Development of Novel Retainer Cleansing Products for During the Day Usage

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Abstract

The aim of this study was to develop retainer cleansing products for during the day usage. These products were designed not only to remove saliva stain on the retainer surface, but also to provide clean and fresh smell and to be easy to carry around. The retainer cleansing products developed were alcohol and persulfate-free formulations and were prepared in two forms, including spray solutions and wet wipes. The spray solutions were first formulated by varying types and quantities of ingredients in the formulations. Then, good formulations, selected based on the homogeneity, clarity, color, odor, pH (ranging between 5.5-6.0), were subjected to stability testing using accelerated conditions; including centrifugation test and temperature cycling test (6 cycles). The characteristics before and after stability test were compared. After that, the good characteristic and stable spray solution formulations were further used to prepare wet wipes. The wet wipes obtained were then subjected to stability test at 50°C, room temperature and 4°C for 2 weeks and evaluated for the changing of color, odor and weight. It was found that the four best spray solution formulations consisted of the following ingredients: water, glycerin, trehalose, PEG-40 hydrogenated castor oil, polyvinylpyrrolidone (PVP) K-30 and/or polyvinyl methyl ether/maleic acid (PVM/MA) copolymer, peppermint oil, parabens or potassium sorbate, triclosan, sorbitol, cetylpyridinium chloride, citric acid and sodium hydroxide. These selected formulations were then absorbed in spunlace non-woven fabrics. It was observed that the wet wipes did not change in color and odor after storing at 4°C, room temperature and 50°C. Moreover, their weight did not notably change. The preliminary cleaning test on retainer surface found that both spray solutions and wet wipes developed in this study could clear up all saliva stain and provided retainer with fresh-smelling and clean-looking.

Keywords: Retainer, Spray solutions, Wet wipes

Introduction

Nowadays, orthodontics is well-known to solve the problem due to abnormal arrangement of the teeth in order to improve a person's smile and oral health. Following the alignment process, the dentists generally let their patients to wear the retainers to hold the teeth in their new positions and prevent from reverting to their original positions. There are three basic types of retainers available nowadays including Hawley retainer, Essix or clear plastic retainer and fixed retainer (Tamilkkumaran & Felicita, 2013). Hawley retainer is made from a thin, tongue-shaped piece of acrylic molded to fit patient mouth, with a wire that holds teeth in position. It is simple and easily removed. Essix retainer is made from thin, clear plastic designed to fit precisely over patient teeth. It is invisible, with no wire showing. This retainer is also easy to remove, but less durable than Hawley retainer. Fixed retainer uses a wire which is bonded to the tongue side of the teeth. It is not removable by the wearer.

Oral cavity of humans have a lot of microbial so retainer users should always take care of their oral cavity sanitation since after waking up, during the day until before going to sleep. Typical methods which dentists suggest their patients to clean retainers are brushing with suds or water (every morning and night) and soaking in effervescent tablet solutions (1 or 2 times per month). However, there is

no product available in Thailand for cleaning retainer during the day and after meals. A person who wears retainer has to find some place to rinse their retainer which is not convenient. In addition, from a search of the literatures through various databases using keyword "retainer", no article has been found. These databases included Science Direct, Thai Library Integrated System (ThaiLIS), Thai Thesis Database, Chulalongkorn University Intellectual Repository (CUIR), TRF e-library and Digital Research Information Center (DRIC). However, a search using keyword "denture", three publications were found. A research project which aimed to develop lemongrass oil cleansing concentrate solution (Taweechaisupapong, 2011) was found in TRF e-library database. This solution was evaluated for the inhibition of *Candida albicans* found on the surface of denture. The other two dissertations were found in DRIC database. However, both studies were not related to the development of retainer cleansing products. First, Chhnoeum (2008) investigated the effects of denture cleanser including Polident® and water on the surface roughness and hardness of denture base materials. Second, Kortrakulkij (2008) investigated the effect of denture cleanser, i.e. Polident® on color stability and flexural strength of denture base materials. Importantly, compared with soaking solution and Polident®, an effervescent tablet, the products developed in this study will be more convenient for during the day usage. Therefore, this study was aimed to develop retainer cleansing products for during the day usage which could remove saliva stain, provide good smell and easy to use and carry. The products developed were alcohol and persulfate-free formulations and were prepared in two forms, i.e. spray solutions and wet wipes.

