Factors Affecting Sensory Acceptance of Thickened Liquids Used in Dysphagia Management

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A Thesis Presented

By

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ABSTRACT

FACTORS AFFECTING SENSORY ACCEPTANCE OF THICKENED LIQUIDS USED IN DYSPHAGIA MANAGEMENT

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Between 4-16% of adults in the United States have experienced difficulty swallowing at some point during their lives. Difficulty swallowing, or clinically referred to as dysphagia, poses increased concern when drinking beverages. While no treatment is currently available, it is often recommended that liquids be thickened to improve the safety of swallowing and prevent liquids from being aspirated in the lungs. However, thickened liquids are poorly accepted by individuals with dysphagia. Taste and flavor suppression has been shown in various thickened liquid matrices, but the mechanisms for understanding these changes in perception are quite complex. Additionally, literature focused on dysphagic patients' experiences with different types of beverages and clinicians' experiences with thickening beverages is minimal.

The study had two main goals: 1) explore how sensory properties including texture, taste, and flavor affect acceptance of specific thickened liquids and 2) determine challenges clinicians experience with thickening different beverages. This was achieved through a quantitative and qualitative online survey administered to clinicians (n=83; 96% speech-language pathologist) in the United States who work with dysphagia patients. Free-response questions related to thickening issues highlighted challenges with carbonation, temperature, and dairy products. Coffee, water, soda, milk, and oral nutritional supplements were the most complained about thickened beverages, respectively. Disliking of texture was a common complaint for each beverage likely due to the dissimilarity to the unthickened version and challenges associated with thickening. Off-flavors were reported for each beverage and were the most present in water. Additionally, clinicians noted the thickened version of the beverage typically has less flavor. To increase the acceptance of thickened liquids, clinicians believe the texture and flavor need significant improvements. Interdisciplinary work in the field of food science is needed to create a smoother consistency, more stable thickness across time and temperature, and improved flavor/taste to develop more enjoyable beverages for dysphagic patients.

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CHAPTER 1

LITERATURE REVIEW: TASTE AND FLAVOR PERCEPTION OF THICKENED LIQUIDS USED IN DYSPHAGIA MANAGMENT

1.1 Introduction

Dysphagia can be defined as a difficulty swallowing which can encompass a complete loss of swallowing or trouble safely swallowing food, liquid, or saliva (NIDCD, 2014). Between 4-16% of adults in the United States have experienced dysphagia at some point during their lives with 31.6% of people reporting that it lasted for 6 years or longer (Adkins et al., 2020; Bhattacharyya, 2014). The prevalence of dysphagia increases among ageing populations. Around 20-38% of independent-living adults at least 58 years of age in the United States have experienced a swallowing disorder in their lifetime with around 33% currently experiencing a swallowing disorder (Roy et al., 2007; Turley & Cohen, 2009). Dysphagia can occur when there is a problem in any part of the swallowing process and often is a result of another health condition that weakens or damages the muscles and nerves used for swallowing. Conditions that affect the nervous system, such as stoke, may cause difficulty initiating the swallowing response which allows food and liquids to move safely through the throat. People with dysphagia can also experience difficulties moving food around in the mouth for chewing and moving foods towards the stomach because of weak tongue, cheek, or throat muscles such as after cancer treatment (NIDCD, 2014). The most frequently reported causes of dysphagia are stroke and other neurologic diseases, head and neck cancer, and gastroesophageal reflux disease (GERD) (Bhattacharyya, 2014; Roy et al., 2007). Dysphagia can lead to aspiration, aspiration pneumonia, dehydration, malnutrition, morbidity, and mortality (Lieu et al., 2001; Marik & Kaplan, 2003; Reber et al., 2019; Serra-Prat et al., 2012; Tagliaferri et al., 2019).

Thickening liquids are common practice for managing dysphagia with goals of reducing the risk of aspiration and increasing hydration and nutrition (Clavé et al., 2006; Garcia et al., 2005; Seshadri et al., 2018; Steele et al., 2015). The International Dysphagia Diet Standardization Initiative (IDDSI) is a relatively new framework designed to create a common terminology to describe drink thickness with accompanying tests to confirm the flow rate (International Dysphagia Diet Standardisation Initiative, 2019). The level of recommended thickness is determined by the patient's clinician and are based on the rate of liquid flow (Cichero et al., 2017; Seshadri et al., 2018). Prior to the IDDSI guidelines, thickness recommendations were based on viscosity following the National Dysphagia Diet recommendations but there are practical and scientific limitations to categorizing based on viscosity (Cichero et al., 2017; International Dysphagia Diet Standardisation Initiative, 2019). A better understanding of sensory textural attributes and relevant measurement besides viscosity such as elasticity, yield stress, frictional coefficient, adhesiveness, and mouthcoating have shown potential for improving the safety of swallowing although are not considered by most standards (Nishinari et al., 2016; Vickers et al., 2015).

While the textural and rheological properties for thickened beverages are important for increasing safety for dysphagic patients, taste and flavor perception vary across viscosity and with the addition of thickeners. These changes in flavor and taste perception can be influenced by the medium being thickened, type of thickener, and concentration of thickener/viscosity (Kim et al., 2017; Lotong et al., 2003; Matta et al., 2006; Ong et al., 2018). Dissatisfaction with the sensory properties, including flavor and taste, of thickened liquids has repeatedly been a top reason for patient non-compliance and reduced intake (Colodny, 2005; King & Ligman, 2011; McCurtin et al., 2018; Shim et al., 2013). A better understanding of these interactions will help to improve the palatability of thickened liquids for dysphagic patients.

To that end, the goal of this review is to summarize the current literature investigating the relationship between texture and taste for thickened beverages. This study highlights all sensory studies that investigate taste and flavor changes of thickened liquids following NDD or IDDSI guidelines. Only studies that compare the thickened liquids to a control (unthickened version) are discussed in-depth. Additionally, studies related to the general liking or disliking of thickened liquids are not included. These studies have many variables including thickener type, thickener concentration, and beverage type thus determining the mechanisms for taste and flavor suppression are difficult to conclude. To better understand the mechanisms behind the changes in taste and flavor perception, select studies investigating the relationship between texture/viscosity with taste and flavor perception are included. These studies have controlled variables (e.g., tastant type, tastant concentration). A range of studies were chosen to span different sensory attributes including sweetness, saltiness, flavor, and aroma.

1.2 Usage and Acceptance of Thickened Liquids

Of people currently experiencing symptoms of dysphagia, around 38% of people stated they drank thickened liquid to help with dysphagia as a compensatory maneuver and 8.3% of residents in skilled nursing facilities receive thickened beverages (Adkins et al., 2020; Castellanos et al., 2004). Starch and gum-based thickeners such as xanthan gum, guar gum, carboxymethylcellulose (CMC), and modified starch can be used to thicken the liquids. Some facilities use pre-thickened beverages while some add powder or gel thickeners to the beverage before serving (Garcia et al., 2005). Despite which type of thickener is used, patients are dissatisfied with thickened liquids and disliking contributes to patient non-compliance (Colodny, 2005; Garcia et al., 2005; King & Ligman, 2011; Shim et al., 2013). Additionally, patients' lives and personal priorities such as social desires and social acceptance can determine how well they will comply to the diet and dysphagia has been shown to decrease the quality of life of patients (Seshadri et al., 2018; Swan et al., 2015).

Poor taste, flavor, and texture attributes are major contributors to the dislike of thickened beverages. Taste is a sensation that occurs when food stimulates taste buds and refers to sweet, sour, bitter, salty, and umami. Flavor is a combination of olfactory, gustatory, and trigeminal sensations (Small & Prescott, 2005). McCurtin et al. (2018) interviewed people using thickened beverages as a treatment post-stroke and 13 out of

14 patients described unpleasant experiences with some responders stating the thickened beverages suppressed the taste or flavor compared to the non-thickened version. It has been reported that starch and gum-based thickeners suppress the main flavor of beverages and introduce off-flavors including metallic, bitter, astringent, and starch (Kim et al., 2014; Lotong et al., 2003; Matta et al., 2006). Flavor and taste perception has also shown to decrease with increasing viscosity (Cook et al., 2002; Ferry et al., 2006; Hollowood et al., 2002).

Patients have also described the consistency or texture of thickened liquids as unpleasant (McCurtin et al., 2018).Texture is a multi-parameter attribute, derived from the structure of food, and detected by several senses (Szczesniak, 2002). Flavor and texture are the most common attributes contributing to food rejection and 94% of people will reject a food due to an unpleasant texture or flavor (Pellegrino & Luckett, 2020). The textural properties of thickened beverages such as perceived thickness, ease of swallowing, and slipperiness can be important for the acceptance of the beverages (Vickers et al., 2015).

There has been a lack of standardization for degree of thickness and descriptions for levels of modification (Cichero et al., 2013). Previously, the National Dysphagia Diet (NDD) was commonly used in the United States to categorize liquids based on viscosity ranges (Seshadri et al., 2018). Recently, the International Dysphagia Diet Standardization Initiative (IDDSI) developed a framework of common terminology to describe drink thickness and tests to confirm the rate of flow (International Dysphagia

Diet Standardisation Initiative, 2019). IDDSI classifications are based on the rate of liquid flow through a 10 mL slip tip syringe rather than viscosity (Cichero et al., 2017; International Dysphagia Diet Standardisation Initiative, 2019). Prior to IDDSI, national descriptors for thickened liquids varied throughout the world with differences present in at least 10 different countries and even within the same country. Common differences were in the number of thickness levels used, if rheological measurements were used, and how the thickness levels were described (Cichero et al., 2013). Table 1.1 compares the differences between NDD and IDDSI framework. All descriptors used in the IDDSI Framework are not shown in the table.

Table 1.1 A comparison between IDDSI and NDD

International Dysphagia Diet Standardization Initiative			**National Dysphagia Diet**	
Level	*Description*	*IDDSI Flow Test*	*Level*	*Viscosity (shear rate 50 s $^{-1}$)*
0 - Thin	• Flows like water • Fast flow • Can drink through any type of teat/nipple, cup or straw as appropriate for age and skills	Less than 1 mL remaining in the 10mL syringe after 10 seconds of flow	Thin	1-50 cP
1 - Slightly Thick	• Thicker than water • Requires a little more effort to drink than thin liquids • Flow through a straw, syringe, teat/nipple	Test fluid flows through a 10 mL slip tip syringe leaving 1-4 mL in the syringe after 10 seconds	-	-
2 - Mildly Thick	• Flows off a spoon • Sippable, pours quickly from a spoon, but slower than thin drinks • Mild effort is required to drink this thickness through standard bore straw	Test fluid flows through a 10 mL slip tip syringe leaving 4 to 8 mL in the syringe after 10 seconds	Nectar-Like	51-350 cP

3 - Moderately Thick	• Can be drunk from a cup • Moderate effort is required to suck through a standard bore or wide bore straw • No oral processing or chewing required - can be swallowed directly	Test liquid flows through a 10 mL slip tip syringe leaving > 8 mL in the syringe after 10 seconds	Honey-Like	351-1750 cP
4 - Extremely Thick	• Usually eaten with a spoon • Cannot be drunk from a cup because it does not flow easily • Cannot be sucked through a straw • Does not require chewing	Not applicable (Fork Pressure Test)	Spoon-Thick	>1750 cP

Information provided from (International Dysphagia Diet Standardisation Initiative, 2019) and (Cichero et al., 2013).

