Effects of thickened drinks on the disintegration of various oral tablets

Taisuke Matsuoa,*, Chinatsu Satoa, Takashi Tomitab, Yasuyuki Sadzukaa

a Division of Advanced Pharmaceutics, Department of Clinical Pharmaceutical Sciences, School of Pharmacy, Iwate Medical University; 1-1-1 Idaikori, Yahaba-cho, Shiwa-gun, Iwate 028-3694, Japan
b Department of Pharmaceutical Sciences, Faculty of Pharmaceutical Sciences, Teikyo Heisei University; 4-21-2, Nakano, Nakano-ku, Tokyo 164-8530, Japan

ABSTRACT

Food thickeners are widely used to aid the oral administration of medications to patients with dysphagia. Powder-type food thickeners are used to modulate the viscosity of therapeutic solutions depending on the swallowing capacity of patients. Food thickeners inhibit or delay the disintegration of some medications, resulting in reduced pharmaceutical effects of the medications and/or their excretion in the stool. A short immersion time (within 1 min) is important to overcome these problems. Although thickened drinks are commercially available, their use as vehicles for medications is not well understood. In this study, we evaluated the effects of thickened drinks on the disintegration time of therapeutic tablets. Furthermore, we compared the thickened drinks with powder-type xanthan gum-based food thickeners. Forty tablets were used, including naked tablets, film-coated tablets, orally disintegrating tablets, enteric-coated tablets, and sugar-coated tablets. For the disintegration test, the tablets were immersed in thickened drinks or food thickeners for 1 min. The changes in the disintegration time of the 40 tablets immersed in the thickened drinks were comparable with those in food thickeners. The disintegration time of several tablets was shorter or unchanged after immersion in the thickened drinks. The disintegration time of rapidly disintegrating tablets tended to increase when immersed in thickened drinks, but it was less than 2 min for the majority of the tablets. These results demonstrate that thickened drinks, similar to food thickeners, could help administer medications to patients. Overall, our study provides valuable information for pharmacists and clinicians to decide the most suitable way to deliver medications to patients with dysphagia.

1. Introduction

Elderly patients with dysphagia may experience problems in eating and drinking normally; furthermore, watery and low viscosity foods and drinks such as water, tea, and miso soup pose a potential risk of aspiration. Powder-type food thickening agents (food thickeners) are widely used to overcome these problems. Food thickeners prevent accidental aspiration by reducing swallowing speed [1]. Food thickeners are classified as mildly, moderately, and extremely thick [2], and individuals with dysphagia can prepare thickened drinks of appropriate concentrations based on their needs. Food thickeners can also be classified as starch-type, guar gum-type, and xanthan gum-type, depending on their formulation [3]. Xanthan-gum-based thickeners are frequently used for patients with dysphagia in nursing facilities, owing to their rapid thickening ability, stability, and tolerable taste and smell [1, 3].

Although food thickeners are used for administering oral medications, they have several limitations. For instance, immersion of orally disintegrating (OD) voglibose tablets in food thickeners for 10 min delays disintegration performance and reduces pharmaceutical effects [4]. Additionally, magnesium oxide tablets, which are frequently taken with food thickeners according to a questionnaire survey in care facilities [5], have been detected in the stool of patients who consumed them with food thickeners [6]. Magnesium oxide tablets immersed in food thickeners for 30 min showed an extended disintegration time and reduced laxative action in mice [7]. Additionally, the dosage of magnesium oxide in patients using food thickeners should be higher than that in patients not using food thickeners [8].

Previously, we highlighted the necessity to prevent significantly delayed disintegration or non-disintegration of magnesium oxide tablets by avoiding the immersion of the tablets in food thickeners for a long time; the immersion time should be approximately 1 min [9]. Furthermore, the effects of different types of food thickener components on the disintegration time of tablets are different [9]. Thickened drinks, which represent a feasible alternative, are also commercially available. However, the thickener components of thickened drinks are
Table 1. Medications.

