yogananda and Rakesh, 2012).

Swelling Index of The Patch

Patches in the size of 6 x 1.5 cm^2 were soaked in a glass container containing 25 mL of artificial saliva solution. The patch was weighed every 5 minutes until the 60th minute (Yogananda and Rakesh, 2012).

Measurement of Water Content

The patch was dried using an oven at 105±5°C for one hour and then cooled in a desiccator for 15 minutes. Patch weight was measured. The patch was reheated to a constant weight (Buckle *et al.*, 2008).

Folding Endurance Test

This test was done by repeatedly folding a patch in the size of 2x1 cm^2 in the same place until the patch breaks or up to 300 times manually. The number of folds that can be folded in the same place without breaking gives the folding resistance value (Yogananda and Rakesh, 2012).

***In-vitro* Residence Time Test**

This test was done by using a modified incubator. The anterior tooth model was moistened with 100 μL of artificial saliva and patches are applied to the teeth by pressing until the patch stays in place. The patch moisture was maintained during the test by dripping 3 mL/10 minutes artificial saliva. This was based on the speed of unstimulated saliva (water flow) in adults (18-64 years), which is 0.3 ml/minute (Cruz *et al.*, 2014). Afterwards, the teeth were placed into the incubator and then the time needed until the patch is detached from the surface of the tooth specimen was observed.

Table 3. The Viscosity of Film-Forming Liquids

Spindel speed (rpm)	Viscosity (cP)		
	F1	F2	F3
1.5	10,113	10,039	10,283
2.0	9,197	9,656	9,390
2.5	8,519	9,056	8,419

RESULTS

The Viscosity of Film-Forming Liquids

Based on the results presented in Table 3, it is known that film-forming liquid with the same polymer concentration and different tomato juice concentrations of tomato juice give similar curve results. 10% polymer concentration in film-forming liquid produces viscosity in the range of 6,000-10,000 cP.

Macroscopic and Microscopic Evaluation of The Film

Visually as shown in Figure 1, the film is described as white to brownish white, opaque, with the upper surface texture rather coarse and the lower surface was smooth and flat. The intensity of the brown color is due to the color of tomato juice. The difference in the concentration of tomato juice on the three formulas did not produce different film color intensity. In Figure 2, it has shown that there was no gap between the matrix and the backing

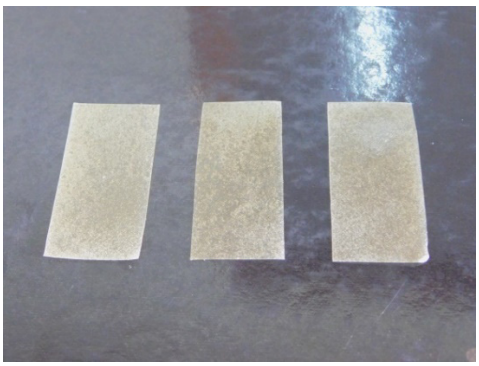

Fig. 1. Macroscopic image of the films. Left: Formula 1; middle: Formula 2; right: Formula 3

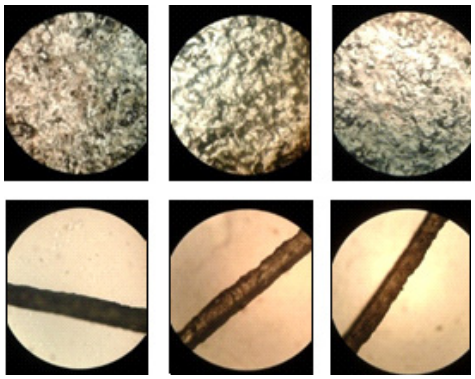

Fig. 2. Microscopic image of the films. Left: Formula 1; middle: Formula 2; right: Formula 3. Top: films surface; buttom: films cross sections.

layer which means these two layers were overlapping each other perfectly.

Physical Evaluation of The Patch

In the physical evaluation of the film, sampling was done by selecting 3 samples randomly from one batch of production in order to determine the slope level of the container during the drying process so that the film is produced with a fairly flat thickness and weight. From the results of the physical evaluation in Table 4, it was concluded that the film produced had a uniform weight and thickness as the desirable standard deviation was obtained (SD ≤ 2.00).

Table 4. Physical Properties of the Patch

Formula	Thickness (μm)	Weight (mg)*
F1	240.27 ± 0.76	245.33 ± 1.52
F2	244.13 ± 2.00	249.00 ± 1.73
F3	240.20 ± 2.00	241.33 ± 1.53

*) in the size of 6 x 1.5 cm^2

Surface pH

The pH of the surface is measured to determine the pH that will be exposed to the tooth when the patch is applied so that it can be estimated the possibility of side effects. Patch surface pH was measured using a universal pH indicator. The pH range of tomato juice in this study was 4.4-4.6 and each formula showed the same pH of the patch which was in the pH range of 4-5. The critical pH limits set for enamel and dentin are respectively 5.2-5.8 and 6.0-6.8 (Crispin, 1995).