1.3 Rheology of Thickened Liquids

Recent studies show that understanding the rheological properties of thickened fluids is beneficial in designing better controlled fluids and plays an important role in the sensory perception of thickened liquids. Rheology, the science of deformation of objects under the influence of applied forces (Fellows, 2017), can provide information about the physical characteristics of thickened liquids. These measurements describe the behavior of thickeners, such as whether they exhibit fluid or viscoelastic properties and how their viscosity changes at different shear rates or over shear time.

One important measurement is apparent viscosity or steady shear viscosity which can be defined as the liquid's internal resistance to flow. Considering a liquid that has many layers, the movement between the layers forms a velocity gradient. The velocity gradient is known as the shear rate and the force that moves the liquid is the shear stress. The ratio of shear rate to shear stress is equal to the viscosity of the liquid. When plotting the shear rate and shear stress against each other, most simple liquids show a linear relationship and are considered Newtonian fluids. When the relationship is nonlinear, the fluids are considered non-Newtonian. Most liquids display varying degrees of non-Newtonian behavior (Fellows, 2017). For non-Newtonian liquids, viscosity is expressed as apparent viscosity because it is possible to be defined for each value of a shear rate. Viscosity changes when the shear rate changes for these types of fluids (Sukkar et al., 2018). Thickened liquids typically show non-Newtonian and viscoelastic behavior, but specific rheological properties, such as degree of shear-thinning, vary between type and concentration of thickener (Cho et al., 2012; H. Kim et al., 2017; Ong et al., 2018; Ross et al., 2019; Vickers et al., 2015; Vieira et al., 2020). For these reasons, the oral shear rate is an important characteristic relevant to thickened beverages in relation to perceived viscosity, slipperiness, stickiness, cohesiveness, and ease of swallowing (Ong et al., 2018; Ross et al., 2019; Vickers et al., 2015).

Wood (1968) found that the average oral shear rate was around 50 s^{-1} which later was the basis for the standard developed by the National Dysphagia Diet, setting the measurement of viscosity to 50 s^{-1} (Vickers et al., 2015). However, there is limited evidence for this standard for its relevance to dysphagia as a single shear rate that describes swallowing is too simplistic, and oral shear rates are believed to vary throughout the swallowing process causing hurdles in characterizing the properties of optimally thick liquids (Ong et al., 2018).

Sensory thickness, sensory viscosity, or perceived viscosity is affected by the rheological properties and can be defined as the force sensed to deform a fluid food. However, instrumental rheological measurements have not been able to accurately predict what sensations occur in the mouth during oral processing (Chen & Stokes, 2012). Most dysphagia standards do not account for textural attributes and relevant measurements such as elasticity, yield stress, frictional coefficient, adhesiveness, and mouthcoating although previous research has shown how these factors could be beneficial for improving the safety of swallowing (Nishinari et al., 2016; Vickers et al., 2015). However, these topics are not of relevance for this review.

Changes in taste and flavor perception have been shown to change with increases in viscosity, texture changes, and the addition of thickeners. An understanding of the taste and flavor changes in these liquids will be beneficial in designing more acceptable products for dysphagia patients. This review will highlight taste and flavor changes that have occurred with different viscosities/consistencies, liquids, and thickeners.

1.4 Taste and Flavor Perception of Thickened Liquids Used for Managing Dysphagia

1.4.1 Overview

Food perception is multimodal, integrating multiple sensory pathways that helps to determine how the food is perceived. Texture-taste and texture-flavor interactions have been broadly studied but are not well understood. Increasing the viscosity of liquids with thickeners is known to change the sensory properties of thickened beverages often reporting decreased taste and flavor perception. It is assumed that by thickening the product, the tastant release and diffusibility will be affected and will differ by type and amount of thickener (Braud & Boucher, 2020). Numerous studies have investigated the thickener concentration relative to its coil, or critical, overlap concentration (c*) as a key factor in flavor and taste suppression for these systems. However, this theory has been challenged and studies have shown that viscosity alone can cause taste suppression, but the food matrix and thickener type also play a role in the perception of taste and flavor (Ong et al., 2018; Wagoner et al., 2018; Wagoner et al., 2019). Descriptive analysis studies of thickened liquids using recommended thickness levels for dysphagia management highlight thickener type, thickener concentration, and beverage type can all play a role in taste and flavor perception of these products.

1.4.2 Descriptive Analysis of Thickened Liquids

There have been five studies using descriptive analyses to compare intensities of taste and flavor attributes of thickened liquids. Some of these studies used unflavored water as a sample but these results will not be included in the review. Since water is a relatively flavorless and tasteless beverage, observed changes in taste and flavor would be considered an off-flavor. Additionally, off-flavors of other beverages will not be included in the results. Attributes were considered an off-flavor if the intensity of the attribute was given a score of 0 for the unthickened beverage and increased with the addition of thickener. Briefly, these studies highlight that the addition of thickeners can elicit astringent, metallic, sour, bitter, and starch off-flavors with differences in intensity between type of thickener, thickness levels, and beverage type (Kim et al., 2017; Lotong et al., 2003; Matta et al., 2006).

Baert et al. (2021), Kim et al. (2017), Lotong et al. (2003), Matta et al. (2006), and Ong et al. (2018) all completed descriptive analyses studies using different types of thickeners, various liquids, and thickness levels. Baert et al. (2021) used thickened soup solutions. Since soup can be considered a thin liquid that may need to be thickened for some patients, it is relevant for the review. Table 1.2 shows the sensory methods and liquid solutions used for each study. Table 1.3 shows the taste intensity results of three of the descriptive studies and Table 1.4 shows the flavor intensity results. Matta et al. (2006) results are not shown in the taste and flavor intensity results tables because they had an aim to compare differences between thickener type, and their statistical analysis did not calculate significant differences between the unthickened version and thickened version. Baert et al. (2021) results are not shown in the table because their descriptors were broad and not defined in a glossary or with references. For example, terms such as "general taste" and "odor intensity" were used. However, the results are briefly described in the text.

The intensity ratings of the attributes for the studies are not shown in the table. In general, thickeners tended to significantly decrease the base or characteristic flavors of the beverage which had a moderate intensity while minor flavors with low intensities seemed to not significantly decrease (Kim et al., 2017; Lotong et al., 2003). Although Matta et al. (2006) did not calculate significant differences between unthickened and thickened versions of the beverage, their results appear to show a similar pattern. Additionally, the results highlighted how different types of thickeners can change the taste and flavor perception of thickened liquids at the same consistency level. In general, the descriptive analyses studies show basic tastes typically decreased in intensity, except for bitterness, but these decreases were not usually significantly different. The results for basic tastes were more inconsistent than for flavors. For example, sweetness perception results varied greatly with different thickeners and beverages. The study done by Ong and colleagues (Ong et al, 2018) showed significant differences were present for the attributes between thickener type, IDDSI level, and medium being thickened. Sweetness was significantly suppressed for all IDDSI levels with corn starch thickened solutions. Using xanthan-gum, sweetness was not significantly decreased in lemon water but for water containing barium sulfate, the sweetness was suppressed at the higher IDDSI levels. Additionally, xanthan-gum significantly decreased sourness of lemon water but corn starch only had a significant effect at IDDSI level 4.

Baert et al. (2021) identified the general taste of the potato-starch thickened soup was significantly lower than the xanthan-gum thickened soup, quinoa flour thickened soup, and unthickened soup. Post hoc analysis demonstrated no difference in vegetable flavor among the soups. The previous studies examined in this section highlighted different types of thickeners often suppressed main flavors of the beverages but this study showed no significant difference in vegetable flavor intensity between the soups. However, the differences in taste intensity aligns with other results suggesting that taste suppression depends on thickener composition and the liquid being thickened.

The results of these descriptive analyses studies highlight thickener type, concentration level, and beverage type all play a role in taste and flavor perception. The results are challenging to compare due to the diverse and complex matrix of different beverages and thickeners. For these reasons, potential mechanisms of these taste and flavor changes are tough to conclude. The following sections will explain potential mechanisms for taste and flavor perception in thickened liquids with examples of studies that control for individual variables including taste and flavor compounds, viscosity level, and thickener type.

Table 1.2 Sensory methods and solutions for descriptive analysis studies

Methods	# of panelists	Thickeners Used	Thickness Levels	Liquids Used	Reference
A lexicon was developed and references (base beverages) with intensities were assigned. Base flavor was not described in detail. Intensities were evaluated on a 15-point scale with 0.5 increments.	5	4 powdered starch-based thickeners • 3 thickeners = modified cornstarch/ maltodextrin • 1 thickener = modified food starch	Honey-like (351 - 1750 cP)	Whole milk, apple juice, orange juice	Lotong et al. (2003)
A lexicon was developed and references (base beverages) with intensities were assigned. Base flavor was not described in detail. Intensities were evaluated on a 15-point scale with 0.5 increments.	5	2 starch-based and 2 gum-based thickeners • Modified corn starch (powder form) • Modified food starch (maize) & maltodextrin (powder form) • Cellulose gum/maltodextrin (powder form) • Xanthan gum, water, citric acid, sodium benzoate, and potassium sorbate (gel form)	• Nectar-like (51-350 cP) • Honey-like (351 - 1750 cP)	2% milk, apple juice, coffee	Matta et al. (2006)