| Generic Name | Product Name | Company | Lot Number | Characteristic |
|--------------|--------------|---------|------------|---------------|
| Magnesium oxide | Magnemit® Tab. 330 mg | Kyowa Chemical Industry Co., Ltd. | 19B028 | naked tablet |
| | Magnesium Oxide Tablet 330 mg “Yoshida” | Yoshida Pharmaceutical Co., Ltd. | B775 | naked tablet |
| | Magnesium Oxide Tablet 330 mg “MOCHIDA” | Mochida Pharmaceutical Co., Ltd. | KE02 | naked tablet |
| | Magnesium Oxide Tablet 330 mg “KENEI” | Kenei Pharmaceutical Co., Ltd. | 919709 | naked tablet |
| | Magnesium Oxide Tablet 330 mg “Mylan” | Mylan Inc. | M238AB7 | naked tablet |
| Furosemide | Lasix® Tablet 40mg | Sano K.K. | 9K190A | naked tablet |
| | Furosemide Tab. 40mg “TAKEDA TEVA” | Teva Takeda Pharma Ltd. | 191,191 | film coated tablet |
| | Furosemide Tablet 40mg “NF” | Nipro Corporation | L631L70 | naked tablet |
| | Furosemide Tablet 40mg “JG” | Nihon Genetic Co., Ltd. | P00159 | naked tablet |
| Amlodipine | Norvasc OD® Tablet 2.5mg | Pfizer Japan Inc. | DC7610 | OD tablets |
| | Amlodin® OD 2.5mg | Sumitomo Dainippon Pharma Co., Ltd. | 3205C | OD tablets |
| | Amlodipine OD 2.5mg “SAWAI” | Sawai Pharmaceutical Co., Ltd. | 619902 | OD tablets |
| | Amlodipine OD 5mg “SAWAI” | Sawai Pharmaceutical Co., Ltd. | 620402 | OD tablets |
| | Amlodipine OD 10mg “SAWAI” | Sawai Pharmaceutical Co., Ltd. | 620202 | OD tablets |
| | Norvasc® Tablet 2.5mg | Pfizer Japan Inc. | CN5424 | film coated tablet |
| | Amlodipine 2.5mg | Sumitomo Dainippon Pharma Co., Ltd. | 2002C | film coated tablet |
| | Amlodipine 2.5mg “SAWAI” | Sawai Pharmaceutical Co., Ltd. | 119406 | film coated tablet |
| Lansoprazole | Takepran® OD Tablet 15mg | Teva Takeda Pharma Ltd. | EB141 | OD tablets |
| | Lansoprazole OD 15mg “TOWA” | Towa Pharmaceutical Co., Ltd. | D0408 | OD tablets |
| | Lansoprazole OD 15mg “SAWAI” | Sawai Pharmaceutical Co., Ltd. | 519903 | OD tablets |
| Famotidine | Gantes® OD Tablet 20mg | LTL Pharma | 19038T1 | OD tablets |
| | Famotidine OD 20mg “TOWA” | Towa Pharmaceutical Co., Ltd. | A0720 | OD tablets |
| | Famotidine OD 20mg “SAWAI” | Sawai Pharmaceutical Co., Ltd. | 419905 | OD tablets |
| | Famotidine OD 20mg “SAWAI” | Sawai Pharmaceutical Co., Ltd. | 119503 | naked tablet |
| Sodium Picosulfate | Laxoberon® Tablet 2.5mg | Teijin Pharma Limited | 4157 | film coated tablet |
| | Sodium Picosulfate tablet 2.5mg “IWAKI” | Iwaki Seiyaku Co., Ltd. | 97101 | film coated tablet |
| | Sodium Picosulfate tablet 2.5mg “NICHIIKO” | Nichi-Iko Pharmaceutical Co., Ltd. | E00500 | film coated tablet |
| | Sodium Picosulfate tablet 2.5mg “SAWAI” | Sawai Pharmaceutical Co., Ltd. | 119703 | naked tablet |
| Warfarin Potassium | Warfarin tablet 1mg | Eisai Co., Ltd. | 98A45K | naked tablet |
| | Warfarin Potassium tablet 1mg “TOWA” | Towa Pharmaceutical Co., Ltd. | D0030 | naked tablet |
| Sodium Valproate | Depakene® Tablet 200mg | Kyowa Kirin Co., Ltd. | 875AHJ | film coated tablet |
| | Valerin® 200mg | Sumitomo Dainippon Pharma Co., Ltd. | 2516C | sugar coated tablet |
| Sodium Ferrous Citrate | Ferron® 50mg | Sannova Co., Ltd. | 93C78S | film coated tablet |
| | Sodium Ferrous Citrate tablet 50mg “SAWAI” | Sawai Pharmaceutical Co., Ltd. | 719927 | film coated tablet |
| | Sodium Ferrous Citrate tablet 50mg “JG” | Nihon Genetic Co., Ltd. | L7L1L70 | film coated tablet |
| Bifidobacterium | IAC-B Tablet | Kowa Company, Ltd. | PL9H | naked tablet |
| | Biofermin® Tablet | BIOFERMIN | 98282 | naked tablet |
| Lactomin/Bifidobacterium | Lebenin®-S Tablet | Wakamoto Pharmaceutical Co., Ltd. | 9810 | naked tablet |
| Aspirin | Bayaspirin® 100mg | Bayer Yakuhin, Ltd | JPS5373 | enteric coated tablet |
| | Aspirin Enteric-Coated Tablet 100mg “TOWA” | Towa Pharmaceutical Co., Ltd. | B0062 | enteric coated tablet |