Patch Swelling Index Test

The test was carried out to obtain an overview of the amount of water that has been absorbed or the increase in hydration that occurs (Wardhana, 2013). The patch was soaked in artificial saliva and the weight was measured every 5 minutes within 30 minutes. An overview of patch swelling index is presented in the curve in Figure 3.

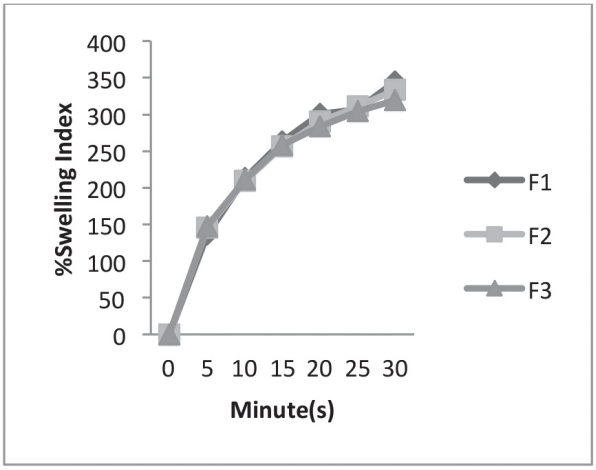

Fig. 3. Patch Swelling Index

Water content

The water content data for 30 minutes test has shown in Table 5.

Table 5. The Water Content of The Patch

Formula	Water Content (%)
F1	15.09 ± 0.59
F2	13.06 ± 0.45
F3	12.69 ± 0.54

Folding Resistance

Patch folding resistance was determined by folding the patch manually in the same position until the patch breaks or folds up to 300 times. The test results showed that all formulas produce patches that are fold-resistant to more than 300 times.

***In-Vitro* Residence Time**

When applying patch to dental specimens, it was quite difficult to attach to dental specimens so the patch needed to be moistened first before application. All formulas produced patches with a residence time of more than 3 hours. In the observation of the 1st hour, the patch was still attached to the specimen. A considerable degree of development results in the film layer expanding beyond the Tegaderm™ backing layer. On the third hour, the patch was still attached to the tooth

specimen so that it can be concluded that the patch has the adhesive strength to the teeth for more than 3 hours and it is dissolved gradually.

DISCUSSION

According to the visual examination, it has shown that the three formulas have the same colors which are the clear reddish-brown solution. Besides, the effect of the different tomato juice concentration on the viscosity of the film-forming liquid was also observed. Viscosity is known to affect several physical aspects of the film, such as transparency, density, and thickness of the film. This statement is in accordance with Kusumawati *et al.* (2013), which stated that there is an increase in film thickness along with an increase in starch concentration on the plate area and the suspension volume of the same film-forming mold plate. Increasing starch concentration will increase the viscosity of the film-forming liquid so that the film formed will be thicker.

The film-forming liquid can produce a film with thin, flexible but sturdy characteristics. It smells like tomatoes. Microscopic observations were also done to observe organoleptic in the surface sections of the film with 100x magnification. The results of the observation showed that the film produced had a homogeneous microscopic organoleptic.

The thickness of the three formulas was in the recommended range for the convenience of use, i.e. 100-300 μm. According to Kim (2010), the thickness is also an important factor in patch efficacy as teeth whitening and expected one-contact time. The thicker the film layer, the better the whitening effect because the content of active substances is more. One-contact time is the contact time of the preparation on the teeth. At the same concentration of whitening agent and thikness, the longer the contact time, the whiter teeth become. The thickness of the film layer must be controlled because if it is too thin, it will be difficult to create good adhesive strength over a long time. However, if it is too thick it will increase the discomfort of patch users.

The pH of the patch produced from this study was still below the critical pH so that pH adjustment is needed to avoid the risk of enamel and dentin excessive damage during patch use. Acid exposure to the bleaching process causes higher erosion of enamel (Al-Qahtani, 2014). It is in line with the Azrak's (2010) study, which conducted in-vitro studies of human anterior tooth specimens incubated in different whitening agents with a pH range of 4.9-10.8. The results showed that exposure to acidic bleaching substances (pH 4.9) caused the enamel surface to be coarser than at a higher pH (pH 6.15). It has shown that the more acidic the pH, the more erosion that occurs in tooth enamel. Therefore, it is necessary to increase the pH of the patch to enter the critical pH range of enamel and dentine, i.e. 5.2-6.0.

The measurement results of the patch swelling index have shown that the patches were significantly swollen in the first 5 minutes, then the ability of the patches to swell gradually decreases until the 30th minute of the test.

The water content measurement has shown the results that the water content from the highest to the lowest were consecutively in the formula F1, F2, and F3. This was because the amount of solvent in F1 is highest, which was 30%, while the amount of solvent in F2 was 25% and the F3 was 20%. From the observations, it can be concluded that the amount of solvent affects the water content of the patch. The more the amount of solvent, the higher the water content of the patch. These amounts of water content have produced the patches with good flexibility, which means that the patches are not too dry.