A lexicon was developed, and references were chosen. Intensities were evaluated on a 15-point scale with 0.5 increments.	9	Xanthan-gum based (59% dextrin, 38% xanthan gum, locust bean gum, sodium carboxymethylcellulose, sodium gluconate, and magnesium chloride)	1% concentration • 118-201 cP • Nectar-like 2% concentration • 305 - 557 cP • Honey-like 3% concentration • 529 - 1199 cP • Honey-like	Apple juice, orange juice, soymilk, Yakult (liquid yogurt)	Kim et al. (2017)
Two separate trained descriptive analysis panels were conducted. Attributes were selected from ultra-flash profiling, but were discussed and modified. Evaluation technique and definitions were decided. Panelists were presented with references and taught to evaluate the intensity. Panelists were considered minimally trained. Panelists used teaspoons to sample each beverage. Barium sulfate samples were expectorated.	•11 (lemon water) •12 (water with barium sulfate)	• Modified corn starch • Xanthan gum	Thin - Extremely Thick/IDDSI Levels 0 - 4	Lemon Splash Water, water with 20% w/w barium sulfate	Ong et al. 2018
Three training sessions comprising free choice profiling analyses were used to develop a lexicon. Intensities of the attributes were evaluated on a 10 cm line scale. Unthickened soup was the reference soup.	21	•Xanthan-gum/maltodextrin • Potato starch •Quinoa flour	IDDSI Level 2/ Nectar-like (51 - 350 cP)	Blended Broccoli Soup	Baert et al. 2021

Table 1.3 Taste results from descriptive analysis studies

Attribute	Beverage	Thickener Type	Results	Reference
Sweet	Apple Juice	Starch-Based	Significantly decreased in 1 brand of thickener.	Lotong et al. 2003
		Xanthan-Gum Based	No significant difference.	Kim et al. 2017
	Orange Juice	Starch-Based	Significantly increased in 1 brand of thickener.	Lotong et al. 2003
		Xanthan-Gum Based	No significant difference.	Kim et al. 2017
	Whole Milk	Starch-Based	Significantly decreased in all 4 brands of thickener.	Lotong et al. 2003
	Soymilk	Xanthan-Gum Based	No significant difference.	Kim et al. 2017
	Yakult (liquid yogurt)	Xanthan-Gum Based	No significant difference.	Kim et al. 2017
	Lemon Water	Xanthan-Gum Based	No significant difference.	Ong et al. 2018
		Modified Corn Starch	All IDDSI levels are significantly less sweet than the unthickened sample.	Ong et al. 2018
	Water w/ barium sulfate	Xanthan-Gum Based	Only levels 3 and 4 were significantly less sweet than the unthickened sample (sig. dif. between some levels).	Ong et al. 2018
		Modified Corn Starch	All IDDSI levels are significantly less sweet than the unthickened sample. Level 4 was significantly less sweet than the other thickened samples.	Ong et al. 2018
Sour	Apple Juice	Starch-Based	No significant difference.	Lotong et al. 2003
		Xanthan-Gum Based	No significant difference.	Kim et al. 2017
	Orange Juice	Starch-Based	Sourness was significantly decreased in two brands of thickeners.	Lotong et al. 2003
		Xanthan-Gum Based	Each concentrations level was significantly less sour. 1% and 3% concentrations are significantly different from each other.	Kim et al. 2017
	Yakult (liquid yogurt)	Xanthan-Gum Based	No significant difference.	Kim et al. 2017
	Lemon Water	Xanthan-Gum Based	All IDDSI levels are significantly less sour than the unthickened samples (sig. dif. between some levels).	Ong et al. 2018

Sour	Lemon Water	Modified Corn Starch	Only Level 4 is significantly less sour than the unthickened sample (sig. dif. between some levels).	Ong et al. 2018
Bitter	Apple Juice	Starch-Based	Significantly increased with 2 brands of thickeners.	Lotong et al. 2003
		Xanthan-Gum Based	No significant difference.	Kim et al. 2017
	Orange Juice	Starch-Based	Significantly increased with all 4 brands of thickeners.	Lotong et al. 2003
		Xanthan-Gum Based	No significant difference.	Kim et al. 2017
	Whole Milk	Starch-Based	Significantly increased with all 4 brands of thickeners.	Lotong et al. 2003
	Soymilk	Xanthan-Gum Based	No significant difference.	Kim et al. 2017
	Yakult (liquid yogurt)	Xanthan-Gum Based	No significant difference.	Kim et al. 2017
	Water w/ barium sulfate	Xanthan-Gum Based	No significant difference.	Ong et al. 2018
		Modified Corn Starch	No significant difference.	Ong et al. 2018
Salty	Apple Juice	Xanthan-Gum Based	No significant difference.	Kim et al. 2017
	Orange Juice	Xanthan-Gum Based	No significant difference.	Kim et al. 2017
	Soymilk	Xanthan-Gum Based	No significant difference.	Kim et al. 2017
	Yakult (liquid yogurt)	Xanthan-Gum Based	No significant difference.	Kim et al. 2017

Green text indicates all 4 brands of starch-based thickeners at the honey-thick level significantly decreased the attribute compared to the unthickened version. Blue text indicates all thickness levels were significantly decreased compared to the unthickened sample.

Table 1.4 Flavor results from descriptive analysis studies

Beverage	Thickener Type	Results	Reference
Apple Juice	Starch-Based	Apple ID significantly decreased in all 4 brands of thickener.	Lotong et al. 2003
	Xanthan-Gum Based	• Apple ID was significantly decreased in all concentration levels (not sig. dif. between 2% and 3% concentrations). • Cooked significantly decreased in all concentration levels (not sig. dif. between concentration levels).	Kim et al. 2017
Orange Juice	Starch-Based	• Orange ID significantly decreased in all 4 brands of thickeners. • Peely significantly increased in all 4 brands of thickeners.	Lotong et al. 2003
	Xanthan-Gum Based	• Orange ID significantly decreased at 2% and 3% concentrations (not sig. dif. between the two concentrations). • No significant effect on Cooked.	Kim et al. 2017
Whole Milk	Starch-Based	• Overall Dairy significantly decreased in all 4 brands of thickener. • Sweet Aromatics significantly decreased in all 4 brands of thickener.	Lotong et al. 2003
Soymilk	Xanthan-Gum Based	• Beany ID and Beany Raw ID significantly decreased for some concentrations. • Overall Dairy, Overall Nutty, and Cooked had no significant effect.	Kim et al. 2017
Yakult (liquid yogurt)	Xanthan-Gum Based	No significant effect for any flavor attributes (overall dairy, dairy/fishy, cooked, baby vomit ID, caramel ID, overall nutty).	Kim et al. 2017
Lemon Water	Xanthan-Gum Based	Levels 2-4 had significantly less lemon flavor than the unthickened sample. Level 4 had significantly less lemon flavor than the other thickened samples.	Ong et al. 2018
	Modified Corn Starch	All IDDSI levels had significantly less lemon flavor than the unthickend sample (sig. dif. between some levels).	Ong et al. 2018
Water w/ barium sulfate	Xanthan-Gum Based	Only level 4 had significantly less strawberry flavor than the unthickened sample. Levels 1 and 4 are significantly different from each other.	Ong et al. 2018

Water w/ barium sulfate	Modified Corn Starch	Only level 4 had significantly less strawberry flavor than the unthickened sample. Level 4 had significantly less strawberry flavor than the other thickened samples.	Ong et al. 2018
Green text indicates all 4 brands of starch-based thickeners at the honey-thick level significantly decreased the attribute compared to the unthickened version. Blue text indicates all thickness levels were significantly decreased compared to the unthickened sample.			

1.5 Factors Influencing Taste and Flavor Perception

1.5.1 Critical Overlap Concentration (c*)

As previously mentioned, many studies have identified c* as a relevant measurement for taste and flavor suppression. These studies have used various thickening agents including carboxymethyl cellulose (CMC), hydroxypropyl methyl cellulose (HPMC), guar gum, carrageenan, locust bean gum, and sodium alginate (Baines & Morris, 1987; Cook et al., 2002; Han et al., 2014; Hollowood et al., 2002; Koliandris et al., 2008; Malone et al., 2003). Baines and Morris (1987) first developed this theory and described c* as the point at which there is an abrupt or sharp increase in solution viscosity as thickener concentration is increased, which corresponds to the point at which the hydrocolloid chains begin to overlap in solution and reduce freedom of molecular movement (Baines & Morris, 1987).

Table 1.5 shows results of perceived intensity of taste or flavor of thickened solutions above c* when compared to thickened solutions below c* for studies with the aim of determining the relevance of c* in taste or flavor perception. The table is limited to studies where panelists tasted samples which only contained added hydrocolloids and tastants/flavoring. Baines and Morris (1987), Hollowood et al. (2002), and Malone et al. (2003) used magnitude estimation testing with different levels of hydrocolloids added in ranges below and above c* and were compared to a fixed control solution. Cook et al. (2002) used paired comparison tests where panelists were presented with one sample above c* and one sample below c* and chose which sample had the highest intensity where both samples contained the same amount of tastant. Han et al. (2014) used a labeled magnitude scale. A not significant result in Table 1.5 does not necessarily mean the perceived intensity of that attribute did not change but rather the decrease was not dependent on c*. Specifically, below c* the intensity of taste and flavor is independent of the amount of thickener but above c* taste and flavor perception decrease steeply with increasing thickener concentration. For the HPMC and sucrose solutions, there is a difference in results. However, this can be explained by methodology of the studies. Cook et al. (2002) used paired comparison tests with only one sample below c* and one sample above c* which explains a significant difference relative to c*. Hollowood et al. (2002) used multiple concentrations of HPMC above and below c* with magnitude estimation testing. The results showed a steady decrease of perceived sweetness with increasing concentration, but the effect was not of relevance to c*.

Table 1.5 Studies comparing the relevance of c* for taste and flavor suppression

Thickening Agent	Tastant/ Flavoring	Perceived Intensity Above C*	Reference
Guar Gum	Sucrose	Sweetness **significantly decreased**	Baines and Morris 1987; Cook et al., 2002
	Aspartame	**No significant effect** on sweetness	Cook et al., 2002
	Strawberry	Strawberry flavor **significantly decreased**	Baines and Morris 1987

Guar Gum	Citric acid	**No significant effect** on acidity	Malone et al. 2003
λ-Carrageenan	Sucrose	**No significant effect** on sweetness	Cook et al., 2002
	Aspartame	Sweetness **significantly decreased**	Cook et al., 2002
HPMC	Sucrose	Sweetness **significantly decreased** and **no significant effect**	Cook et al., 2002; Hollowood et al., 2002
	Aspartame	Sweetness **significantly decreased**	Cook et al., 2002
	Fructose	Sweetness **significantly decreased**	Cook et al., 2002
	Neohesperidin dihydrochalcone (NHDC)	Sweetness **significantly decreased**	Cook et al., 2002
	Citric acid	**No significant effect** on acidity	Cook et al., 2002
	Sodium chloride	Saltiness **significantly decreased**	Cook et al., 2002
	Quinine hydrochloride	**No significant effect** on bitterness	Cook et al., 2002
	Strawberry	Strawberry flavor **significantly decreased**	Hollowood et al., 2002
CMC	Aspartame	Sweetness **significantly decreased**	Han et al., 2014
Sodium Alginate	Aspartame	**No significant effect** on sweetness	Han et al., 2014

Table 1.5 highlights taste and flavor suppression may not always be dependent on concentration related to c*. The type of thickening agent and tastant can also determine the magnitude of suppression. For example, the perceived sweetness of aspartame significantly decreased with c* in solutions thickened with carboxymethylcellulose but not in solutions thickened with sodium alginate. Additionally, Cook et al. (2002) found HPMC significantly reduced sweetness perception of a range of sweet tasting molecules above c*. The sucrose in λ-Carrageenan and aspartame in guar gum were one judgement short of significance meaning the magnitude of sweetness reduction may differ between hydrocolloid type and concentration. However, these results should be validated with more research which uses methods containing more concentration ranges and scaling techniques.