Materials and Methods

Materials

PEG-40 hydrogenated castor oil (*Cremophor*® RH 40) and poloxamer 407 (*Pluronic*® *F127*) were *obtained from BASF (Thai) Co., Ltd.,* Chonburi, *Thailand. Cocamidopropyl betaine (Amidobataine C) was obtained from Zohar dalia, Kitbbutz Dalia, Israel.* Glycerin, potassium sorbate and triclosan were obtained from *Namsiang International Co., Ltd,* Bangkok, Thailand. Trehalose 100 belonged to The East Asiatic (Thailand) Public Co., Ltd., Bangkok, Thailand. Sorbitol, 70% solution was obtained from *P.C. Drug Center Co.,* Ltd, Bangkok, Thailand. Cetylpyridinium chloride, propolis extract was received as gifts from *Rubia Industries Ltd.,* Samutprakarn, Thailand. Peppermint oil was obtained from Thai - China Flavours and Fragrances Industry Co., Ltd., Nonthaburi, Thailand. Polyvinylpyrrolidone (PVP) K 30 was obtained from Flukachemika, Buchs, Switzerland. Polyvinyl methyl ether/maleic acid (PVM/MA) copolymer (Gantrez™ S polymers) was purchased from Connell Brothers Company, Ltd., Bangkok, Thailand. Methyl paraben, propyl paraben and propylene glycol were obtained from Sharon Laboratories Ltd., Ashdod, Israel. Citric acid was obtained from Flukachemica, Buchs, Switzerland. Sodium hydroxide (97%) *was obtained from RCI Labscan* Co., Ltd., Samutsakorn, Thailand.

Methods

The development of retainer cleansing products for during the day usage was performed in two forms, i.e. the spray solutions and wet wipes.

1. Development of spray solutions

1.1 Formulation of spray solutions

The spray solutions formulated were the alcohol and persulfate-free formulations.

The ingredients used are shown in Table 1. The preparation of spray solutions was performed as following. First, antimicrobial agents were dissolved in a single or combined solubilizing agent and mixed until completely dissolved (phase A). Heating might be required if the antimicrobial agent (s) could not be completely dissolved. However, the temperature should be not higher than 50°C. After the temperature cooled down to 40°C, a flavoring agent was added drop by drop. In a separation container (phase B), either single or combined viscosity-increasing agents was dispersed in deionized water. A humectant was then added and stirred until completely dissolved. Then, phase B was slowly added into phase A. After that, a preservative was added. Finally, pH of the solution was adjusted within the range of 5.5 to 6.0 using 1% sodium hydroxide and/or 1% citric acid solutions. The prepared formulations were evaluated for organoleptic properties including color, odor, clarity and homogeneity. The formulations showing good organoleptic properties, including colorless/pale in color, pleasant odor, transparent and homogenous were selected to test for their stability in the next step.

Table 1 The ingredients used in the formulation of spray solutions and their functions

Functions	Ingredients
Antimicrobial agents	Triclosan
	Cetylpyridinium chloride
	Propolis
Solubilizing agent/ Cleansing agents	PEG-40 hydrogenated castor oil
	Poloxamer 407
	Cocamidopropyl betaine
Humectants	Glycerin
	Trehalose
	Sorbitol, 70% solution
Viscosity-increasing agents	Polyvinylpyrrolidone (PVP) K 30
	PVM/MA copolymer
Vehicle	Water
Preservatives	Parabens
	Potassium sorbate
Flavor	Peppermint oil
pH adjusters	Sodium hydroxide, 1% and 10% solution
	Citric acid, powder and 1% solution

1.2 Stability testing of spray solutions

Stability testing of spray solutions was performed using the following method.

Centrifugation test

The selected formulations were evaluated for their stability by centrifugation test at 3,000 rpm for 30 minutes. The formulations which showed no separation were subjected to test their stability again by temperature cycling test.

