

Viscosity Measurement Results a Line Spread Test (LST) After Adding Eight Types of Thickeners to Three Types of Universal Design Food (UDF: Can Be Crushed with the Tongue)

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Abstract

Aiming at nursing care food that can be prepared at home, we measured the viscosity after adding a thickener using a commercially available universal design food (UDF: Crush with tongue). Viscosity was measured after mixer treatment using UDF (Crush with tongue: "Eel with egg", "Boiled cutlet", and "Miso soup with pork and vegetables"). Furthermore, eight types of thickening agents were added to the UDF after the mixer process, and the amount of thickening agent to be added was investigated to achieve an appropriate value (viscosity of 23-32 mm) for nursing care food. Addition of 2g of thickeners A, G, and H resulted in three types of UDF with appropriate viscosities. However, 3g of other thickeners were required to obtain proper viscosity. However, for boiled cutlet, the appropriate value was obtained with the addition of 2g of all eight types of thickeners. Compared to the other two types of UDF, boiled cutlet is characterized by a higher sugar and calcium content. Eight kinds of thickeners are commercially available products containing xanthan gum, among which the thickener containing xanthan gum, polysaccharide thickener, and emulsifier 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

1. Introduction

Aiming at nursing care food that can be prepared at home, we measured the viscosity of three types of universal design food (UDF: crush with tongue) on the market by line spread test (LST) after adding eight types of thickeners. Because, 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 (Leder 2013, Murray 2014). In a previous study, Shyoko Kondo (Kondo 2019, Katayama 2020), Mayumi Hirabayashi (Hirabayashi 2020, Hirabayashi 2020), and Sahoko Ito (Ito 2023) reported the results of a line spread test on a commercially available universal design hood (UDF) that can be crushed with the gums, and can be chewed quickly, and can be crushed with tongue (Shrimp gratin). However, there is still only one example of UDF (can be crushed with the tongue). Therefore, in this study, three 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.

2. Method

2.1 Universal Design Food (UDF)

“Eel with egg”, “Boiled cutlet”, and “Miso soup with pork and vegetables”, which are 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.

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

Product name	Energy	Protein	Fat	Carbohydrates (g)		sodium	Calcium
	(kcal)	(g)	(g)	Sugar (g)	Dietary fiber (g)	(mg)	(g)
Eel with egg	55	3.1	2.8	4.4	0.1	0.7	
Boiled cutlet	57	2.6	2.2	6.6	0.4	0.9	148
Miso soup with pork and vegetables	52	1.9	2.7	4.3	1.2	0.9	72

2.2 The Eight Commercially Available Thickeners (A-H)

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 Dextrin, Polysaccharide thickener, Starch	226	1.2	0.2	64.4	25.1	188~405	10~20	868	18.5	1.5
B Dextrin, Polysaccharide thickener	292	0.5	0	60.5	23.4	1550				
C Dextrin, Xanthan gum, Calcium lactate, Trisodium citrate	346	0.5	0		86					
D Dextrin, Polysaccharide thickener, CMC	390	0.8	0	54.9	34.3	1850	144	7.4	71	0.47
E Dextrin, Polysaccharide thickener, Potassium chloride, Sucralose	263		0~1.0	64.3	23.5	540	870	13	72	0.3
F Dextrin, Polysaccharide thickener, Potassium chloride	240		0	54	35	1180				
G Dextrin, Polysaccharide thickener, Sodium chloride	260	0.7	0	46	37					
H Dextrin, Polysaccharide thickener, Emulsifier	288	7.3	0.4~1.7	54	33	1773	107~288		85	

2.3 Sample (food with Thickener added) Adjustment

Samples were adjusted according to previous reports (Kondo 2019, Katayama 2020, Hirabayashi 2020, Hirabayashi 2020). 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 30 seconds, 5 minutes.
- 2) The thickness of the food product was measured with change (homogenized with a mixer) after 30 seconds, 5 minutes.
- 3) The thickness was measured on the food product with modification (homogenized with a mixer) after adding 1 gram of Thickener (A, B, C, D, E, F, G, and H) to the food (100g) after 30 seconds, 5 minutes.
- 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 30 seconds, 5 minutes.
- 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 30 seconds, 5 minutes.

2.4 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 the ring (20ml) and let stand for 30 seconds.
- 3) Lift the ring vertically, and after 30 seconds, measure the spread distance of the solution (Hirabayashi 2022), 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.