Most studies relating c* to taste or flavor suppression are in aqueous solutions or solutions that do not include more complex ingredients such as fat or protein which would be relevant for dysphagia patients using thickened dairy products such as milk or oral nutritional supplements. Wagoner et al. (2019) used CMC thickened solutions at various levels above and below c* to observe the sweetness perception of samples with or without milk protein concentrate. In the CMC solutions well above c*, the sweetness perception was suppressed; however, sweetness suppression was not observed in solutions slightly above c*. Furthermore, when milk protein concentrate was combined with the CMC solutions at the same concentrations, sweetness suppression did not occur. In the 0.90% CMC solution with milk protein concentrate, sweetness perception significantly increased meaning c* may not be relevant for more complex beverages containing protein and fat (Wagoner et al., 2019).

1.5.2 Viscosity

Malone et al. (2003) found there was no specific relationship with c* with suppression of acidity in citric acid and guar gum solutions. Between 0.001 and 0.1 Pa s the influence of viscosity was small (25% decrease) but further increases in viscosity up to 17 Pa s at a shear rate of 50 s^{-1} significantly reduced the taste intensity presumably because of poor mixing, mass transfer at the surface of the sample, and surface area between the sample and mouth. Again, these results highlight viscosity plays a role in taste and flavor perception, specifically when thickeners are added, but c* is likely not a reliable measurement to predict taste and flavor suppression.

Taste and flavor suppression by modifying the texture without thickening agents has been minimally studied. Wagoner et al. (2018) changed the texture of whey-protein based model foods containing different sweeteners by altering the heating time to form three different textures: thin fluid (milk consistency), thick fluid (drinkable yogurt consistency), and semisolid (spoonable pudding). All samples showed a significant texture-taste interaction of decreased sweetness perception with increased thickness which was displayed through either iso-sweetness concentration or slope of the power function. Thus, texture can impact sweetness perception without changing formulation (adding thickeners). More research needs to be done to determine if texture alone can suppress other taste or flavor attributes.

1.5.3 Transport of Taste and Aroma Molecules

Baines and Morris (1987) suggested changes in perceived taste and flavor could be linked to inefficient mixing in solutions above c* and inhibiting the transport of taste and aroma molecules to their appropriate receptors. However, they were unable to explain why taste and aroma perception were affected similarly when the mass transport and transduction pathways for taste and aroma molecules are very different. Cook et al. (2002) noted that diffusion effects or interferences of receptor binding are unlikely to act independently in reducing sweetness perception especially considering the bitterness of quinine hydrochloride was not affected by the HPMC concentration.

Han et al. (2014) found CMC and sodium alginate both weakened the binding affinity of aspartame and receptors causing a decrease in the association constant. Additionally, water bound more tightly in CMC when the concentration was above c* which resulted in a decreased diffusion coefficient. The weakened binding strength for aspartame with taste receptors along with the decrease in water mobility and diffusion could account for the suppression of sweet taste for CMC in aspartame solution. Free water availability in solutions could result in a decrease in sweetness intensity resulting in a decrease in flavor intensity. This could potentially explain the results of Baines & Morris (1987) and Hollowood et al. (2002) related to flavor perception as both sample sets contained sucrose.

Koliandris et al. (2008) reported salt release was unaffected by a range of gelatin concentrations but locust bean gum showed a large decrease above c*. Koliandris et al. (2008) also suggested reduced flavor perception above c* is not due to restricted mixing but rather the restricted mixing reduces the transport of tastants. Furthermore, Hollowood et al. (2002) found there was no significant effect of HPMC or sugar concentration on the headspace concentration of benzaldehyde. There was a significant effect of volatile concentration on the headspace values. The lack of effect with HPMC concentration suggests there was no binding or chemical interaction occurring between HPMC and benzaldehyde.

Different types of thickeners can also mix more efficiently with water and saliva to play a role in taste and flavor perception. For example, Ferry and colleagues (Ferry et al., 2006)used three different types of starch thickener and HPMC in solutions containing basil flavoring (0.05%) and salt (0.5%). Different concentrations of each thickener were added to form solutions with viscosity ranging from 80 – 480 mPa s at 50 s^{-1}. Magnitude estimation scaling was used to evaluate the samples. Differences were present in perception of saltiness and basil flavor between starch thickeners and HPMC significantly decreased taste and flavor compared to all starch thickened solutions. A reduction in viscosity due to amylase in the mouth is not a likely conclusion because previous research has shown a more rapid reduction of viscosity for waxy maize starch compared to wheat starch with the addition of amylase (Ferry et al., 2004) but this research shows the flavor and taste perception was more intense in wheat starch (Ferry et al., 2006). However, a possible explanation for the starch-based solutions showing higher taste and flavor perception compared to HPMC could be due to starch pastes mixing more efficiently with water or saliva.

1.5.4 Sweetness and Flavor Perception

Hollowood et al. (2002) used varying concentration of HPMC, sucrose, and benzaldehyde to investigate the perception of sweetness and almond flavor. Low-order polynomial models revealed that for any given sweetness intensity, the concentration of sugar must be increased with an increase in HPMC. For flavor perception, the model showed for any given level of HPMC, the relationship between perceived almond intensity and volatile concentration was dependent on sugar level indicating a decrease in flavor is dependent on sugar level which indicates a decrease in flavor perception may be due to decreased stimulation of taste receptors by sugar molecules.

He et al. (2016) found similar results for solutions of xanthan, dextran, sucrose and banana flavor. The results revealed maximum intensity of flavor released and the total amount of flavor release were not significantly different among samples. However, the intensity ratings for overall fruity flavor from a modified Quantitative Descriptive Analysis panel ranged from 3.23 to 8.52. Despite a constant amount of sucrose in each sample, overall scores for sweetness intensity ranged from 2.91 to 8.01 with differing concentrations of xanthan-gum and dextran. Flavor perception was highly correlated to sweetness perception meaning the perception of sweetness affected flavor perception.

He et al. (2016) indicated that the perceived sweetness may be less affected by samples that are less shear-thinning. Ferry et al. (2006) showed solutions that were matched to a mouthfeel shear rate or shear stress had different mouthfeel perceptions and the different mouthfeel perceptions could explain differences in flavor suppression. Additionally, Kokini oral shear stress was correlated with sweetness and pineapple flavor intensity for different types of thickeners with different mouthfeels (Cook et al., 2003). Cognitive effects with texture may also play a role in perception. Cook et al. (2002) suggested a psychological element may be involved with sweetness perception and perceived viscosity such as viscosity arousing the expectation of sweetness which is not actually provided by the hydrocolloid thickener.

1.6 Conclusion

Decreases in flavor and taste perception are evident in thickened solutions, but the mechanisms for understanding these perceptions are intricate. Overcoming these challenges will require interdisciplinary work between rheologists, colloid scientists, and sensory scientists. Descriptive analysis studies using thickened beverages showed differences in taste and flavor depend on the thickener type, beverage matrix, and thickness level. Model solutions help to better understand these interactions. However, due to a high number of variables including thickener and tastant type along with concentration range, viscosity range, and differences with sensory evaluation techniques, the results are often difficult to compare. While IDDSI is the most recent dysphagia standard, there are limited sensory studies investigating taste and flavor differences between thickened solutions and unthickened controls which follow the recommendations of IDDSI. While there are many studies investigating texture-taste and texture-flavor interactions in controlled solutions, these solutions are often aqueous based, aren't thickened relevant to dysphagia guidelines, and often use thickeners that are not commonly seen in thickened beverages for dysphagic patients.

The studies summarized here highlight different mouthfeels due to poor mixing could play a role in cognitive interactions with tastants. Additionally, poor mixing will reduce the rate at which the tastant reaches the receptors. Flavor perception appears to be more affected by a reduction in the release of tastants rather than aroma release. Restricted mixing with high concentrations of thickener can result in a reduction of flavor and taste perception. However, c* cannot be generalized as a measurement to predict taste and flavor suppression since the food matrix and thickener type can affect the perception or magnitude of suppression. Tastant release, especially sugar, will affect overall perceived flavor because of multimodal interactions between taste and aroma perception. Overall, a decrease in flavor perception appears to be a combination of texture, aroma, and taste signal processing in the brain.

A better understanding of how texture and flow properties of various thickened solutions affect tastant release and diffusibility will be required to improve the palatability of thickened beverages for dysphagic patients. This review highlights that one type of thickener is not more favorable than other types and consideration for the type of beverage being thickened needs to be evaluated when recommending the type of thickener. More research is needed to understand what type of thickener has the most favorable taste and flavor properties in different types of beverages at all IDDSI levels.

CHAPTER 2

FACTORS AFFECTING SENSORY ACCEPTANCE OF THICKENED LIQUIDS USED IN DYSPHAGIA MANAGEMENT: A CLINICIANS' VIEWPOINT

2.1 Introduction

Dysphagia is defined as difficulty swallowing. The estimate among all adults in the United States who have experienced dysphagia at some point during their lives is around 4-16% and this prevalence increases with ageing populations (Adkins et al., 2020; Bhattacharyya, 2014; Roy et al., 2007; Turley & Cohen, 2009). Individuals with dysphagia may experience a complete loss of swallowing function or have trouble swallowing liquids, food, or saliva (NIDCD, 2014). Stroke and other neurologic diseases, head and neck cancer, and gastroesophageal reflux disease (GERD) are the most commonly reported causes of dysphagia (Bhattacharyya, 2014; Roy et al., 2007).

