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Viscosity Measurement Results of a Commercially Available Universal Design Food (UDF: Can be Crushed with the Longue) using the Line Spread Test (LST)

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Abstract- In Japan, which is a super-aged society, people need the nursing care foods in recent years. For the prevention of aspiration pneumonia, there is a demand for safe and delicious nursing care food for not only patients but also senior citizen. To create food for swallowing that can be easily prepared even at ordinary homes, among the previous studies that have already been reported, using a type of universal design food, but that can be crushed with the tongue, for which the results have not yet been shown, is suitable or not for nursing care food is not sure. To obtain the viscosity, we investigated using eight types of thickeners and reported them. After adding 1 g, 2 g, and 3 g of each of the eight types of thickeners to commercially available shrimp gratin, a line spread test (LST) was performed using a superficial thickness measuring plate (manufactured by Saraya Co., Ltd.). As a result, by adding 1 g, it was possible to obtain a thick viscosity of 30 mm or more and less than 32 mm, which is thought to promote safe swallowing.

Keywords: nursing care food, universal design food, line spread test, thickener.

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Viscosity Measurement Results of a Commercially Available Universal Design Food (UDF: Can be Crushed with the Longue) using the Line Spread Test (LST)

Comparison after Adding Eight Different Types of Thickeners to Shrimp Gratin

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Abstract- **In Japan, which is a super-aged society, people need the nursing care foods in recent years. For the prevention of aspiration pneumonia, there is a demand for safe and delicious nursing care food for not only patients but also senior citizen. To create food for swallowing that can be easily prepared even at ordinary homes, among the previous studies that have already been reported, using a type of universal design food, but that can be crushed with the tongue, for which the results have not yet been shown, is suitable or not for nursing care food is not sure. To obtain the viscosity, we investigated using eight types of thickeners and reported them. After adding 1 g, 2 g, and 3 g of each of the eight types of thickeners to commercially available shrimp gratin, a line spread test (LST) was performed using a superficial thickness measuring plate (manufactured by Saraya Co., Ltd.). As a result, by adding 1 g, it was possible to obtain a thick viscosity of 30 mm or more and less than 32 mm, which is thought to promote safe swallowing. Eight kinds of thickeners are commercially available products containing xanthan gum, among which the thickener containing xanthan gum, calcium lactate, and trisodium citrate showed the highest viscosity. In the future, it will be necessary to investigate the effects of thickeners on universal design foods (UDF) that can be crushed with the tongue and have different nutritional values.**

Keywords: nursing care food, universal design food, line spread test, thickener.

I. Introduction

As of October 1, 2021, the total population of Japan was 125.5 million (announcement by the Statistics Bureau of the Ministry of Internal Affairs and Communications). The population aged 65 and over is 36.21 million (15.72 million men, 20.49 million women), accounting for 28.9% of the total population. Among the population aged 65 and over, the population aged 65-74 is 17.54 million (8.39 million men, 9.15 million women), accounting for 14.0% of the total population. The population aged 75 and over is 18.67 million (7.33 million males and 11.34 million females), accounting for 14.9% of the total population, which exceeds those aged 65-74. It is speculated that the need for nursing care food will increase in Japan, which will become an increasingly aged society in the future. To prevent aspiration pneumonia, it is necessary to provide safe and delicious nursing care food[1,2]. In a previous study, Shyoko Kondo[3,4] and Mayumi Hirabayashi[5,6] reported the results of a line spread test on a commercially available universal design hood (UDF) that does not require chewing, can be crushed with the gums, and can be chewed quickly. However, there are no reports yet regarding crushing with the tongue. Therefore, in this study, among the commercially available universal design foods (UDF) that are available in general households, foods labeled as being crushable with the tongue were treated with a simple thickening board (manufactured by Saraya Co., Ltd.) with eight types of thickeners. The purpose was to measure the viscosity after addition and to indicate the amount of thickener to be added to obtain a concentration that can be safely swallowed.

II. Materials and Methods

Shrimp gratin, which is a universal design food (UDF) available on the market, was labeled as being crushable with the tongue. Is the nutritional value of shrimp gratin labeled as crushable with the tongue shown in Table 1.