2.5 Criteria for viscosity

There are three levels of classification by LST value (Claire 2014). 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 (Katayama 2020). 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 (Katayama 2020). 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 (Claire 2014).

3. Results

3.1 Results of LST

Table 3 shows the LST value results of the commercially available UDF (tongue crushable) “Eel with egg” and the eight types of commercially available LST values. Table 4 shows the LST value results of the commercially available UDF (tongue crushable) “Boiled cutlet” and the eight types of commercially available LST values. Table 5 shows the LST value results of the commercially available UDF (tongue crushable) “Miso soup with pork and vegetables” and the eight types of commercially available LST values.

Table 3 Viscosity measurement results of eight types of thickeners for Eel with egg

	After 30 seconds		After 5 minutes		After 30 seconds		After 5 minutes		After 30 seconds		After 5 minutes	
Non mizer processing (NMP)	34.1	± 2.9	37.7	± 3.3								
Mixer processin (MP)	49.6	± 4.4	53.2	± 7.1								
MP with Thickener A	39.4	± 2.2	40.4	± 9.4	29.4	± 4.2	31.1	± 4.7	24.5	± 7.1	25.5	± 8.3
MP with Thickener B	41.9	± 2.2	46.2	± 2.4	31.1	± 6.3	33.2	± 6.8	24.6	± 4.1	27.1	± 5.4
MP with Thickener C	42.4	± 3.1	45.4	± 3.1	33.1	± 1.6	35.1	± 1.6	24.6	± 4.8	25.4	± 5.2
MP with Thickener D	Add 39.8	± 2.4	43.7	± 2.6	Add 38.7	± 1.9	41.2	± 2.2	Add 23.3	± 8.8	24.8	± 9.6
MP with Thickener E	1g 41.6	± 1.9	46.6	± 2.3	2g 31.6	± 6.4	33.4	± 6.8	3g 29.6	± 5.2	27.4	± 4.1
MP with Thickener F	43.7	± 2.9	47.7	± 3.9	33.5	± 1.2	36.2	± 1.4	25.8	± 5.8	27.5	± 6.4
MP with Thickener G	45.6	± 2.7	49.2	± 3.4	29.3	± 1.8	31.2	± 2	23.9	± 3.6	24.8	± 4
MP with Thickener H	38.9	± 2.7	43.3	± 2.2	27.2	± 5.3	28.9	± 5.4	24.7	± 7.3	25.8	± 8.1

Table 4 Viscosity measurement results of eight types of thickeners for Boiled cutlet

	After 30 seconds		After 5 minutes		After 30 seconds		After 5 minutes		After 30 seconds		After 5 minutes	
Non mizer processing (NMP)	28.8	± 4.2	31.4	± 3.5								
Mixer processin (MP)	44.3	± 3	47.8	± 3.5								
MP with Thickener A	30	± 7.2	32.2	± 7.3	23.3	± 6.9	24.7	± 7.6	21.9	± 3.9	22.6	± 4.7
MP with Thickener B	31.2	± 2.5	33.9	± 2.6	24.2	± 2.6	26.3	± 2.9	21.2	± 5.3	21.9	± 5.6
MP with Thickener C	32.2	± 4.8	33.9	± 4.9	27.1	± 8.2	28.3	± 7.1	22.6	± 2.3	23.2	± 2.6
MP with Thickener D	Add 32.7	± 2.9	35.2	± 2.3	Add 23.2	± 7.5	25.4	± 8.2	Add 21.9	± 3.7	22.6	± 3.7
MP with Thickener E	1g 34.2	± 3	37.6	± 2.6	2g 25	± 4.9	27.7	± 4.9	3g 21.8	± 4.3	22.8	± 4.9
MP with Thickener F	36.4	± 2.2	39.4	± 2.3	27	± 2.2	29.6	± 2.2	22.6	± 3.6	23.7	± 4.3
MP with Thickener G	35.2	± 3.2	38.6	± 3	23.2	± 5.1	24.1	± 5.6	22	± 3.3	22.8	± 4
MP with Thickener H	33.1	± 3.4	35.1	± 3.6	23.1	± 2.7	24.5	± 3.2	21.7	± 2.7	22.5	± 3.4

Table 5 Viscosity measurement results of eight types of thickeners for Miso soup with pork and vegetables