Dysphagia can lead to aspiration, aspiration pneumonia, dehydration, malnutrition, morbidity, and mortality (Lieu et al., 2001; Marik & Kaplan, 2003; Reber et al., 2019; Serra-Prat et al., 2012; Tagliaferri et al., 2019). Thin liquids can flow too quickly for people with dysphagia. Adding thickeners to liquids slows the rate of flow which reduces the chance for liquids to enter the airways and cause aspiration (Clavé et al., 2006; Steele et al., 2015). Therefore, thickened liquids are a customary practice for managing swallowing difficulties. A variety of thickening products including starch and gum-based thickeners are often used to thicken liquids. Some facilities use pre-thickened beverages, while some will add powder or gel thickeners to the beverage

(Garcia et al., 2005). The National Dysphagia Diet (NDD) was previously used in the United States with four levels of recommended viscosity for liquids including thin, nectar-thick, honey-thick, and spoon-thick (Seshadri et al., 2018). Recently, the International Dysphagia Diet Standardization Initiative (IDDSI) developed a framework of common terminology, definitions, and flow properties to describe thickened liquids. The framework is divided into 5 different levels ranging from “Thin” to “Extremely Thick” and are based on rate of liquid flow rather than viscosity (Cichero et al., 2017).

However, dissatisfaction with thickened beverages results in non-compliance rates ranging from 40-80% (Colodny, 2005; King & Ligman, 2011; Shim et al., 2013). Poor adherence to thickened liquids is often attributed to lack of flavor, poor taste, disliking of texture, and effects on quality of life. Dysphagia and using thickened liquids have shown to decrease quality of life due to feelings of embarrassment, self-consciousness while eating, social avoidance, low self-esteem, feelings of anxiety or panic during mealtime, and depression (Ekberg et al., 2002; Roy et al., 2007; Swan et al., 2015; Turley & Cohen, 2009).

Thickened liquids have been shown to suppress flavor, not adequately quench thirst, and judged as too thick due to thickening inconsistencies which could also contribute to decreased fluid intake and risk of dehydration (Cichero, 2013; McGrail et al., 2012; Ong et al., 2018; Seshadri et al., 2018). In fact, an interview with people using thickened beverages revealed considerable unpleasant experiences with some patients describing a decrease in taste or flavor and disliking of the texture (McCurtin et al., 2018). Prior research has shown both starch-based and gum-based thickeners suppress the main flavors of the base beverage and impart off-flavors (Matta et al., 2006). In a study using either modified cornstarch or xanthan gum to thicken flavored water samples to IDDSI levels, taste and flavor attributes decreased with increasing IDDSI levels and certain taste attributes depended on thickener type (Ong et al., 2018). Additionally, patients seem to prefer gum-based thickeners over starch-based thickeners. Starch-based thickeners have been described to be grainy or lumpy with a starchy flavor and increase in thickness over time (Cichero, 2013; Lotong et al., 2003; Matta et al., 2006). Gum-based thickeners have been reported to feel sticky or slimy, but they tend to keep a more consistent thickness over time (Lotong et al., 2003; Matta et al., 2006).

The consensus among previous research is that thickened liquids are disliked by patients and vary by thickener type, thickness level, and liquid being thickened. A goal of this study was to determine how texture, flavor, and taste attributes differ for specific beverages to understand which attributes may play a role in patient acceptance of the products. Understanding the sensory experiences of patients is critical to improve the palatability of thickened liquids and increase patient compliance. This was determined through a survey administered to clinicians who work with dysphagia patients to provide the experiences of their patients and challenges the clinicians have experienced with thickening the products.

2.2 Methods

2.2.1 Overview

We recruited clinicians who work with individuals diagnosed with dysphagia in the United States. Eligible participants completed an online survey which focuses on common complaints of thickened liquids reported by their patients. The survey did not ask any questions related to different thickness levels or about other diet modifications dysphagic patients may consume. The complaints were specific to sensory-related sensations including texture, flavor, taste, and appearance. Other questions related to patient compliance, main concerns for the patients they treat, and areas for improvement of thickened liquids were asked. Additionally, clinicians who prepare thickened liquids for their patients were asked questions related to challenges with thickening certain types of beverages. The aim of the study was to understand which attributes of different beverages can affect acceptance of thickened liquids and to understand areas for improvement to increase palatability.

2.2.2 Clinicians

The survey was targeted for clinicians who work with individuals with dysphagia with recruitment efforts focused on speech-language pathologists. Speech-language pathologists are a primary member of a multidisciplinary team of swallowing specialists who perform swallowing examinations, help increase safety, and recommend diet modification. Before beginning the survey, participants were directed to the screening questionnaire. Participants were eligible to take the survey if they (1) were 18 years or older, (2) work in the United States, and (3) work with dysphagia patients. Additionally, questions about the participants' degree and profession were asked. After the screening questionnaire, participants were directed to an informed consent form and decided if they would like to participate in the survey. Participation in the survey was voluntary and anonymous. All participants were eligible to submit an entry for a raffle drawing as means of compensation. All study protocols received approval from the University of Massachusetts Institutional Review Board. All data was collected using Compusense Cloud (Guelph, ONT).

2.2.3 Questionnaire

The questions for the survey were determined based on prior literature regarding dislike of sensory properties of thickened liquids and challenges with thickening liquids. There were two main goals of the survey: 1) identify sensory-related complaints of thickened liquids and 2) identify challenges with thickening various beverage types (e.g., dairy, soda, coffee) and beverage properties (e.g., temperature, carbonation). The survey was designed to collect information pertaining to patient complaints for texture, flavor/taste perception, thickening issues and clinicians' thoughts on how thickened liquids can be improved. Here we summarize the questions presented to the clinicians with a full list of the survey questions available in the Appendix**.**

First, clinicians were asked a variety of demographic questions (e.g., age, ethnicity, sex, state) along with profession and types of patients they care for. Additionally, they were asked which dysphagia guidelines (i.e., IDDSI or NDD) they followed, barriers for implementing IDDSI, and main concerns of the patients they treat. If the clinician indicated they prepare thickened liquids for their patients, they were asked a series of free-response questions to describe any challenges they experience with thickening dairy, carbonated, and hot beverages. Next, all participants were asked to select the top 3 thickened liquids their patients most complain about from a given list of 9 common liquids (see Table 2.1). Fruit juice, tomato juice, tea, and broth were chosen by less than 20% of the clinicians and will not be discussed in the paper.

Table 2.1 Thickened liquid options

Milk
Water
Fruit Juice
Tomato Juice
Soda
Coffee
Tea
Broth
Oral Nutritional Supplements (ONS)

For each beverage selected, clinicians were then asked to choose a maximum of 3 attributes from a list of sensory descriptors. They could write in answers if the descriptors did not accurately portray their patients' experiences. The list of sensory descriptors for clinicians to choose from for each beverage were chosen by the researchers based on prior literature about sensory perception of thickened liquids or based on the natural sensory properties of the unthickened version of the beverage. Since each beverage has unique taste and flavor properties, different descriptors were chosen by the researchers for some beverages. Common descriptors among beverages were used when possible and are included in Table 2.2. Water did not have options related to flavor or sweetness. Coffee had the option of “more bitter” or “less bitter” as opposed to the option “bitter". The participants were not trained on the descriptors used for each beverage, and they could use their own interpretation for understanding each descriptor. The researchers considered “not smooth/chunky” to be a mixture of texture and appearance. “Not the same” was included for instances where patients may not comment on a specific attribute, or the beverage does not meet the patient’s expectations in general.

Table 2.2 Descriptors used for each beverage

Less Flavor
No Flavor
Texture
Not the same
Appearance
Not smooth/chunky
Less sweet
Too sweet
Not sweet
Bitter
Starchy
Metallic
Astringent
Off-flavors
Other (please specify)

Lastly, the survey included questions related to patient compliance and concerns clinicians had regarding thickened liquids. For example, there is often a concern regarding hydration and consumption of liquids. Therefore, clinicians were asked if they recommended the Frazier Free Water Protocol to eligible patients, what percentage of patients complain of their thirst not being quenched, and if they thought their patients drink an adequate amount of water per day. Frazier Free Water Protocol allows patients to drink unthickened water under specified conditions with the goal to decrease the risk of dehydration (*Frazier Free Water Protocol*, 2013). As a follow up, clinicians reported what they thought was the top reason for patients not drinking an adequate amount of water per day. Regarding compliance with prescribed thickened liquid diet, clinicians were asked to report the percentage of patients that are not compliant with their dysphagia diet recommendations and what they thought was their top reason for patient non-compliance. Clinicians were then asked if they thought they had adequate information to help dysphagic patients develop a diet that is most enjoyable for them and to describe any resources they use or would be helpful. Finally, the clinicians supplied their opinion on the areas, attributes, or qualities of thickened beverages that they believe need the most improvement related to flavor or mouthfeel of thickened liquids.

2.3 Results

2.3.1 Clinician Characteristics

A total of 83 clinicians spanning 28 states completed the survey. Speech-language pathologists were the primary participants (96%) along with 2 dieticians and 1 physician. Additionally, 94% of the clinicians have worked with dysphagia patients for longer than 1 year with 65% of the clinicians working with dysphagia patients for longer than 5 years. Most of the clinicians (93%) work with adult, geriatric, or a blend of adult/geriatric patients. All but 5 of the clinicians served beverages to their patients while 83% prepared beverages. IDDSI guidelines were followed by 48% of the clinician's while NDD was followed by 46% of the clinicians.

2.3.2 Thickened Beverage Complaints

From a list of 9 beverages, clinicians selected the top 3 beverages that their patients most complained about when thickened. Of the 9 beverages, 5 beverages were selected by 20% or more of clinicians. The remaining 4 beverages (tea, fruit juice, broth, tomato juice) were selected by less than 20% of the clinicians and will not be included in the analysis. The results of the most complained about thickened liquids are shown in Table 2.3. Coffee, water, soda, milk, and oral nutritional supplements (ONS) are the most complained about thickened liquids, respectively.

Table 2.3 The number of times a beverage was selected as top 3 most complained about

Beverage	# of Clinicians Selecting Beverage (%)
Coffee	72 (87%)
Water	68 (82%)
Soda	45 (54%)
Milk	29 (35%)
ONS	18 (22%)
Tea	7 (8%)
Fruit Juice	6 (7%)
Broth	3 (4%)

The results for the attributes most often complained about for each beverage selected by the clinicians are shown in Figure 2.1**.** Texture was a major complaint for each beverage. It was the most frequently selected complaint for each beverage besides soda where “not the same” was selected slightly more times than texture. The texture of thickened milk appears to be marginally more of a problem than the texture of other beverages. Texture was chosen as a complaint for thickened milk by 82.8% of the clinicians who selected milk, while thickened water, the second most complained about texture, was chosen by 76.5% of the clinicians who selected water. Milk also received the highest number of complaints on appearance with 41.4% of clinicians who chose milk. Oral nutritional supplements have the highest number of complaints for chunkiness with 44.4% of clinicians who chose ONS noting it as a common complaint. Off-flavors were most commonly reported in water. Around 51% of the clinicians who chose water thought off-flavors were often complained about while coffee, the second most complained about beverage for off-flavors, was only selected by 23.6% clinicians who selected coffee. “Not the same” was commonly chosen for each beverage with soda, water, and coffee being chosen most often, respectively. “Other” was chosen 22.2% of the time for soda, 16.7% of the time for oral nutritional supplements, and 13.8% of the time for milk. The “other” comments for milk included warm temperature, not mixing well with coffee, grainy when using powder, and slimy. For soda, all comments were related to reduced carbonation and all comments for oral nutritional supplements mentioned challenges with properly thickening.