OD tablets: orally disintegrating tablet.

Table 2. Nutrient compositions of the thickened drinks (100 g).

| Nutrient | Roasted Green tea | Green Tea | Sports Drink | Black Coffee | Apple |
|----------|------------------|-----------|--------------|--------------|-------|
| Energy kcal | 6 | 12 | 24 | 12 | 28 |
| Protein g | 0 | 0 | 0 | 0.1 | 0 |
| Lipid g | 0 | 0 | 0 | 0 | 0 |
| Carbohydrate g | 1.8 | 3.2 | 6.3 | 3.3 | 7.4 |
| Sodium mg | 26.7 | 27 | 51.8 | 33 | 20.6 |
| Potassium mg | 27.8 | 28 | 20.4 | 72 | 31.2 |
| Calcium mg | 0 | 0 | 1.7 | 1 | 0 |
| Phosphorus mg | 1.8 | 1 | 0 | 4 | 1.5 |
| Iron mg | 0 | 0 | 0 | 0 | 0 |
| Zinc mg | 0 | 0 | 0 | 0.1 | 0 |

Apple-flavored drink is 10% juice.
Table 3. LST and pH values of the thickened drinks.

|                | Roasted green tea | Green tea | Sports drink | Coffee | Apple |
|----------------|-------------------|-----------|--------------|--------|-------|
| LST 0 h        | 45.1 ± 0.4        | 45.3 ± 0.6| 45.8 ± 0.8   | 45.7 ± 0.7 | 45.9 ± 0.9 |
| 24 h           | 45.1 ± 0.2        | 45.7 ± 1.1| 46.1 ± 0.2   | 45.8 ± 0.7 | 45.8 ± 1.0 |
| 48 h           | 46.2 ± 0.8        | 45.8 ± 0.6| 46.7 ± 1.1   | 45.9 ± 1.4 | 46.1 ± 0.5 |
| pH 0 h         | 6.5 ± 0.0         | 6.6 ± 0.1 | 3.8 ± 0.0<sup>b</sup> | 5.9 ± 0.0<sup>bc</sup> | 3.5 ± 0.0<sup>bc,d</sup> |
| 24 h           | 6.6 ± 0.0         | 6.7 ± 0.0<sup>d</sup> | 3.8 ± 0.1<sup>b</sup> | 5.9 ± 0.0<sup>bc</sup> | 3.5 ± 0.0<sup>bc,d</sup> |
| 48 h           | 6.7 ± 0.1         | 6.8 ± 0.1 | 3.8 ± 0.0<sup>b</sup> | 6.0 ± 0.1<sup>bc</sup> | 3.5 ± 0.0<sup>bc,d</sup> |

The time shown is the time after opening. Statistically significant differences among 0, 24, and 48 h are shown at p < 0.05 (*) (vs. 0 h) (Tukey–Kramer post-hoc test). Statistically significant differences among all tastes at the same time point are shown at p < 0.001 (a), p < 0.05 (a) (vs. roasted green tea); p < 0.001 (b) (vs. green tea); p < 0.001 (c), p < 0.01 (c) (vs. sports drink); p < 0.001 (d) (vs. coffee) (Tukey–Kramer post-hoc test).