	After 30 seconds		After 5 minutes		After 30 seconds		After 5 minutes		After 30 seconds		After 5 minutes	
Non mizer processing (NMP)	37.9	± 3.8	38.8	± 4.2								
Mixer processin (MP)	46.8	± 3.1	48.9	± 3.2								
MP with Thickener A	36.4	± 2.7	39.5	± 2.7	29.3	± 2.8	31.4	± 3	24.5	± 5.7	25.4	± 6.3
MP with Thickener B	36.7	± 2.6	40.6	± 3.3	31.7	± 2.3	34.7	± 1.8	25.9	± 1.2	27.4	± 1.4
MP with Thickener C	37.5	± 2.2	41.2	± 2.5	32.6	± 2.1	35.7	± 2.5	25.5	± 2.5	26.9	± 2.7
MP with Thickener D	Add 35.2	± 1.8	37.9	± 1.9	Add 29.9	± 2.8	32	± 3	Add 24.2	± 2.9	25.5	± 3.3
MP with Thickener E	1g 39.3	± 2.7	42.6	± 2.8	2g 31.7	± 1.7	34.3	± 1.7	3g 27.2	± 1.4	28.7	± 1.6
MP with Thickener F	38.1	± 1.9	42.3	± 1.8	31.1	± 2.6	34.3	± 2.6	26.3	± 5.1	28.1	± 5.3
MP with Thickener G	36.8	± 1.9	40.4	± 2.1	26.1	± 5.7	28.2	± 5.7	22.2	± 8.7	22.9	± 9
MP with Thickener H	36.8	± 2.5	40.1	± 2.8	28.4	± 2.5	30.9	± 2.8	23.2	± 7.3	24.2	± 7.4

3.2 Comparison of LST values before adding thickener to UDF

Table 6 shows the line spread test (LST) results of universal design hoods (UDF: can be crushed with tongue). UDF (Cod with colorful sauce: “Eel with egg”, “Boiled cutlet”, and “Miso soup with pork and vegetables”) with a high water content had an LST value of 43 mm or more after the mixer treatment. However, the LST value of UDF (“Boiled cutlet”) was within 32 mm without the mixer treatment.

Table 6 Line spread test (LST) results ofr three types of universal design food (can be crushed with the tongue): raw food

	Standing time	Eel with egg		Boiled cutlet		Miso soup with pork and vegetables	
		平均值	SD	平均值	SD	平均值	SD
Raw food	30 seconds	34.1	2.9	28.8	4.2	37.9	3.8
	5 minutes	37.7	3.3	31.4	3.5	38.8	4.2
After mixer processing	30 seconds	49.6	4.4	44.3	3.0	46.8	3.1
	5 minutes	53.2	7.1	47.8	3.5	48.9	3.2

Very thin thickness	LST value (mm) 43 or more	Addition of thickener is necessary
Light thickness	LSTvalue (mm) 43 – 36	Addition of thickener is necessary
Middle thickness	LST value (mm) 36 – 32	In some cases, it is determined that the addition of a thickener is necessary
Tick thickness	LST value (mm) 32 – 30	Easy to make bolus. Suitable as food for nursing care.
Very thick thickness	LST value (mm) 30 or less	Easy to make bolus. Suitable as food for nursing care.

3.3 Comparison of LST values after adding thickener to UDF

Table 7 shows the results when 1 g, 2 g, and 3 g of 8 types of thickeners were added to 2 types of UDF (can be crushed with the tongue) after mixer treatment of 100g “Eel with egg”, “Boiled cutlet”, and “Miso soup with pork and vegetables”. UDF (“Eel with egg”, “Boiled cutlet”, and “Miso soup with pork and vegetables”) required the addition of a thickening agent to obtain the correct viscosity for safe swallowing. By adding 2g of all thickeners, UDF (“Boiled cutlet”) became viscous enough to be swallowed safely. By adding 2 g of thickeners A, G, and H, UDF (“Eel with egg” and “Miso soup with pork and vegetables”) became viscous enough to be swallowed safely. However, 3 g of all thickeners were required to obtain the viscosity required for UDF (“Eel with egg”, “Boiled cutlet”, and “Miso soup with pork and vegetables”) to be safely swallowed.