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Table 1 Nutritonal value of commercial UDF (cruch with tongue)

Product name	Energy (kcal)	Protein (g)	Fat (g)	Carbohydrates (g)		sodium (mg)	Calcium (g)
				Sugar (g)	Dietary fiber (g)		
Shrimp gratin	76	1.6	5	5.8	0.6	0.5	131

Furthermore, after adding 1 g, 2 g, and 3 g of each of the eight commercially available thickeners (A-H) to the shrimp gratin, the viscosity after 30 seconds and 5 minutes was measured using a superficial thickness measuring plate (manufactured by Saraya Co., Ltd.). Line spread test (LST) was performed using. The ingredients of the eight types of thickeners are listed, and the nutritional elements are listed in Table 2.

Table 2 Content and nutritional value of eight types of thickeners

	Contents	Nutrient contents (per 100g)									
		Energy (kcal)	Protein (g)	Fat (g)	Carbohydrates (g)		sodium (mg)	Potassium (g)	Calcium (g)	Phosphorus (g)	Iron (g)
					Sugar (g)	Dietary fiber (g)					
A	Dextriin, Polysaccharide thickener, Starch	226	1.2	0.2	64.4	25.1	188～405	10～20	868	18.5	1.5
B	Dextriin, Polysaccharide thickener	292	0.5	0	60.5	23.4	1550				
C	Dextriin, Xanthan gum, Calcium lactate, Trisodium citrate	346	0.5	0		86					
D	Dextriin, Polysaccharide thickener, CMC	390	0.8	0	54.9	34.3	1850	144	7.4	71	0.47
E	Dextriin, Polysaccharide thickener, Potassium chloride, Sucralose	263		0～1.0	64.3	23.5	540	870	13	72	0.3
F	Dextriin, Polysaccharide thickener, Potassium chloride	240		0	54	35	1180				
G	Dextriin, Polysaccharide thickener, Sodium chloride	260	0.7	0	46	37					
H	Dextriin, Polysaccharide thickener, Emulsifier	288	7.3	0.4～1.7	54	33	1773	107～288		85	

a) Sample (food with Thickener added) adjustment

Samples were adjusted according to previous reports[3,4,5,6]. Each of the three foods was prepared as follows.

1) The thickness of the food product was measured without any change (homogenized with a mixer) after 30seconds, 5minnutes.
2) The thickness of the food product was measured with change (homogenized with a mixer) after 30seconds, 5minnutes.
3) The thickness was measured on the food product with modification (homogenized with a mixer) after adding 1gramof Thickener (A, B, C, D, E, F, G, and H) to the food (100g) after 30seconds, 5minnutes.
4) The thickness was measured on the food product with modification (homogenized with a mixer) after adding 2 grams of Thickener (A, B, C, D, E, F, G, and H) to the food (100g) after 30seconds, 5minnutes.
5) The thickness was measured on the food product with modification (homogenized with a mixer) after adding 3 grams of Thickener (A, B, C, D, E, F, G, and H) to the food (100g) after 30seconds, 5minnutes.

b) Viscosity measurement method

Using the Line Spread Test Start Kit (LST) manufactured by SARAYA, the viscosity of each food was measured. The measurement procedure is as follows. The line spread test (LST) was performed in a room with a room temperature of 24 degrees. Thickness measurements by line spread test (LST) were performed three times using the same sample. Data was obtained by averaging the viscosity results of three repeated measurements. The measurement method was according to Line Spread Test Start Kit (LST) manufactured by SARAYA.

1. Place the sheet on a level surface. Place a ring with an inner diameter of 30mm in the center of the concentric circles.
2. Add the liquid to be measured to the total thickness of thering (20ml) and let stand for 30 seconds.
3. Lift the ring vertically, and after 30 seconds, measure the spread distance of the solution[7]. Six points on the outermost circumference of the sample spread concentrically were measured, and the average value was calculated as the result of LST values.