Table 4. Disintegration time of naked tablets.

| Generic Name         | Product Name         | non-immersion | Thickened Drink | 1% Food Thickener | 3% Food Thickener |
|----------------------|----------------------|---------------|----------------|-------------------|------------------|
| Magnesium Oxide      | Magnesium Oxide Tab. | 5.7 ± 1.3     | 11.9 ± 2.8<sup>c</sup> | 7.7 ± 2.9<sup>c</sup> | 7.3 ± 1.2<sup>c</sup> |
| Sodium Picosulfate   | Sodium Picosulfate   | 112.2 ± 11.3  | 106.7 ± 24.6   | 104.4 ± 18.3      | 97.2 ± 17.2      |
| Warfarin Potassium   | Warfarin tablet      | 31.3 ± 1.7    | 44.6 ± 3.6<sup>c</sup> | 49.2 ± 11.0<sup>c</sup> | 59.4 ± 10.7<sup>c</sup> |
| Lactobacillus        | Lactobacillus Tablet | 0.7 ± 0.8     | 65.7 ± 25.6    | 68.0 ± 15.7<sup>c</sup> | 78.0 ± 15.0<sup>c</sup> |
| Biofermin®           | Biofermin® Tablet    | 21.3 ± 16.5   | 262.7 ± 19.7<sup>c</sup> | 311.8 ± 32.1<sup>c</sup> | 316.2 ± 17.0<sup>c</sup> |

First fluid was used as the test fluid for all tablets, and all disintegration times are shown in seconds. Statistically significant differences are shown at p < 0.05 (a), p < 0.01 (a), p < 0.001 (a') (vs. non-immersed); p < 0.05 (b), p < 0.01 (b), p < 0.001 (b') (thickened drink); p < 0.05 (c), p < 0.001 (c') (vs. 1% food thickener) (Tukey–Kramer post-hoc test).

2. Materials and methods

2.1. Medications and auxiliary foods

In this study, various oral tablets, which are taken with food thickeners according to a questionnaire survey in care facilities [5], were used.

Table 5. Disintegration time of film-coated tablets.

| Generic Name         | Product Name         | non-immersion | Thickened Drink | 1% Food Thickener | 3% Food Thickener |
|----------------------|----------------------|---------------|----------------|-------------------|------------------|
| Furosemide           | Furosemide Tab. 40mg | 84.2 ± 25.1   | 63.3 ± 9.0<sup>c</sup> | 58.2 ± 7.1<sup>c</sup> | 63.4 ± 8.2<sup>c</sup> |
| Amlodipine           | Amlodipine Tablet 2.5mg | 99.8 ± 18.6   | 71.6 ± 2.7<sup>c</sup> | 74.7 ± 3.8<sup>c</sup> | 76.9 ± 7.4<sup>c</sup> |
| Sodium Picosulfate   | Sodium Picosulfate   | 136.6 ± 17.7  | 77.9 ± 24.6<sup>c</sup> | 100.9 ± 15.7<sup>c</sup> | 108.1 ± 15.0<sup>c</sup> |
| Sodium Valproate     | Sodium Valproate     | 56.0 ± 11.4   | 20.0 ± 4.9<sup>c</sup> | 22.2 ± 4.9<sup>c</sup> | 25.2 ± 1.9<sup>c</sup> |
| Sodium Ferrous Citrate | Sodium Ferrous Citrate 50mg | 620.3 ± 35.9 | 635.2 ± 35.3 | 633.1 ± 40.2 | 729.7 ± 83.3<sup>c</sup> |

First fluid was used as the test fluid for all tablets, and all disintegration times are shown in seconds. Statistically significant differences are shown at p < 0.05 (a), p < 0.01 (a), p < 0.001 (a') (vs. non-immersed); p < 0.01 (b), p < 0.001 (b') (thickened drink); p < 0.01 (c), p < 0.001 (c') (vs. 1% food thickener) (Tukey–Kramer post-hoc test).
in this study (Table 1). Specifically, 15 naked tablets, 11 film-coated tablets, 11 OD tablets, 2 enteric tablets, and 1 sugar-coated tablet were used. The powder-type food thickener used for comparison was Tsururinko Quickly (3.0 g/pack; Clinico Co., Tokyo, Japan). Oi Ocha Roasted Green Tea (ITO EN, Tokyo, Japan) was used to dissolve food thickeners. Five different flavors of Ever Smile thickened drinks were used (roasted green tea, green tea, sports drink, black coffee, and apple; Daiwa Can Company, Tokyo, Japan). The contents of the food thickener and thickened drinks are presented in Table 2.