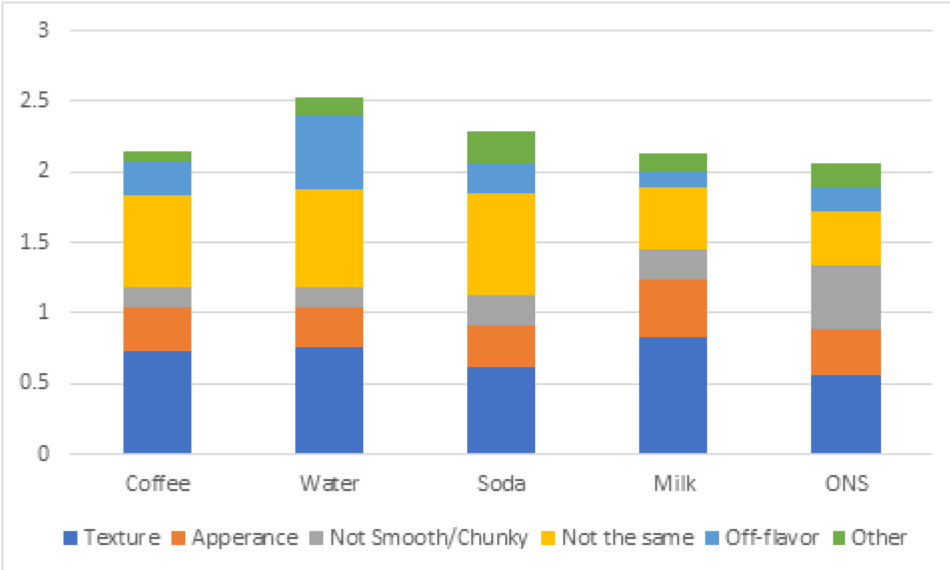

Figure 2.1 Proportion of times an attribute was chosen as top 3 most complained about per number of times a beverage was chosen

The percent of clinicians who chose complaints related to flavor and taste for each beverage are shown in Table 2.4. **"**Less flavor" and "no flavor" are calculated together under the assumption that clinicians would only choose one of the options for each beverage. The same assumption was followed for "less sweet", "not sweet", "too sweet", "more bitter", and "less bitter". For coffee, 10% considered coffee to have less flavor while 2% chose no flavor. Interestingly, 11% considered thickened coffee to be more bitter while 1.5% chose less bitter. Regarding the flavor of thickened soda, 13% chose less flavor while 4% chose no flavor. Only less sweet was chosen as a complaint about the sweetness of soda. Less flavor and not sweet was chosen for all responses about the flavor and sweetness of thickened milk. No flavor and too sweet was chosen regarding the flavor and sweetness of oral nutritional supplements.

Flavor and starchiness are top complaints across all beverages. Soda and coffee had the most reported complaints for a reduction in flavor. However, complaints about flavor were noted for each beverage. Bitter, starchy, and metallic sensations were reported as complaints in thickened water.

Table 2.4 Percent of times a flavor or taste attribute was chosen as top 3 most complained about per number of times a beverage was chosen

	Flavor	**Sweet**	**Bitter**	**Starchy**	**Metallic**	**Astringent**
Coffee	12.5	0.0	12.5	8.3	1.4	1.4
Water	-	-	5.9	7.4	2.9	0
Soda	17.8	2.2	0	4.4	0	0
Milk	6.9	3.5	0	6.9	0	0
ONS	5.6	5.6	0	5.6	0	0

2.3.3 Challenges Clinicians Experience with Thickening Liquids

A total of 69 clinicians indicated they prepared thickened liquids for dysphagic patients and were provided the opportunity to answer free-response questions related to challenges they have experienced when thickening dairy/milk, carbonated, and hot beverages. These beverages were chosen due to the composition and complexity of the liquids. Only clinicians who selected oral nutritional supplements as a top complained about beverage were asked questions related to challenges with thickening.

For challenges with thickening dairy/milk, 55 clinicians provided responses. However, some responses indicated they did not have trouble with thickening milk/dairy products, or their facilities use pre-thickened dairy products. This left a remaining 31 responses related to challenges with thickening milk or dairy. A total of 57 clinicians responded regarding challenges with thickening carbonated beverages with one of the clinicians indicating they do not experience challenges with thickening and 3 clinicians do not attempt to thicken carbonated beverages. For hot beverages, 53 clinicians contributed responses with 14 of the clinicians indicating they do not have problems or had not thickened hot beverages. Eighteen clinicians selected oral nutritional supplements as a top complained about thickened beverage, and 67% of the clinicians indicated they had difficulties thickening them. The clinicians who indicated they experienced challenges with thickening oral nutritional supplements provided responses about their experiences. All questions related to challenges with thickening were asked in free-response form and samples of direct quotes are shown below in Table 2.5**.** The sample quotations chosen represent common responses and supported general themes.

Three general themes for challenges with thickening were identified: thickener type, consistency/texture, and stability. For thickener type, powdered thickeners were generally described to be more problematic compared to gel thickeners for each beverage type. Challenges with consistency/texture varied by beverage type. Milk/dairy products were reported to be clumpy or grainy, especially with powdered thickeners, and the thickened dairy becomes overly thick and forms a paste or pudding-like consistency. For carbonated beverages, clinicians indicated the beverages can become clumpy, too thick with the consistency changing over time, and thickener can deposit on the walls of the cup. Many clinicians reported hot beverages and ONS become clumpy or chunky. Stability also varied depending on beverage type. Milk/dairy takes a long time to thicken with increasing time and different temperatures creating inconsistent results. The major challenge with carbonated beverages was the loss of carbonation and the beverages foaming up/fizzing over the cup with the addition of thickeners. Time is an important factor for hot beverages. Many clinicians indicated the hot beverages will become thicker as the beverage starts to cool and it also takes longer for the beverages to reach the appropriate thickness. These challenges can result in difficulties determining the appropriate amount of thickener to add. Clinicians revealed ONS tend to not thicken or it is difficult to thicken evenly.

Table 2.5 Sample quotations from clinicians when asked to describe challenges with thickening different types of beverages

General Categories of Responses	**Beverage Type**	**Selected Clinicians' Responses**
Thickener Type	Dairy	"In all my work settings I have learned that powdered starch packets are inferior with dairy. Gel does better but over time does not last. Best is individual pre-thickened dairy beverages - can be refrigerated."
	Carbonated	"The biggest issue I have in my hospital is that there is a myth with nursing that carbonated beverages cannot be thickened at all. When trying to thicken carbonated beverages; however, I do notice that I have to keep it to 4 oz at a time due to the bubbles that rise once simply thick Xanthan gum-based thickened is added. The drink then ends up being very frothy (which some patients don't mind) but it definitely does not look like a normal soda. If powdered thickener is added, it is just clumpy."
	Hot	"With powder thickener it is difficult to hit the target consistency it seems to take longer to absorb the water molecules so it's very easy to over thicken. No issues if using gel thickener."
	ONS	"Dietary supplements (boost, ensure) do not thicken with powder thickeners."

Consistency/Texture	Dairy	"I've noticed that some milk/dairy products turn more into a paste - the viscosity is appropriate for IDDSI guidelines, but the texture is stickier. (using simply thick Xanthan gum-based thickener)."
	Carbonated	"I usually utilize 1/2 empty container to compensate for foaming/bubbling up with introduction of a thickener. Thickeners typically deposit on the wall of the cup above the liquid level thus not reaching the targeted thickness level."
	Hot	"Almost always gritty/chunky."
	ONS	"Don't thicken smoothly. Chunky."
Stability	Dairy	"Milk always thickens more than I'd like, it becomes more of a pudding consistency as time progresses in my opinion."
	Carbonated	"They tend to react to the thickener and overflow from the cup. They also lose their carbonation."
	Hot	"They appear too thin and need to add more thickener. This is an issue once the beverage cools."
	ONS	"Depending on the type of thickener and type of ONS - many factors may be affected: initial texture, how long the modified texture lasts, taste, uniformity."

2.3.4 Information To Develop Enjoyable Diets And Areas for Improvement

When the clinicians were asked "Do you think you have adequate information to help dysphagia patients develop a diet that is most enjoyable for them?", 79% of clinicians indicated they did. For the clinicians that answered "yes", they were then asked to freely respond to the questions "How do you get information to help patients with dysphagia develop a diet that is most enjoyable for them?" and "What information is provided?". A total of 84% of the clinicians provided answers. Clinicians generally stated they search the Internet for resources or ideas from other speech-language pathologists, tailor diets specific to their patients' preferences and lifestyle, use handouts and in person education, and involve the patients' family in the process. One clinician stated:

> *I get info everywhere: ASHA, conventions, seminars, webcasts, podcasts, networking, social media, friends, patients and their families, dieticians, doctors, etc. I get info about products, prep methods, food items, $$ sales, mixers/blenders, strategies, counseling, etc.*

For clinicians who answered "no" to the question, they were asked "Why do you think you do not have adequate information to help patients with dysphagia develop a diet that is most enjoyable for them?" and "What type of information would be helpful?". Clinicians stated concerns with unfamiliarity with local cuisine, cultural aspects of diet preferences, and food insecurity in rural areas. Clinicians also shared there are not enough resources regarding thickening agents, flavor profiles, recipes/cookbooks, naturally thickened options that fall into IDDSI guidelines, and ways to optimize nutrition.

Lastly, clinicians were asked the following two questions "What area/attributes/qualities of thickened beverages do you think need the most improvement?" and "Do you have any other comments about the flavor or mouthfeel of thickened beverages?". The most common answers referring to areas of improvement are adequately discussed in the previous results and include smoother texture/appearance, stability of consistency over time and temperature, more pre-thickened options, flavor/taste, and cost. Table 2.6 highlights some quotations from clinicians about flavor and mouthfeel of thickened beverages.

Table 2.6 Sample quotations from clinicians when asked "Do you have any other comments about the flavor or mouthfeel of thickened beverages?"