4. After standing for 5 minutes, the spread of the samples is measured again at 6 points, and the average value is recorded as the LST value.

c) Criteria for viscosity

There are three levels of classification by LST value[8]. The first stage is mildly thick with a viscosity that falls within the 43mm to 36mm (50-150 mPa・s). As for the properties, when the spoon is tilted, it flows down quickly[4]. The second stage is moderately thick with a viscosity that falls within the 36mm to 32mm (150-300 mPa・s). As for the properties, when you tilt the spoon, it flows to the surface[4]. The third stage is highly thick with a viscosity that falls within the 32mm to 30mm (300-500 mPa・s). Even if the spoon is tilted, the shape is maintained to some extent, and does not flow easily[8].

d) Statistical processing

This study was statistically processed using statistical processing software (Excel 2010: SSRI Co., Ltd). The data to be compared were first tested for normal distribution by F-test. For comparisons between correlated data, the paired Student-t test was used for normally distributed data. Wilcoxon test was used for non-normally distributed data[7].

III. Results

Table 3-1 shows the LST value results of the commercially available UDF (tongue crushable) shrimp gratin and the eight types of commercially available LST values. It was found that after homogenizing the sample using a mixer, the mixture food became thin, increasing the risk of aspiration when swallowing. Therefore, it is necessary to increase the viscosity of the mixture food with a commercially available thickener. Addition of 1 g of all eight types of thickeners resulted in thicker LST values after 30 seconds. However, after 5 minutes, it became intermediate thickness in thickener C. With the addition of 2 g and 3 g, the value for all thickeners was 30 mm or less, and the thickness was thicker than thicker. In this study, the appropriate value was set to 23-32 mm (previous research; according to Mayumi Hirabayashi), so it is possible to obtain the proper value by adding 1 g of thickeners A and G and 1 g or 2 g of thickener B,C,D,E,F, and H have understood. When 1 g was added and after standing for 30 seconds, the viscosity increased in the order of Thickeners D, G, and A. When 2g was added and after standing for 30 seconds, the density increased in the order of Thickeners G, A, and H. Thickeners E, H, and G had high density when 3 g was added and after standing for 30 seconds.

Table 3 Viscosity measurement results of eight types of thickeners for Shrimp gratin

		After 30 seconds			After 5 minutes				After 30 seconds			After 5 minutes				After 30 seconds			After 5 minutes		
Non mizer processing (NMP)		19.6	±	1.4	21.8	±	2.1														
Mixer processin (MP)		39.8	±	2.1	43.6	±	2.2														
MP with Thickener A		24.6	±	1.8	26.6	±	1.8		21.7	±	5.7	22.4	±	6		21.6	±	4.5	21.8	±	4.7
MP with Thickener B		26.9	±	5.3	28.5	±	5.2		23.8	±	3.8	24.7	±	3.8		22	±	4.8	22.3	±	5
MP with Thickener C		30.5	±	2	32.3	±	2		25.1	±	3.8	26	±	3.9		21.7	±	4	22.1	±	4.3
MP with Thickener D	Add	24.3	±	4.2	25.8	±	4.5	Add	23.6	±	2.6	24.3	±	2.8	Add	21.7	±	4.9	22.3	±	5.2
MP with Thickener E	1g	25.6	±	3	27.3	±	3	2g	23.4	±	1.9	24.1	±	2.2	3g	19.9	±	2.2	20.5	±	2.5
MP with Thickener F		30.3	±	1.7	31.9	±	1.6		26.4	±	2.4	28.2	±	3.4		21.7	±	1.2	22.2	±	1.5
MP with Thickener G		24.5	±	3	25.8	±	3.4		21.4	±	3.3	22.1	±	3.8		21.5	±	2.1	21.3	±	2.2
MP with Thickener H		25.6	±	1.9	27.3	±	1.8		22.5	±	6.7	23.3	±	7.2		20.6	±	3.3	21.6	±	4.3

Table 3-2 shows the results of multiple comparisons of LST values after 5 minutes of stirring after adding 1 g of 8 types of thickeners and after 30 seconds of LST standing according to the Scheffe method. Thickener A and Thickeners C and F, Thickener C and Thickeners D, E, G and H, Thickener D and Thickener F, Thickener E and Thickener F, thickener A statistically significant difference was shown between agent F and Thickeners G and H.