Temperature cycling test

Temperature cycling test was performed by keeping the tested samples at 50±2ºC for 24 hours and then switching to keep at 4±2ºC for 24 hours. This condition was repeated for 6 cycles

(i.e. 12 days). The stability before (time=0) and after testing was evaluated by using the following parameters: color, odor, clarity, homogeneity and pH.

2. Development of wet wipes

2.1 Formulation of wet wipes

The best spray solution formulation obtained from the previous experiment was selected. The ideal properties of selected spray solutions were pale color or colorless, pleasant odor, clarity, homogeneity and have pH range between 5.5 - 6.0. Then the solutions were absorbed on wipes which made from spunlace nonwoven (kindly supplied by Pathawin Co., Ltd, Sam Khok, Pathumthani). The wettability of wipes was examined by weighing before and after soaking wipe with retainer cleansing solutions using the following equation.

$$\frac{\text{Wet wipe weight - Dried wipe weight}}{\text{Dried wipe weight}} \text{ X } 100$$

2.2 Stability testing of wet wipes

Following soaking dried, spunlace nonwoven wipes in the selected retainer cleansing solutions, the wet wipes were individually packed in a sealed foil bag. They were then stored in three different conditions including 50±2 ºC, room temperature and 4±2 ºC, at 75%±5% relative humidity (RH) for 2 weeks. The stability of wet wipes was evaluated from changing of color, odor and wet wipe weight. Changing of the wet wipe weight before and after stability test was observed. If the variation of weight obtained after stability test falls within ±5%, the change is considered not substantial.

3. Preliminary evaluation of cleaning efficacy on Hawley retainer

The cleansing efficacy on retainer surface of the formulated spray solutions and wet wipes was evaluated by observing the remaining of saliva stain on retainer surface and smelling after cleaning by using the developed products.

Results and Discussion

Persulfate which presents in most of denture cleansers as an oxidizing (bleaching) agent has been reported to strongly adsorb onto porous dental prosthesis and dental tartar, especially interstices of the teeth (Le Coz & Bezard, 1999). It can cause allergic reaction (Le Coz & Bezard, 1999; Gajwani-Jain, Magdum, Karagir, & Pharane, 2015) and the symptoms observed are irritation, tissue damage, rash, hives, gum tenderness, breathing problems and low blood pressure (Gajwani-Jain et al., 2015). On the other hand, alcohol may desiccate the plastic retainer especially that made from acrylic. Therefore, in this study, the cleansing products developed were aimed to be alcohol and persulfate- free formulations. These products were prepared for during the day usage and were in two forms, i.e. spray solutions and wet wipes.

1. Development of spray solutions

1.1 Formulation of spray solutions

The formulation of the spray solutions was started by varying types of solubilizing agents as well as types and percentages of viscosity-increasing agents. The ingredients of these formulations (i.e. F1 - F9) are shown in Table 2. It was observed that only F1 - F3 which were using PEG-40 hydrogenated castor oil as the solubilizing agent showed the desired characteristics including colorless, clean and fresh odor, clear and homogeneous and pH between 5.5 - 6.0 (Table 3). These results are expected because PEG-40 hydrogenated castor oil is known as an effective solubilizer of perfumes, essential oils and lipophilic actives. However, when the solubilizing agent changed to poloxamer 407 and