2.2. Food thickener preparation

The method of food thickener preparation has been described previously [9]. Briefly, 1.0 or 3.0 g of Tsururinko Quickly was added to roasted green tea (100 mL) and immediately mixed with a spoon. After 2 min of mixing, the solution was used in the experiments.

2.3. Line spread test (LST) and pH evaluation

The LST was performed according to the Japanese Dysphagia Diet 2013 guidelines defined by the Dysphagia Diet Committee of the Japanese Society of Dysphagia Rehabilitation (JDD2013) using a plastic measuring disk (Saraya Co., Osaka Japan) [2]. The pH of food thickeners was measured using LAQUAtwin (HORIBA, Ltd., Kyoto, Japan). The thickened drinks were stored at 4 °C. Before the experiments, the drinks were returned to room temperature. LST and pH were examined thrice independently.

2.4. Disintegration test

The tablets were immersed in the food thickener or thickened drinks for 1 min. The disintegration time of non-immersed tablets was used as control. The disintegration test was performed according to the method described in the Japanese Pharmacopoeia (17th Edition). The test solutions used were the first (pH 1.2) and second fluids (pH 6.8). As the food thickeners could not be completely removed from the surface of the tablets, the disintegration time was defined as the time at which the contents of the tablets were released [9]. The experiments were performed for a maximum of 2 h; the tablets that were not disintegrated after 2 h were considered “non-disintegrated.” Each test was performed with nine tablets.

2.5. Statistical analysis

The results are shown as mean ± standard deviation. Statistical analyses were performed using a one-way analysis of variance (ANOVA) with Tukey–Kramer post-hoc test. Results with a P-value < 0.05 were considered statistically significant. When the tablets were not disintegrated within 2 h, the disintegration time was defined as 2 h.

3. Results

3.1. LST and pH of the thickened drinks

The LST and pH of the five thickened drinks (roasted green tea, green tea, sports drink, black coffee, and apple) were examined 48 h after opening the bottles (Table 3). The LST values of the thickened drinks were in the range of 45.1–45.9 mm; the pH of the thickened roasted green tea, green tea, and black coffee drinks was 6.5, 6.6, and 5.9, respectively, immediately after opening the bottles. The pH of the sports drink- and apple-flavored thickened drinks was 3.8 and 3.5, respectively. The LST and pH values were maintained for 48 h.