Table 3－3 Multiple comparison (upper probability) of LST values after 5 minutes of stirring after adding 2g of 8 types of thickeners by Scheffe's method (after atanding still for 30 seconds)

	Thickener A	Thickener B	Thickener C	Thickener D	Thickener E	Thickener F	Thickener G	Thickener H
Thickener A	------	0.9679	0.6211	0.9880	0.9940	0.1198	1.0000	1.0000
Thickener B	0.9679	------	0.9995	1.0000	1.0000	0.8813	0.9294	0.9990
Thickener C	0.6211	0.9995	------	0.9973	0.9940	0.9986	0.4977	0.8949
Thickener D	0.9880	1.0000	0.9973	------	1.0000	0.7980	0.9679	0.9998
Thickener E	0.9940	1.0000	0.9940	1.0000	------	0.7368	0.9817	1.0000
Thickener F	0.1198	0.8813	0.9986	0.7980	0.7368	------	0.0734	0.3556
Thickener G	1.0000	0.9294	0.4977	0.9679	0.9817	0.0734	------	0.9998
Thickener H	1.0000	0.9990	0.8949	0.9998	1.0000	0.3556	0.9998	------

Table 3－2 Multiple comparison (upper probability) of LST values after 5 minutes of stirring after adding 1g of 8 types of thickeners by Scheffe's method (after atanding still for 30 seconds)

	Thickener A	Thickener B	Thickener C	Thickener D	Thickener E	Thickener F	Thickener G	Thickener H
Thickener A	------	0.7789	0.0001	1.0000	0.9992	0.0002	1.0000	0.9992
Thickener B	0.7789	------	0.1315	0.6064	0.9945	0.2040	0.7101	0.9945
Thickener C	0.0001	0.1315	------	0.0000	0.0037	1.0000	0.0000	0.0037
Thickener D	1.0000	0.6064	0.0000	------	0.9926	0.0000	1.0000	0.9926
Thickener E	0.9992	0.9945	0.0037	0.9926	------	0.0077	0.9977	1.0000
Thickener F	0.0002	0.2040	1.0000	0.0000	0.0077	------	0.0001	0.0077
Thickener G	1.0000	0.7101	0.0000	1.0000	0.9977	0.0001	------	0.9977
Thickener H	0.9992	0.9945	0.0037	0.9926	1.0000	0.0077	0.9977	------

Table 3-3 shows the results of multiple comparisons of LST values after 5 minutes of stirring, after 2 g of 8 types of thickeners were added, and after 30 seconds of LST standing according to the Scheffe method. There was no significant difference between all groups.

Table 3-4 shows the results of multiple comparisons of LST values after 5 minutes of stirring after adding 3 g of 8 types of thickeners according to the Scheffe method and after 30 seconds of LST standing. There was no significant difference between all groups.

Table 3－4 Multiple comparison (upper probability) of LST values after 5 minutes of stirring after adding 3g of 8 types of thickeners by Scheffe's method (after atanding still for 30 seconds)

	Thickener A	Thickener B	Thickener C	Thickener D	Thickener E	Thickener F	Thickener G	Thickener H
Thickener A	------	1.0000	1.0000	1.0000	0.9864	1.0000	1.0000	0.9998
Thickener B	1.0000	------	1.0000	1.0000	0.9341	1.0000	1.0000	0.9953
Thickener C	1.0000	1.0000	------	1.0000	0.9736	1.0000	1.0000	0.9991
Thickener D	1.0000	1.0000	1.0000	------	0.9736	1.0000	1.0000	0.9991
Thickener E	0.9864	0.9341	0.9736	0.9736	------	0.9786	0.9894	1.0000
Thickener F	1.0000	1.0000	1.0000	1.0000	0.9786	------	1.0000	0.9994
Thickener G	1.0000	1.0000	1.0000	1.0000	0.9894	1.0000	------	0.9998
Thickener H	0.9998	0.9953	0.9991	0.9991	1.0000	0.9994	0.9998	------

Table 3-5 shows the results of multiple comparisons of LST values after 5 minutes of stirring after adding 1 g of 8 types of thickeners and after 5 minutes of LST standing according to the Scheffe method. Thickener A and Thickeners C and F, Thickener C and Thickeners D, E, G, H, Thickener D and Thickener F, Thickener E and Thickener F, thickener A statistically significant difference was shown between agent F and Thickeners G and H and Thickener G.