cocamidopropyl betaine, the formulations obtained became turbid and not homogeneous (Table 3). According to the manufacturer's information sheet, poloxamers (non-ionic surfactants, particularly poloxamer 407) are recommended to use in toothpaste and mouthwash as a solubilizer. Poloxamer 188, but not 407, has been reported to be incompatible with phenols and parabens (Moreton, 2010). However, Oral-B mouthwash also contains propyl paraben and poloxamer 407 (information from product label). The study of Garala et al. (2013) which aimed to develop gel for the treatment of periodontal disease also used poloxamer 407 as a gelling agent and methyl paraben as a preservative. Incompatibility has not been reported. Oral care formulations are very complex and thus an explanation is focused on the different in the ingredients used in F5 and F6, compared to F4. The manufacturer's information sheet stated that poloxamer 407 tolerates pH range 5.0-7.5. However, it is incompatible with anionic surfactants and at low pH which are not the case for formulations F5 and F6. However, these formulations contain PVM/MA copolymer (negatively charge). Thus, a possible explanation for the turbidity occurred may be due to incompatibility between poloxamer 407 and PVM/MA copolymer. This assumption may be confirmed by a clear solution of F4 which contains PVP K30 (positively charge) instead of PVM/MA copolymer. For F7-F9, these formulations used cocamidopropyl betain, an amphoteric surfactant. Cocamidopropyl betain was selected into this study because it possessed mild, biodegradable and foaming properties. It is compatible with anionic, cationic and nonionic surfactants. Thus it is recommended to be used in oral care products. Unfortunately, it caused turbidity formulations. This may be due to cocamidopropyl betain is a secondary surfactant and thus shows low solubilizing capability. In general, it is suggested to be used in combination with other surfactants.

Concentration of surfactant (i.e. solubilizing agents) used in aqueous oral care products is recommended to be in the range of 0.6 – 2.0 %w/w (Cloyd Dixon & Hunter-Rinderle, 1996; Leelapornpisid, 2002). With the expectation to use lower amount of individual surfactants, next formulations (F10- F21) were therefore prepared using the combined solubilizing agents. The ingredients of these formulations are shown in Table 4.

Table 2 Ingredients used in spray solution F1- F9

Ingredients	%w/w								
	F1	F2	F3	F4	F5	F6	F7	F8	F9
Triclosan	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Cetylpyridinium chloride	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
PEG-40 Hydrogenated Castor Oil	**2.00**	**2.00**	**2.00**	-	-	-	-	-	-
Poloxamer 407	-	-	-	**2.00**	**2.00**	**2.00**	-	-	-
Cocamidopropyl betaine	-	-	-	-	-	-	**2.00**	**2.00**	**2.00**
Glycerin	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Trehalose	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Sorbitol, 70% solution	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
PVP K30	**0.50**	-	**0.50**	**0.50**	-	**0.50**	**0.50**	-	**0.50**
PVM/MA copolymer	-	**0.25**	**0.25**	-	**0.25**	**0.25**	-	**0.25**	**0.25**
Paraben concentrate	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Peppermint oil	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

Table 2 (Cont.)

Ingredients	%w/w								
	F1	F2	F3	F4	F5	F6	F7	F8	F9
DI water	83.72	83.97	83.47	83.72	83.97	83.47	83.72	83.97	83.47
1% NaOH solution	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.07
1% Citric acid solution	0.27	0.33	0.33	0.13	0.27	0.27	0.13	0.13	0.13

Note: Paraben concentrate contained 20%w/w of methyl paraben, 2%w/w of propyl paraben and 78% w/w of propylene glycol.

Table 3 Appearances of the spray solutions F1 – F9

Appearances	Formulation								
	F1	F2	F3	F4	F5	F6	F7	F8	F9
Color	colorless	colorless	colorless	colorless	milky	milky	milky	milky	milky
Odor	clean and fresh								
Clarity*	Y	Y	Y	Y	N	N	N	N	N
Homogeneity*	Y	Y	Y	N	N	N	N	N	N
pH	5.50	5.65	5.72	5.50	5.54	5.51	5.52	5.54	5.60