3.2. Tablet disintegration time in the thickened roasted green tea drink and food thickeners

3.2.1. Naked tablets

The disintegration times of the 15 naked tablets immersed in the thickened drinks and food thickeners are shown in Table 4. Food thickeners were used at concentrations of 1% (LST: 45.0) and 3% (LST: 32.7).
Figure 1. Comparison of the disintegration time among thickened drinks of various flavors. Effects of five thickened drinks on the disintegration time of the tablets were examined. A: Magmitt® tablet 330 mg, B: Magnesium oxide tablet 330 mg “Mylan”, C: Lasix® tablet 40 mg, D: Furosemide tablet 40 mg “NP”, E: Furosemide tablet 40 mg “TAKEDA TEVA”, F: Amlodipine 2.5 mg “SAWAI”, G: Norvasc OD® tablet 2.5 mg, H: Amodinit® OD 2.5 mg, I: Amodipine OD 2.5 mg “SAWAI”, J and K: Bayaspirin® 100 mg, L: Valerin® 200 mg. 1: non-immersed, 2: roasted green tea, 3: green tea, 4: sports drink, 5: coffee, 6: apple. Test fluids were first fluid (A-J and L) and second fluid (K). The disintegration time of non-immersed tablets and of those immersed in roasted green tea-flavor thickened drink is the same as mentioned in Tables 4, 5, 6, and 7. Statistically significant differences in the disintegration times of non-immersed tablets and of those immersed in the five thickened drinks are shown at p < 0.05 (a), p < 0.01 (a'), p < 0.001 (a'') (vs. non-immersed); p < 0.01 (b), p < 0.001 (b') (vs. roasted green tea); p < 0.001 (c') (vs. green tea); p < 0.001 (d') (vs. sports drink); p < 0.01 (e'), p < 0.001 (e'') (vs. coffee) (Tukey–Kramer post-hoc test).
An evaluation of the disintegration time of the non-immersed tablets revealed that 8 tablets disintegrated within 1 min, 6 disintegrated within 1–10 min, and 1 tablet took more than 10 min to disintegrate. The non-immersed magnesium oxide tablets—Maggmit, Mochida, Kenei, and Yoshida—disintegrated in 6–7 s, whereas when immersed in thickened roasted green tea or 1.0% or 3.0% food thickeners, they required 6–14 s to disintegrate. The disintegration time of the non-immersed “Mylan” magnesium oxide tablet was prolonged from 30 s to 2 min when immersed in the thickened drink. In general, the disintegration time of magnesium oxide tablets was similar in 1% or 3% food thickeners or thickened roasted green tea. The non-immersed “Lasix” furosemide tablets fully disintegrated in 18 s, whereas it took 1.5 and approximately 3–3.5 min when immersed in thickened drinks and food thickeners, respectively. The disintegration time of the non-immersed LAC-B Bifidobacterium and warfarin tablets, that is, 18 and 31 s, was slightly prolonged to 23–36 and 45–59 s when immersed in thickened drinks and food thickeners, respectively. Leibenin-S tablets disintegrated in approximately 10.5 min under all conditions. Other naked tablets, which disintegrated within 1–10 min, showed some changes in the disintegration times when immersed in thickened drinks or food thickeners, but the changes were not marked.

3.2.2. Film-coated tablets

The disintegration times of the 11 film-coated tablets immersed in thickened drinks and food thickeners are shown in Table 5. All non-immersed tablets disintegrated in 1–14 min. When the tablets were immersed in thickened drinks or 1% food thickeners, their disintegration times were shortened or remained unaltered. Ferromia and sodium ferrous citrate 50 mg “SAWAI” tablets showed a delay in disintegration by a few minutes when immersed in 3% food thickeners.

3.2.3. Orally disintegrating tablets

The disintegration times of OD tablets are shown in Table 6. All tablets disintegrated within 40 s, and they showed delayed disintegration when immersed in thickened roasted green tea and food thickeners. In particular, the disintegration of amlodipine OD “SAWAI” tablets was delayed by approximately 5.5 and 12.5 min when immersed in thickened roasted green tea and 3% food thickeners, respectively. The other tablets fully disintegrated in 30 s to 3 min when immersed in thickened drinks and food thickeners.

3.2.4. Enteric- and sugar-coated tablets

The disintegration times of the enteric- and sugar-coated tablets are shown in Table 7. Although the two enteric-coated aspirin tablets did not disintegrate in the first fluid (pH 1.2) even after 2 h, they fully disintegrated within 7–10 min in the second fluid (pH 6.8) regardless of the presence of food thickeners. Sugar-coated valerin tablets, which disintegrated in 11.5 min when not immersed in food thickeners, required approximately 10 min to disintegrate in thickened roasted green tea and food thickeners.

3.3. Effect of different thickened drinks on the disintegration time of tablets

The effects of the thickened drinks on the disintegration time of the tablets were examined (Figure 1). Although Norvasc OD tablets showed delayed disintegration in all types of thickened drinks, the effects of the apple-flavored drink were less pronounced. Moreover, the delay in the disintegration of amlodipine OD “SAWAI” tablets immersed in sports-, coffee-, and apple-flavored drinks was shorter than that in the roasted green tea and green tea thickened drinks. The disintegration time of the other tablets was similar among all the thickened drinks.

3.4. Comparison of the disintegration time of amlodipine OD “SAWAI” tablets at three doses

The disintegration times of amlodipine OD “SAWAI” tablets at three doses (2.5, 5, and 10 mg) were compared when these tablets were immersed in thickened drinks (roasted green tea and apple) and 3% food thickener. The disintegration times of amlodipine OD “SAWAI” tablets of different doses immersed in apple-flavored thickened drink were similar. However, the disintegration time of tablets immersed in roasted green tea-flavored thickened drink and 3% food thickener increased in the following order: 10 mg < 5 mg < 2.5 mg (Figure 2).