Selected Clinicians' Responses
"Some thickeners still feel 'gritty'. Use of thickeners is very psychological to the [patient]. Some just can't get past the texture changes in their minds (especially with water) despite understanding the need/purpose for it. We can't use Frazier Water protocol in my acute care hospital for various reasons, but I do see the need for it when appropriate. I have also had [patient's] tell me that use of thickeners makes them feel full faster and therefore they don't want to eat or drink as much. It's also a lot of work for people to eat/drink when they are ill, so use of thickeners is 'work' for them and their swallowing endurance is low."
"Sometimes it feels like the thickened drinks are coating your mouth which is discouraging for patients. This can also cause gagging or sensitivity for patients with texture issues."
"Flavor absolutely changes despite companies saying it does not. Powder thickener has the tendency to be granular."
"They have reduced flavor and feel sticky."
"When I try thickened liquids myself, I find it more difficult to overcome the association and expectation I have with the given beverage in the unthickened form; therefore, it is difficult to accept the thickened form. I think this association is the biggest deterrent for our patients in accepting the thickened liquids."
"I do not feel they adequately quench thirst and they can make you feel more full and decrease hunger."

2.3.5 Concerns and Compliance of Dysphagic Patients

The clinicians were asked to select their top three concerns for the dysphagic patients they treat related to their health and well-being from a given list. The top three concerns were quality of life, dehydration, and aspiration pneumonia. The results are shown in Figure 2.2**.** Questions related to hydration revealed 94% of clinicians did not think their patients drink an adequate amount of water. Clinicians reported their opinion on the top reason for not consuming an adequate amount of water with 46% reporting dislike of thickness while 15% thought the majority of patients disliked the taste. To try to overcome these barriers, 88% of clinicians recommend the Frazier Free Water Protocol to eligible patients. “Other” was a frequent response for not consuming an adequate amount of water with the majority of write-in responses related to not being offered water as often as the clinician would like or caregivers not being accessible to provide assistance. Other reasons mentioned were acute illness, cognitive impairment, not wanting to go to the bathroom, and preference for other beverages. Regarding all thickened liquids, 44% of the clinicians thought less than half of their dysphagic patients are compliant with their diet recommendations with dislike of texture (48%) and taste (20%) being the top two reasons for non-compliance. Lastly, half of the clinicians reported more than 50% of their patients complain of their thirst not being quenched after drinking a thickened beverage.

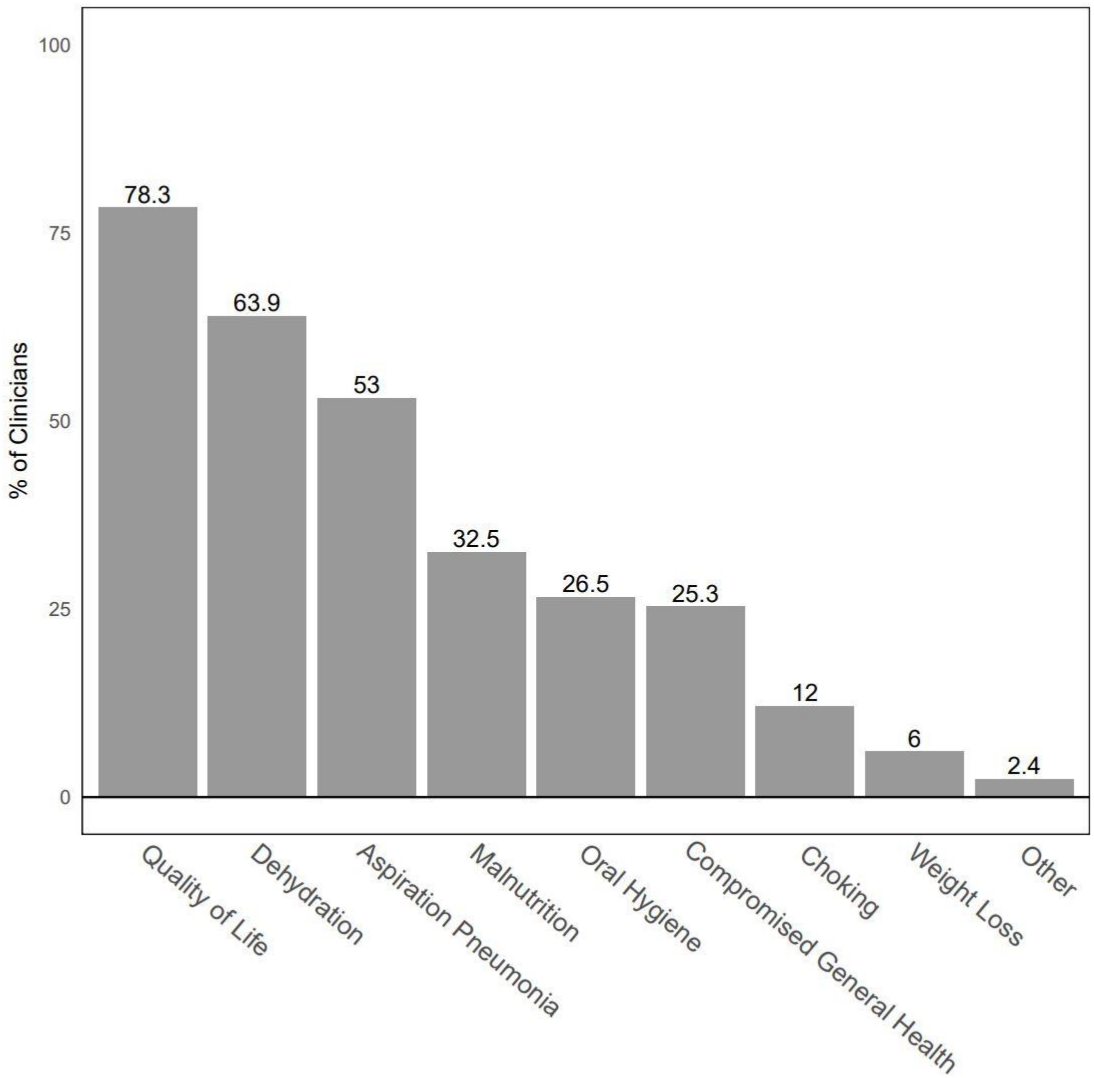

Figure 2.2 Percentage of clinicians choosing a concern as their top 3 main concerns for dysphagic patients

2.4 Discussion

The purpose of this research was to identify sensory characteristics and challenges with thickening liquids that could impact acceptance of specific thickened beverages used in dysphagia management. It is important to understand dysphagic patients' experiences with different types of beverages and challenges that exist for clinicians when thickening these beverages to identify areas for improvement and increase palatability. Increased palatability and enjoyment could help increase compliance rates, decrease dehydration risk, and improve quality of life for dysphagic patients. This survey identified multiple areas which may contribute to the acceptance of thickened liquids such as sensory properties (texture, taste, flavor, appearance) and challenges with thickening liquids which could also result in aversive sensory experiences including chunky or grainy texture and appearance, changes in preferred serving temperature, too thick of a consistency, and loss of carbonation after thickening.

The texture of the products was a common complaint for each beverage. Challenges with thickening could contribute to this. However, as some clinicians stated, it is hard for patients to overcome the association and expectation of the unthickened beverage when it is given in thickened form. Flavor and texture are the most common sensory attributes contributing to food rejection (Pellegrino & Luckett, 2020). Consumers typically do not comment on the texture of food unless they are asked specific questions, or the texture is inappropriate or unexpected (Szczesniak, 2002). Additionally, mechanical features of food make up the majority of texture aversions with viscosity as a leading cause encompassing terms such as slimy and mushy (Pellegrino & Luckett, 2020). Oral nutritional supplements with a lower thickness level have shown to increase intake in healthy adults (den Boer et al., 2019). As noted by some clinicians in this survey, thickened beverages can also affect satiety thus also impacting their intake. Humans are sensitive to small changes in viscosity which also plays a role in perceived satiation (Pellegrino et al., 2019).

Milk and oral nutritional supplements received the highest proportion of appearance complaints. These results could be affected by the smoothness of the drink or inconsistencies in maintaining an appropriate thickness. Prior research has shown that Yakult (liquid yogurt) and soymilk thickened with xanthan-gum based thickener scored highest in "particles" when compared to other beverages (Kim et al., 2017). "Particles" was visually analyzed by panelists and defined as the amount of small particles which do not dissolve. Interfering particles, such as protein, could affect the ability for thickeners to dissolve in these products (Kim et al., 2017). Additionally, the protein and fat in milk can increase the final viscosity and the mineral content can slow down the speed of the thickening process (Hadde et al., 2015; Hadde et al., 2014). Clinicians in this survey also noted they experience challenges with maintaining an appropriate consistency and experience clumping for dairy and oral nutritional supplements. These results highlight a need for thickening agents that create a more consistent texture and consistency.

Off-flavors were reported for all beverages with water receiving considerably higher complaints than other beverages. Considering water is relatively flavorless, these results indicate adding the thickeners introduces off-flavors. Starchiness was commonly reported in each beverage and is likely more of a problem when starch-based thickeners are used but starchy flavor has also shown to increase with increasing amounts of a xanthan-gum based thickener in various beverages likely due to a high amount of dextrin in the thickener used (Kim et al., 2017; Matta et al., 2006). Interestingly, increased bitterness was a common complaint in thickened coffee. One study identified differences in taste depending on thickener type in hot beverages but there were not significant differences in cold beverages indicating there could be a relationship between temperature and taste that affects acceptance of thickened liquids (Horwarth et al., 2005). Further research on temperature and taste of thickened liquids is needed. Considering bitterness was reported in water, the taste of the thickeners alone could account for the increased complaints of bitterness in coffee although bitterness was only reported as a common complaint for coffee and water. Since this survey is recalling patients' experiences in general from the perspective of clinicians, more detailed sensory evaluation studies are required to better understand specific changes in taste and flavor in more complex beverages.

A reduction in sweetness and flavor have commonly been reported for thickened solutions (Cook et al., 2002, 2003; Hollowood et al., 2002; Kim et al., 2017; Matta et al., 2006). The effect on taste or flavor intensity depends on thickening agent and concentration (Cook et al., 2002; Ferry et al., 2006). It is thought that the nature and concentration of the thickener affects tastant release and diffusibility (Braud & Boucher, 2020). The food matrix also plays a role in taste perception. Wagoner et al. (2019) found solutions containing sucrose, protein, fat, lactose, and varying amounts of carboxymethyl cellulose significantly increased perceived sweetness with viscosity. However, this increase may not be detectable in most cases. The relationships between thickeners, viscosity, and taste/flavor pose a significant challenge in improving the acceptability of thickened beverages.