Note*: Y = Yes, N = No

Table 4 Ingredients used in spray solution F10– F21

Ingredients	%w/w											
	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21
Triclosan	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Cetylpyridinium chloride	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
PEG-40 Hydrogenated castor oil	**1.67**	**1.67**	**1.67**	**1.67**	**1.67**	**1.67**	–	–	–	**1.33**	**1.33**	**1.33**
Poloxamer 407	**0.33**	**0.33**	**0.33**	–	–	–	**0.33**	**0.33**	**0.33**	**0.33**	**0.33**	**0.33**
Cocamidopropyl betaine	–	–	–	**0.33**	**0.33**	**0.33**	**1.67**	**1.67**	**1.67**	**0.33**	**0.33**	**0.33**
Glycerin	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Trehalose	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Sorbitol, 70% solution	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
PVP K30	**0.50**	–	**0.50**	**0.50**	–	**0.50**	**0.50**	–	**0.50**	**0.50**	–	**0.50**
PVM/MA copolymer	–	**0.25**	**0.25**	–	**0.25**	**0.25**	–	**0.25**	**0.25**	–	**0.25**	**0.25**
Paraben concentrate	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Peppermint oil	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
DI water	83.72	83.97	83.47	83.72	83.97	83.47	83.72	83.97	83.47	83.72	83.97	83.47
1% NaOH solution	0.13	0.13	0.07	0.13	0.13	0.07	0.13	0.07	0.07	0.07	0.07	0.07
1% Citric acid solution	0.13	0.13	0.13	0.2	0.13	–	0.13	–	–	–	–	–

From the results demonstrated in Table 5, it was observed that the use of combined solubilizing agents could produce clear and homogeneous solutions only when they contained PEG-40 hydrogenated castor oil in the combination. Without PEG-40 hydrogenated castor oil, the formulations (F16 – F18) were not homogeneous and were turbid. Therefore, next formulations were developed by using formulation F1 – F3 as the prototypes.

Table 5 Appearances of the spray solutions F10 – F21

Appearances	Formulation											
	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21
Color	colorless						milky			colorless		
Odor	clean and fresh											
Clarity*	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N
Homogeneity*	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y
pH	5.80	5.84	5.67	5.64	5.74	5.81	5.71	5.54	5.52	5.71	5.66	5.80

Note*: Y = Yes, N = No

Formulation F22 – F27 were developed from formulation F1 – F3 but formulation F22 – F24 were added propolis and formulation F25 – F27 were used potassium sorbate as a preservative. Ingredients of these formulations are shown in Table 6. Propolis is a natural complex substance produced by honeybees and secreted through their hypopharyngeal glands. It is used as a sealant and sterilizer in honeybee nests (Vagish Kumar, 2014). It is known to have antibacterial activity by inhibiting RNA-polymerase (Cavalcante et al., 2011) and widely used in dentistry. Thus propolis was included in this study.

From the results shown in Table 7, it was observed that the color of formulation F22 – F24 was pale yellow which was due to the color of propolis. On the other hands, the formulation F25 – F27 was colorless. Although the color of formulation F22 – F24 was pale yellow but other appearances including odor, clarity, homogeneity and pH met the criteria set. Therefore, formulation F1 – F3 and F22 –F27 were selected for the next studies.

Table 6 Ingredients used in spray solution F22- F27

Ingredients	%w/w					
	F22	F23	F24	F25	F26	F27
Triclosan	0.20	0.20	0.20	0.20	0.20	0.20
Cetylpyridinium chloride	0.03	0.03	0.03	0.03	0.03	0.03
Propolis	**1.00**	**1.00**	**1.00**	–	–	–
PEG-40 Hydrogenated Castor Oil	2.00	2.00	2.00	2.00	2.00	2.00
Glycerin	8.00	8.00	8.00	8.00	8.00	8.00
Trehalose	5.00	5.00	5.00	5.00	5.00	5.00
Sorbitol, 70% solution	0.15	0.15	0.15	0.15	0.15	0.15
PVP K30	**0.50**	–	**0.50**	**0.50**	–	**0.50**
PVM/MA copolymer	–	**0.25**	**0.25**	–	**0.25**	**0.25**
Paraben concentrate	**0.20**	**0.20**	**0.20**	–	–	–
Potassium sorbate	–	–	–	**0.20**	**0.20**	**0.20**
Peppermint oil	0.20	0.20	0.20	0.20	0.20	0.20
DI water	82.48	82.79	82.23	83.72	83.97	83.47

Table 6 (Cont.)