The patch has a strong endurance to the folding. Previously, Wardhana (2013) and Ginting (2013) stated that the addition of 40% plasticizers was able to form a polymer layer that was not easily torn. Based on the results of this study, it can be concluded that the addition of plasticizers as much as 50% w/w of the weight of the polymer is able to form a polymer layer that is not easily torn.

The patch has also fulfilled the expected residence time. Patches were quite difficult to apply at the beginning of use. The patch needed to be moistened first so that the patch is more flexible following the contour of the tooth and PVP can actively work as an adhesive agent after contact with water. However, after patches were attached to the teeth, patches have one-contact time for more than 3 hours but with a high swelling index.

CONCLUSION

Tomato (*Solanum lycopersicum* L.) juice patch has been established as a natural dental bleaching product. The results of this research have shown that all formulas have thicknesses in the range 100-300 μm; pH in range 4-5; folding endurance >300

times; and can be attached on teeth specimens for more than 3 hours. The pH of the patch produced from this study was still below the critical pH so that pH adjustment is needed to avoid the risk of enamel and dentin excessive damage during patch use. Patches were quite difficult to apply at the beginning of use. The patch needed to be moistened first so that the patch is more flexible following the contour of the tooth and PVP can actively work as an adhesive agent after contact with water. However, this product still needs improvement in order to improve the efficiency while using the patch. Physical and chemical stability testing of the tomato juice patch is also suggested.

REFERENCES

Al-Qahtani. 2014. Tooth bleaching procedures and their controversial effects: A Literature Review. *The Saudi Dental Journal.* 26 : 33-46.

Azrak, B. 2010. Influence of bleaching agents on the surface roughness of sound or eroded dental enamel specimens. *J. Esthet. Restor. Dent.* 22 : 391-399.

Buckle, K.A., Edward, R.A., Fleet, G. H. and Wootton, M. Food Science. 2018. Translator Hari Purnomo and Adiono in Ilmu Pangan. Jakarta: Universitas Indonesia.

Chang, Inventors. 2002. Patches for Teeth Whitening. Patent Publication No.: US2003/0133884A1.

Crispin, B. 1995. Nonrestorative esthetic procedure in contemporary aesthetic dentistry: Practice Fundamentals. Chicago: Quintessence Books; 33-56.

Cruz, 2014. Salivary characteristics and dental caries: evidence for general dental practices. *J Am Dent Assoc. Author Manuscript.*

Fitriyah, H. 2013. Formulasi patch natrium diklofenak berbasis polimer Hidroksi Propil Metil Selulosa (HPMC) sebagai sediaan lokal penanganan inflamasi pada penyakit periodontal. UIN Syarif Hidayatullah Jakarta. 25-27.

Ginting, D. 2014. Formulasi patch natrium diklofenak berbasis polimer Hidroksi Propil Metil Selulosa (HPMC) dan Natrium Karboksi Metil Selulosa (NaCMC) sebagai antiinflamasi lokal pada penyakit periodontal. UIN Syarif Hidayatullah Jakarta. 24-25.

Kim, Inventors, L.G. Household and Health Care, Ltd, Daejeon (KR); assignee. 2010. Method and device for teeth whitening using a dry type adhesive. Patent Publication No.: US7785572B2.

Kusumawati, 2013. Karakteristik fisik dan kimia edible film pati jagung yang diinkorporasi dengan perasan temu hitam. *Jurnal Pangan dan Agroindustri.* 1(1): 90-100.

Lumuhu, Martha M. Kaseke and Wulan G. Parengkuan. 2016. Perbedaan efektivitas jus tomat (Lycopersicon esculentum Mill.) dan jus apel (Mallus sylvesteris Mill.) sebagai bahan alami pemutih gigi. *Jurnal e-GiGi* (eG). 4(2) : 83-89.

Meizarini, A. and Rianti, D. 2005. Bahan pemutih gigi dengan sertifikat ADA/ISO. Maj. Ked. Gigi. (Dent. J.). 38 (2): 73-76.

Pratiwi, S.A. 2009. Pengaruh pemberian jus tomat (*Lycopersicon esculentum* Mill.) terhadap perubahan warna gigi pada proses *in-vitro*. Semarang : Universitas Diponegoro.

Shravan, K.Y. 2012. Comprehensive review on buccal delivery. *Int J Pharm.* 2(1): 205-217.

Wardana, M.S. 2013. Formulasi patch natrium diklofenak berbasis polimer Hidroksi Propil Metil Selulosa (HPMC) sebagai sediaan lokal penanganan inflamasi pada penyakit periodontal. Jakarta: UIN Syarif Hidayatullah Jakarta.

Yogananda and Rakesh. 2012. An overview on mucoadhesive buccal patches. *International Journal of Universal Pharmacy and Life Sciences.* 2(2): 348-373.