As previously discussed, results from this survey align with previous research on thickening dairy products. Our results also align with research regarding thickening products with different temperatures. Clinicians shared struggles of reaching and maintaining appropriate consistencies with changing temperatures. Prior research has shown differences in viscosity based on temperature (Payne et al., 2012). The survey also revealed challenges with thickening carbonated beverages which is a topic that has been minimally studied. Improvements in maintaining the carbonation in soda products are necessary to increase patient enjoyment. Furthermore, clinicians noted challenges with clumping and maintaining appropriate consistencies for all thickened liquid products asked about in the survey. Patients have indicated an inappropriately thickened liquid contributes to their lack of compliance in consumption (Rosenvinge & Starke, 2005). Additionally, foods that are stringy, gummy, or slimy or contain unexpected lumps are rejected (Szczesniak, 2002). Irrelevant of sensory acceptance, too thick of liquids can be hazardous to patients with dysphagia because they can promote the accumulation of pharyngeal residue (Cichero et al., 2017). Clinicians indicated they were interested in more pre-thickened options due to better stability with time and temperature. More pre-thickened options may be necessary to improve consumer acceptance. However, it is important to consider the cost of these products for patients.

2.5 Conclusion

Texture and flavor have repeatedly been deterrents for acceptance of thickened beverages. This research highlights complaints of specific attributes in different thickened beverages that are viewed by clinicians to be disliked by dysphagic patients. Decreases in flavor and an introduction of “starchy” flavor were reported for each beverage. Additionally, drastic changes in texture are difficult for dysphagic patients to accept. Clinicians also experience significant challenges with thickening different types of beverages which may affect the texture and appearance properties of beverages. Improvements in the stability and dissolving properties of thickeners among different beverages could help overcome these challenges and improve the sensory experiences for patients. Interdisciplinary research in the field of food science including rheology, tribology, colloidal science, and sensory science is needed to overcome flavor and texture challenges in thickened liquids. Improvements in the palatability of thickened liquids could increase enjoyment and compliance of thickened liquid diets which could help decrease the risk of dehydration and improve the quality of life for patients.

CHAPTER 3

FUTURE RESEARCH

The current study shows numerous factors that contribute to the sensory acceptance of thickened liquids, and more research in various scientific disciplines will be required to increase the acceptability among dysphagia patients. The research from this survey focused on individual beverages rather than thickener type and thickness level. While the survey was not targeted towards dysphagic patients, by surveying clinicians a broader understanding of necessary improvements is provided.

New advances in the field of food science could help improve the flavor and textural properties of thickened beverages. Aguilera & Park (2016) highlights emerging structuring microtechnologies that could be used to improve texture and nutrition of texture modified foods and liquids. The review highlights microgels as a technological potential to thicken liquids. A different review by McClements (2017) highlights how microgel suspensions can be formed in solutions to achieve desired texture and rheological properties. The biopolymer microgels can be used to encapsulate, protect, or release bioactive agents such as flavors, vitamins, nutraceuticals, proteins, and lipids (McClements, 2017). Microgel particles of different sizes and compositions have been able to control the release of taste and aroma molecules under physiological conditions in the mouth (Malone et al., 2003; Mark E. Malone & Appelqvist, 2003). A recent paper by Galaniha et al. (2020) suggests ways to improve the flavor, nutrition, and viscosity properties of oral nutritional supplements for cancer patients through relevant food design approaches. The considerations discussed in this paper would also be important for other thickened beverages used in clinical and elderly populations

Additionally, more sensory evaluation studies need to be completed which better control for individual variables at levels recommended by IDDSI. Considering any type of liquid can be thickened for dysphagia diets, understanding how individual ingredients affect taste and flavor when combined with different types of thickeners is necessary to create optimal sensory acceptance. For example, more research on how different thickener types, thickness levels, and non-nutritive sweeteners interact would be necessary to increase enjoyment for dysphagic patients who may have other dietary restrictions from health conditions such as diabetes. Considering results for sweetness and flavor perception have varied across thickener type, thickness level, and beverage type, there is also a need for more sensory studies which utilize diverse evaluation techniques when beverages are thickened following IDDSI guidelines as most studies have used descriptive analysis with trained panelists.

Furthermore, more research on preferences for different clinical populations and how they perceive thickened beverages is needed. For example, Baert et al. (2021) had Parkinson's disease patients and healthy control participants complete a series of paired comparison analyses. Both groups found starch-based thickened soups to have more intense taste and aroma than gum-based thickened soups. However, a descriptive analysis panel for the same study determined potato starch thickened soup to have a lower intensity of "general taste" than xanthan-gum thickened soups. Patients' voices, experiences, and preferences are essential in new product development for these products and should be studied for each type of thickened beverage.

Lastly, Nishinari et al. (2016) reviews the importance of understanding rheological properties related to swallowing of texture modified foods. A better understanding of rheological properties would not only allow for safer swallowing but also better design of thickened liquids for dysphagia patients with favored texture and taste/flavor interactions. One important key for designing texture and optimizing bolus rheology is understanding dynamic food structure changes during oral processing. Tribology is a relatively new discipline contributing to understanding food oral processing, texture, and mouthfeel because it incorporates rheological properties and surface properties of the interacting substrates in relative motion involving the study of oral friction, lubrication, and wear (Chen & Stokes, 2012). Texture, taste, and flavor can all vary significantly from the beginning of the eating process until after the swallow because of changing physical and chemical properties. Chen & Stokes (2012) review the difference between rheology and tribology in texture sensation. Briefly, some properties such as hardness or elasticity are more intensely perceived at the beginning of oral processing when mechanical or rheological properties are important. However, smoothness and slipperiness could be more important towards the later stages of oral processing when surface and lubrication properties are important, and thickness or consistency could depend on both bulk rheology and tribology. This highlights why simple rheology tests cannot satisfactorily be used to understand texture perception of fluids and semi-fluid foods. Ultimately, improving texture and understanding texture-taste interactions will require colloidal, sensory, rheological, and tribological involvements to design more effective food structures to increase acceptance.

APPENDIX

CLINICIAN QUESTIONNAIRE

1. Please select your age range.
    a. Drop down list of age ranges
2. Please indicate how you identify your ethnicity.
    a. American Indian or Alaska Native
    b. Asian
    c. Black or African American
    d. Hispanic or Latino
    e. Native Hawaiian or Other Pacific Islander
    f. White
    g. Other (please specify)
3. Please indicate your sex.
    a. Female
    b. Male
    c. Prefer not to say
4. Which state do you work in?
    a. Drop down list of states
5. What is your degree?
    a. Associate's degree (please specify)
    b. Bachelor's degree (please specify)
    c. Master's degree (please specify)
    d. Doctoral degree (please specify)
    e. Other (please specify)
6. What is your profession?
    a. Speech-Language Pathologist
    b. Nurse
    c. Dietician
    d. Occupational therapist
    e. Other (please specify)
7. How long have you been serving in your profession (in years)?
    a. Drop down list of ranges
8. How long have you been treating/providing care to dysphagic patients (in years)?
    a. Drop list of ranges
9. Please select your primary care setting.
    a. In-patient
    b. Out-patient
    c. Acute care

    d. Long-term care
    e. Other (please specify)

10. What group of patients do you most commonly work with?
    a. Adult
    b. Geriatric
    c. Pediatric
    d. Blended (adult/pediatric)
    e. Blended (adult/geriatric)
    f. Other (please specify)
11. Do you serve thickened beverages to patients with dysphagia?
    a. Yes
    b. No
12. Do you prepare thickened beverages to dysphagia patients?
    a. Yes
    b. No
13. {If yes to #12} How do you make sure the beverage is at the appropriate thickness level?
    a. Spoon
    b. Syringe
    c. Fork
    d. Other (please specify)
14. {If yes to #12} What guidelines are you following?
    a. National Dysphagia Diet (NDD)
    b. International Dysphagia Diet Standardization Initiative (IDDSI)
    c. Other (please specify)
15. {If yes to #12} Please describe any challenges you have experienced with thickening milk/dairy products.
    a. Free response question
16. {If yes to #12} Please describe any challenges you have experienced with thickening carbonated beverages.
    a. Free response question
17. {If yes to #12} Please describe any challenges you have experienced with thickening hot beverages.
    a. Free response question
18. {If #14 does not equal IDDSI} Have you heard of the International Dysphagia Diet Standardization Initiative (IDDSI)?
    a. Yes
    b. No
19. {If yes to #18} What do you perceive as barriers to initiating/adopting the IDDSI protocol?
    a. Administrative

b. Training
c. Other (please specify)

20. What are your main concerns for patients you are treating with dysphagia? (pick top 3)
    a. Malnutrition
    b. Dehydration
    c. Aspiration pneumonia
    d. Quality of life
    e. Compromised general health
    f. Choking
    g. Weight loss
    h. Oral hygiene
    i. Other (please specify)
21. What type of beverages do patients complain about most? (pick top 3)
    a. Milk
    b. Water
    c. Fruit juice
    d. Tomato juice
    e. Soda
    f. Coffee
    g. Tea
    h. Broth
    i. Oral Nutritional Supplements (such as Boost or Ensure)

22 – 30. What are the most common complaints about ~beverage selected from question 21~? (asked for each of the three selections)

a. Answer choices varied for each question
b. Refer to Table 2.2

31. {If selected Oral Nutritional Supplements from question #21} Are there any difficulties with preparing thickened oral nutritional supplements?

a. Yes (please describe)

b. No

32. Do you recommend the Frazier free water protocol to eligible patients?

a. Yes

b. No

33. What percentage of patients complain of not having their thirst quenched following drinking a thickened beverage?

a. None

b. 1-25%

c. 26-50%

d. 51-75%

e. 76-100%

34. In your opinion, do the dysphagia patients you treat/care for drink an adequate amount of water per day?

a. Yes

b. No

35. {If no from question #34} What do you think is the top reason for patients not meeting their daily water consumption?

a. Dislike of thickness

b. Dislike the taste

c. Nausea

d. Fear of choking

e. Pain/discomfort while swallowing

f. Decreased appetite

g. Other (please specify)

36. In your opinion, what percentage of patients are compliant with their dysphagia diet recommendations?

a. Unsure

b. 1-25%

c. 26-50%

d. 51-75%

e. 76-100%

37. In your opinion, what is the top reason for patient non-compliance?

a. Ease of mixing

b. Trouble making it at home

c. Social aspect of eating

d. Taste

e. Texture

f. Cost

g. Other (please specify)

38. Do you think you have adequate information to help dysphagia patients develop a diet that is most enjoyable for them?

a. Yes

b. No

39. {If yes to #38} How do you get information to help patients with dysphagia develop a diet that is most enjoyable for them? What information is provided?

a. Free response question

40. {If no to #38} Why do you think you do not have adequate information to help patients with dysphagia develop a diet that is most enjoyable for them? What type of information would be helpful?

a. Free response question

41. What area/attributes/qualities of thickened beverages do you think needs the most improvement?

a. Free response question

42. Do you have any other comments about the flavor or mouthfeel of thickened beverages?

a. Free response question

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