Table 7 Line spread test results when 1g, 2g, and 3g of eight types of thickeners were added to three types of universal desing food (can be crushed with the tongue)

	Standing time	Thickener A			Thickener B			Thickener C			Thickener D		
		1 g	2 g	3 g	1 g	2 g	3 g	1 g	2 g	3 g	1 g	2 g	3 g
Eel with egg	30 seconds	39.4	29.4	24.5	41.9	31.1	24.6	42.4	33.1	24.6	39.8	38.7	23.3
	5 minutes	40.4	31.1	25.5	46.2	33.2	27.1	45.4	35.1	25.4	43.7	41.2	24.8
Boiled cutlet	30 seconds	30.0	23.3	21.9	31.2	24.2	21.2	32.2	27.1	22.6	32.7	23.2	21.9
	5 minutes	32.2	24.7	22.6	33.9	26.3	21.9	33.9	28.3	23.2	35.2	25.4	22.6
Miso soup with pork and vegetables	30 seconds	36.4	29.3	24.5	36.7	31.7	25.9	37.5	32.6	25.5	35.2	29.9	24.2
	5 minutes	39.5	31.4	25.4	40.6	34.7	27.4	41.2	35.7	26.9	37.9	32.0	25.5
	Standing time	Thickener E			Thickener F			Thickener G			Thickener H		
		1 g	2 g	3 g	1 g	2 g	3 g	1 g	2 g	3 g	1 g	2 g	3 g
Eel with egg	30 seconds	41.6	31.6	29.6	43.7	33.5	25.8	45.6	29.3	23.9	38.9	27.2	24.7
	5 minutes	46.6	33.4	27.4	47.7	36.2	27.5	49.2	31.2	24.8	43.3	28.9	25.8
Boiled cutlet	30 seconds	34.2	25.0	21.8	36.4	27.0	22.6	35.2	23.2	22.0	33.1	23.1	21.7
	5 minutes	37.6	27.7	22.8	39.4	29.6	23.7	38.6	24.1	22.8	35.7	24.5	22.5
Miso soup with pork and vegetables	30 seconds	39.3	31.7	27.2	38.1	31.1	26.3	36.8	26.1	22.2	36.8	28.4	23.2
	5 minutes	42.6	34.3	28.7	42.3	34.3	28.1	40.4	28.2	22.9	40.1	30.9	24.2
Very thin thickness	LST value (mm)	43 or more			Addition of thickener is necessary								
Light thickness	LST value (mm)	43-36			Addition of thickener is necessary								
Middle thickness	LST value (mm)	36-32			In some cases, it is determined that the addition of a thickener is necessary								
Tick thickness	LST value (mm)	32-30			Easy to make bolus. Suitable as food for nursing care.								
Very thick thickness	LST value (mm)	30 or less			Easy to make bolus. Suitable as food for nursing care.								

4. Discussion

The three types of universal design food (UDF: can be crushed with the tongue) measured this time had almost the same amount of energy and fat. The major difference between these three types of food is the amount of carbohydrates (sugars), and the content of “Boiled cutlet” was 1.5 times (6.6g of sugars) than that of “Eel with egg” and “Miso soup with pork and vegetables”. Therefore, UDF of “Boiled cutlet” had an LST value of 30mm or less at an added amount of 2g for all eight kinds of thickeners, and had a viscosity suitable for swallowing. The other two types of UDF (“Eel with egg” and “Miso soup with pork and vegetables”) had LST values suitable for swallowing foods with 2g of thickeners A, G, and H. When 3g of thickening agent was added to

three kinds of UDF (“Eel with egg”, “Boiled cutlet”, and “Miso soup with pork and vegetables”), all eight kinds of thickeners had appropriate viscosity (less than 32mm) for swallowing food. Differences in viscosity due to differences in the main components of thickeners (xanthan gum, guar gum, starch, etc.) (Nakamura 2009, Kim 2014) was reported.

In addition, nutrients (calcium, phosphoric acid etc.) of food have a synergistic effect and help increase viscosity (Yoshinaga2017). The production of food pastes affects not only adversely their appearance, but also their palatability and texture (Nagai 2014). The effectiveness of thickening agents is in preventing gastroesophageal reflux and in enteral feeding (Kanaoka 2005) and thickeners made food easier to swallow (Shiozawa 2007) were reported. The use of thickeners in water may have a negative effect on the efficacy of drugs when administered to patients with swallowing dysfunction (Tomita 205, Hashimoto 2016).

Using a small amount of thickener is effective for palatability and digestion and absorption of nursing care food. Therefore, in the future, we believe that further research on safety, palatability, cost, etc., in swallowing is necessary.

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.

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