Table 3－5 Multiple comparison (upper probability) of LST values after 5 minutes of stirring after adding 1g of 8 types of thickeners by Scheffe's method (after atanding still for 5 minutes)

	Thickener A	Thickener B	Thickener C	Thickener D	Thickener E	Thickener F	Thickener G	Thickener H
Thickener A	------	0.9246	0.0004	0.9999	1.0000	0.0013	0.9999	1.0000
Thickener B	0.9246	------	0.1260	0.6002	0.9971	0.2350	0.6002	0.9971
Thickener C	0.0004	0.1260	------	0.0000	0.0049	1.0000	0.0000	0.0049
Thickener D	0.9999	0.6002	0.0000	------	0.9865	0.0001	1.0000	0.9865
Thickener E	1.0000	0.9971	0.0049	0.9865	------	0.0137	0.9865	1.0000
Thickener F	0.0013	0.2350	1.0000	0.0001	0.0137	------	0.0001	0.0137
Thickener G	0.9999	0.6002	0.0000	1.0000	0.9865	0.0001	------	0.9865
Thickener H	1.0000	0.9971	0.0049	0.9865	1.0000	0.0137	0.9865	------

Table 3-6 shows the results of multiple comparisons of LST after 5 minutes of stirring after adding 2 g of 8 types of thickeners according to the Scheffe method and after 5 minutes of LST standing. A statistically significant difference was shown between Thickener A and Thickener F and between Thickener F and G.

Table 3－6 Multiple comparison (upper probability) of LST values after 5 minutes of stirring after adding 2g of 8 types of thickeners by Scheffe's method (after atanding still for 5 minutes)

	Thickener A	Thickener B	Thickener C	Thickener D	Thickener E	Thickener F	Thickener G	Thickener H
Thickener A	------	0.9698	0.6283	0.9901	0.9960	0.0362	1.0000	1.0000
Thickener B	0.9698	------	0.9995	1.0000	1.0000	0.6504	0.9366	0.9995
Thickener C	0.6283	0.9995	------	0.9969	0.9920	0.9745	0.5151	0.9179
Thickener D	0.9901	1.0000	0.9969	------	1.0000	0.5151	0.9745	1.0000
Thickener E	0.9960	1.0000	0.9920	1.0000	------	0.4256	0.9878	1.0000
Thickener F	0.0362	0.6504	0.9745	0.5151	0.4256	------	0.0208	0.1732
Thickener G	1.0000	0.9366	0.5151	0.9745	0.9878	0.0208	------	0.9997
Thickener H	1.0000	0.9995	0.9179	1.0000	1.0000	0.1732	0.9997	------

Table 3-7 shows the results of multiple comparisons of LST values after 5 minutes of stirring after adding 3 g of 8 types of thickeners and after 5 minutes of LST standing according to the Scheffe method. There was no significant difference between all groups.

IV. Discussion

Among the universal design food (UDF) tongue, crushable foods used this time, shrimp gratin had a nutritional value of 76 kcal of energy, 6 g of protein, 5 g of fat, and 8 g of sugar. The results of the line spread test (LST) performed on this food homogenized with a mixer were 39.3 ± 2.1 mm after standing for 30 seconds, and a thin thickness of 43.6 ± 2.2 after standing for 5 minutes. It was shown that adding a thickening agent was necessary for safe swallowing. As a result of adding eight types of thickeners to this food, 1g of any thickener per 100g of food resulted in a viscosity of 30mm-33mm, which was determined as an appropriate value. Thickener G had the highest thickening effect, reaching 25.6±3.4 mm after standing for 5 minutes. The main component of this thickener G was xanthan gum, and it also contained polysaccharide thickener and sodium chloride. Thickener G had the highest thickening effect, riaching 25.6±3.4 mm after standing for 5 minutes. The main component of this Thickener G was xanthan gum, and it also contained polysaccharide thickener and sodium chloride.