Ingredients	%w/w					
	F22	F23	F24	F25	F26	F27
1% NaOH solution	-	-	-	-	-	-
1% Citric acid solution	-	-	-	-	-	-
10% NaOH solution	1.38	1.50	1.42	1.64	1.56	1.62
Citric acid	0.20	0.20	0.20	0.20	0.20	0.20

Table 7 Appearances of the spray solutions F22 – F27

Appearances	Formulation					
	F22	F23	F24	F25	F26	F27
Color	pale yellow	pale yellow	pale yellow	colorless	colorless	colorless
Odor	clean and fresh					
Clarity	Y	Y	Y	Y	Y	Y
Homogeneity	Y	Y	Y	Y	Y	Y
pH	5.50	5.54	5.51	5.51	5.52	5.51

Note: Y = Yes

1.2 Stability testing of spray solutions

The selected solutions from the above experiment, i.e. formulation F1 – F3 and F22 –F27 were subjected to test for their stability by centrifugation test and temperature cycling test.

Centrifugation test

It was observed that all formulations of the selected spray solutions could resist to centrifugation force and did not separate after passing centrifugation test at 3,000 rpm for 30 minutes, suggesting that all formulations were stable. Therefore, all of formulations were subjected to temperature cycling test in the next study.

Temperature cycling test

The stability of the selected spray solutions was again performed using temperature cycling test. The changing in color, odor, clarity and homogeneity was observed in comparison with the formulations stored at room temperature. Following temperature cycling test, it was found that odor, clarity and homogeneity of all formulations were not change. However, color of formulation F22 – F24 containing propolis was unsatisfactory. The color changed to dark yellow. Therefore, these formulations were excluded from the further studies. Although, the color of F1 – F3 and F25 – F27 was slightly changed, it hardly observed visually without comparing with the same formulations stored at room temperature under the same light. The pH of all tested formulations was remained in the range of 5.5 to 6.0.

2. Development of wet wipes

2.1 Formulation of wet wipes

From the development of the spray solutions, it was found that formulation F1–F3 and F25–F27 were shown good organoleptic properties and also found to be stable. However, formulation F1 is similar to formulation F2 and F3 but having lower viscosity. Therefore F1, F25, F26 and F27 were selected to absorb with wipes and evaluated the properties, i.e. wipe color, odor, wet wipe weight and wettability. The wet wipes absorbed with these formulations were named WF1, WF25, WF26 and WF27. The results are tabulated in Table 8.

All wet wipes color was white and had clean and fresh odor. The weight of wet wipes was between 10.9 – 14.8 g/cm^2 (Table 8). From the results, it was found that the weight of wet wipes which were absorbed with the solutions containing

PVM/MA copolymer, i.e. WF26 and WF27 was heavier than those wipes which were absorbed with the solutions containing no PVM/MA copolymer. In addition, the formulations which contained PVM/MA copolymer yielded wet wipes with higher wettability when compared with PVM/MA free formulations. This can be explained by the higher viscosity of the solutions F26 (27.87 cps) and F27 (30.40 cps) which used to prepare wet wipes WF26 and WF27 compared with F1 (13.73 cps) and F25 (13.60 cps) which used to prepare wet wipes WF1 and WF25.

Table 8 Properties of wet wipes

Formulations	Wipe color	Odor	Wet wipe weight (g/cm^2) (mean ± SD)	Wettability (%) (mean ± SD)
WF1	white	fresh	10.94 ± 0.11	649.58 ± 5.01
WF25	white	fresh	11.31 ± 0.28	657.29 ± 11.15
WF26	white	fresh	13.92 ± 0.95	865.76 ± 78.05
WF27	white	fresh	14.84 ± 0.67	912.42 ± 62.71

2.2 Stability Testing

WF1, WF25, WF26 and WF27 were selected to test for their stability by storing under three different conditions. The results are shown in Table 9. It was found that all formulations did not change in wipe color and odor. In addition, after stability test, no notable change in wet wipe weight was observed. Therefore, all formulations were subjected to preliminary evaluation for cleaning efficacy on Hawley retainer surface in the next experiment.