4. Discussion

Powder-type food thickeners can be used in a personalized manner, per the needs of the patient; however, the thickeners should be prepared every time they are used. Therefore, thickened drinks represent a feasible and ready-to-use alternative, if their thickening strength is appropriate for patients with dysphagia.

Thickening strength can be defined using LST values (mm) according to the Japanese Dysphagia Diet 2013 guidelines as extremely thick (LST value: 30–32), moderately thick (LST value: 32–36), and mildly thick (LST value: 36–43) [2]. Herein, the LST of the thickened drinks tested was approximately 45–46. Taking into consideration that moderately thick drinks were first tried in patients with dysphagia after a stroke [2], thickened drinks may be appropriate for patients with mild dysphagia. Here, although the thickened drinks maintained their stability when stored at 4 °C, with unchanged line spread and pH values for 48 h after opening the bottles, the potential risk of bacterial contamination with prolonged storage should be considered.

In this study, the effect of thickened drinks on the disintegration times of 40 tablets, which are taken with food thickeners according to a...
questionnaire survey in care facilities [5], was examined. The roasted green tea-flavor drink was used as the main test thickened drink to avoid potential confounder elements, such as caffeine and various ions in the other drinks. Several tablets showed a significant delay in disintegration when immersed in the thickened drinks; however, the tablets whose disintegration time was short in the absence of thickened drinks or food thickeners tended to show delayed disintegration. Additionally, the effects of the thickened drinks and food thickeners were similar. In particular, the disintegration time of all OD tablets was longer (maximum 12.5 min) than that of the non-immersed tablets when immersed in thickened drinks and food thickeners. The retention time of medications in the stomach ranges from 5 min to 2 h [10]; therefore, the effects of food thickeners on OD tablets might be low. However, OD tablets generally rapidly disintegrate in the oral cavity by saliva, and they could be taken without water. When food thickeners were used for taking OD tablets, it is difficult to gain the advantage. It might be safe for patients taking OD tablets to take them without food thickeners or other types of tablets with food thickeners.

Masuda classified OD tablets on technical bases such as manufacturing methods and additives used [11]. The characteristics of such OD tablets were different. This might also be the reason for the difference in the rate of disintegration delay among OD tablets. The disintegration time of amlodipine OD “SAWAI” at different doses increased in the following order: 10 mg < 5 mg < 2.5 mg. The same additives are used in these tablets, but their weight and size are different. The diameter, thickness, and weight in the 2.5 mg tablets were 6.0 mm, 2.9 mm, and 85 mg; 5 mg tablets were 7.0 mm, 3.0 mm, and 120 mg; and 10 mg tablets were 8.5 mm, 4.1 mm, and 240 mg, respectively. A longer time is required for food thickeners to penetrate larger OD tablets; therefore, the disintegration of 10 mg tablets immersed in food thickeners could be faster than that of the other dose tablets. Furthermore, the sports drink- (pH 3.8) and apple-flavored thickened drinks (pH 3.5), with weak acidic pH, had less effect on the disintegration time of tablets than roasted green tea- (pH 6.5) and green tea-flavored thickened drinks (pH 6.6). The pH of thickened drinks might affect the disintegration time of tablets. Further studies are warranted to better understand the underlying cause of these differences.

We previously demonstrated that the disintegration pattern of several types of magnesium oxide tablets was different between xanthan gum- and guar gum-based food thickeners [9], an effect that could be dependent on the components of the food thickener. Although the company that markets the thickened drinks does not disclose the thickening components used, the observed effects of the thickened drinks on the disintegration time of tablets were similar to those of xanthan gum-based food thickeners. However, to decide whether thickened drinks can be used to take medications, knowledge of the components of thickened drinks is crucial. Additionally, the disintegration times of most tablets were not significantly different among the five thickened drinks, which provide a broad spectrum of flavor possibilities for patients to select according to their preferences. However, it is noteworthy that the pharmaceutical effects of medications change with the components of drinks.

In conclusion, the thickened drinks evaluated in this study may be useful for patients with mild dysphagia to help them take medications, representing a potential ready-to-use alternative to food thickeners. Our study provides valuable information for pharmacists and clinicians to decide the most suitable way to deliver medications to patients with dysphagia.