Table 3－7 Multiple comparison (upper probability) of LST values after 5 minutes of stirring after adding 3g of 8 types of thickeners by Scheffe's method (after atanding still for 5 minutes)

	Thickener A	Thickener B	Thickener C	Thickener D	Thickener E	Thickener F	Thickener G	Thickener H
Thickener A	------	1.0000	1.0000	1.0000	0.9991	1.0000	1.0000	1.0000
Thickener B	1.0000	------	1.0000	1.0000	0.9859	1.0000	1.0000	1.0000
Thickener C	1.0000	1.0000	------	1.0000	0.9946	1.0000	1.0000	1.0000
Thickener D	1.0000	1.0000	1.0000	------	0.9887	1.0000	1.0000	1.0000
Thickener E	0.9991	0.9859	0.9946	0.9887	------	0.9911	0.9993	0.9997
Thickener F	1.0000	1.0000	1.0000	1.0000	0.9911	------	1.0000	1.0000
Thickener G	1.0000	1.0000	1.0000	1.0000	0.9993	1.0000	------	1.0000
Thickener H	1.0000	1.0000	1.0000	1.0000	0.9997	1.0000	1.0000	------

In the case of UDF shrimp gratin, only when Thickener C was added, the LST value after standing for 5 minutes became moderately thick. This result is considered to be influenced by xanthan gum, calcium lactate, and trisodium citrate contained in the Thickener C.

2007, Shiozawa et al. reported that thickeners made food easier to swallow[9]. In 2005, Kanaoka et al. also reported the effectiveness of thickening agents in preventing gastroesophageal reflux in enteral feeding10).

Studies on the palatability of thickeners have reported that the production of food pastes does not look good and gives poor taste and texture.

Studies on the palatability of thickeners have reported that the production of food pastes not only adversely affects their appearance, but also their palatability and texture[11].

However, in this study, it was shown that adding a small amount of thickening agent can achieve the desired thickness in the case of foods containing a large amount of carbohydrates. The result is beneficial in terms of taste and cost.

Since around 2010, many research reports on adding thickeners to food have been published. The content was helpful in unifying food properties in various facilities[12,13,14].

Many studies have also been reported on differences in viscosity due to differences in the main components of thickeners (xanthan gum, guar gum, starch, etc.)[12,15].

In addition, calcium, phosphoric acid, whey protein, etc., have a synergistic effect and help increase viscosity[16].

However, it has been reported that the use of thickeners in water may have a negative effect on the efficacy of drugs when administered to patients with swallowing dysfunction, so that caution may be necessary[17,18]. Using a large amount of thickener, the viscosity will increase and it can expect a good effect on swallowing. But it cannot be said that it is very food for palatability and digestion and absorption. Therefore, in the future, we believe that further research on safety, palatability, cost, etc., in swallowing is necessary.

Using too much thickener can affect digestion and palatability. Regarding the prevention of aspiration pneumonia due to gastroesophageal reflux disease and the prevention of digestive absorption inhibition, it is necessary to continue research, including the type and amount of thickener used, compatibility with food, etc.

In the future, we believe it will be possible to provide safer nursing care food by investigating the combination and additional amount of multiple target foods and thickeners. In a super-aging society, it is essential to quickly to cook safe and stable viscosity-adjusted foods at home easily. I would like to continue research and report the results so that ordinary households can eat a safer and more stable meal.

V. Conclusions

As the population ages, the number of older people with impaired eating and swallowing functions is increasing. Around the world, the number of patients who develop pneumonia due to aspiration and decreased immunity due to weakened swallowing reflexes due to aging and brain disease is increasing.

Thickeners are being used increasingly to make food safer for people with dysphagia. This Thickener must have low viscosity, no syneresis, no change over time, no loss of palatability, and low reactivity with saliva. Shrimp gratin, a universal design food (UDF) on the market that can be crushed with the tongue, has a nutritional value of 76 kcal of energy, 6 g of protein, 5 g of fat, and 8 g of sugar. This food had a stable viscosity with 1 g thickening agent containing various xanthan gums as the main component. In addition, xanthan gum as the main component and thickeners containing thickening polysaccharides and sodium chloride showed the most stable viscosity.

Using a large amount of thickener, the viscosity will increase and it can expect a good effect on swallowing. But it cannot be said that it is very food for palatability and digestion and absorption. Therefore, in the future, we believe that further research on safety, palatability, cost, etc., in swallowing is necessary.

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