Table 9 Properties of wet wipes before and after stability testing under different storage conditions

Formulations	Conditions	Color		Odor		Wet wipe weight (g/cm^2) (mean ± SD)	
		Before	After	Before	After	Before	After
WF1	4°C	white	not change	clean and fresh	not change	11.17±0.33	11.19±0.34
	Room temperature					10.94±0.11	10.99±0.20
	50°C					10.77±0.19	10.78±0.20
WF25	4°C					10.71±0.80	10.74±0.76
	Room temperature					11.31±0.28	10.92±0.18
	50°C					11.13±0.31	11.17±0.32
WF26	4°C					13.76±0.52	13.82±0.51
	Room temperature					13.92±0.95	13.17±2.12
	50°C					14.27±0.91	13.95±0.66
WF27	4°C					14.11±0.73	13.76±1.47
	Room temperature					14.84±0.67	14.32±1.27
	50°C					14.67±0.58	14.51±0.36

3. Preliminary evaluation of cleaning efficacy on Hawley retainer

3.1 Spray solutions

From the development of the spray solutions, the best formulations were F1-F3 and F25-F27. These formulations were preliminary evaluated for the cleaning efficacy on Hawley retainer surface by spraying the solutions directly onto the retainer surface and then wiping off using a sheet of tissue paper or facial tissue. It was observed that the solutions could be easily sprayed. The formulations have clean and fresh smell of peppermint oil. Moreover, after cleaning, the retainer also has minty fresh smell. Importantly, it was clearly observed that all formulations of the spray solutions could remove saliva stain.

3.2 Wet wipes

As shown above, the selected formulations of wet wipes were formulation WF1 and WF25 - WF27. These ready to use wipes were also evaluated for their cleaning efficacy on Hawley retainer surface. It was shown that all formulations of wet wipes could remove saliva stain because cleaning by wet wipe not only clean by the ingredient in formulations but also have physical force to help in cleaning of saliva stain. Moreover, the retainer smelled clean and fresh. On top of that, these wet wipes can be used anywhere and anytime just simply tear the package open, pull the wipe out and instantly clean your retainer.

Conclusion and Suggestion

In this study, the novel retainer cleansing products i.e. spray solution (Figure 1) and wet wipe (Figure 2) were successfully developed. They were alcohol-free and persulfate- free. The solutions consisted of the following ingredients: water, glycerin, trehalose, PEG-40 hydrogenated castor oil, PVP K-30 and/or PVM/MA copolymer, peppermint oil, parabens or potassium sorbate, triclosan, sorbitol, cetylpyridinium chloride, citric acid and sodium hydroxide. The best formulations of spray solutions were formulations F1 - F3 and F25 - F27. While the best formulations of wet wipes were formulations WF1 and WF15 - WF27. Preliminary evaluation showed good cleaning efficacy. On top of that, these developed products can be used anywhere and anytime. The evaluation on anti-microbial activity is suggested to be examined in further studies.

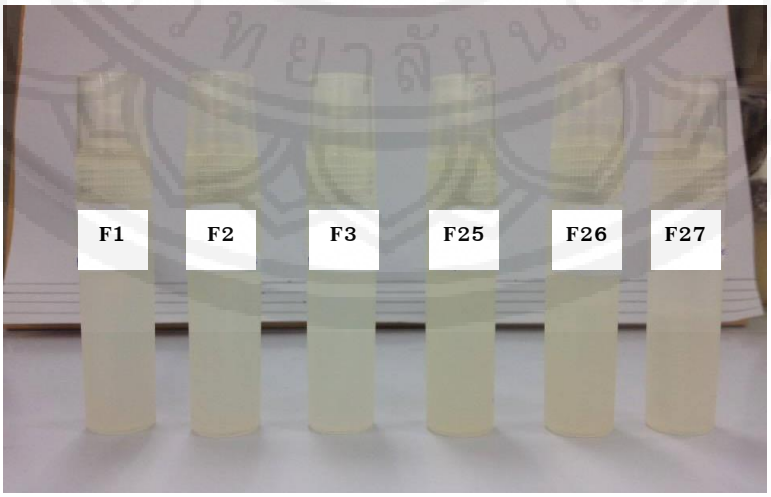

Figure 1 The retainer cleansing products in form of spray solutions

Figure 2 An example of retainer cleansing products in form of wet wipe

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