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A Comparative Analysis of Sensory Properties of Thickeners used for Dysphagia Management: Experimental Study

Disfaji Yönetiminde Kullanılan Kıvam Artırıcıların Duyusal Özelliklerinin Karşılaştırılması: Deneysel Çalışma

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ABSTRACT Objective: Dysphagia may lead to complications such as malnutrition, dehydration, and aspiration pneumonia. Liquid thickening is a common management strategy for dysphagia, but, the sensory properties of thickeners may influence patient compliance. This study aims to compare the sensory characteristics of a domestically produced thickener, PraThick, with imported thickeners. **Material and Methods:** Thirty-seven healthy assessors evaluated the liquids prepared with 5 different thickeners (PraThick, ThickenUp Clear, Nutilis Clear, Nutilis Powder, ThickenUp Powder). The samples were prepared according to the manufacturers' instructions and presented in randomized order. Each sample was rated for appearance, odor, taste, and overall acceptability using a 10-point visual analog scale. **Results:** ThickenUp Clear and the domestic product, PraThick, received the highest ratings across all categories, with no significant difference between them ($p>0.05$). For appearance, ThickenUp Clear scored significantly higher than all other products except PraThick, while PraThick received significantly higher scores than Nutilis Powder and ThickenUp Powder ($p<0.05$). In the odor evaluation, ThickenUp Clear achieved significantly higher scores than Nutilis Powder, Nutilis Clear, and ThickenUp Powder ($p<0.05$), while no difference was found between the other products ($p>0.05$). Regarding taste, ThickenUp Clear obtained significantly higher scores than all the other products except PraThick, and PraThick attained significantly higher scores than ThickenUp Powder ($p<0.05$). In terms of overall acceptability, both ThickenUp Clear and PraThick received significantly higher scores than the other 3 products ($p<0.05$). **Conclusion:** Gum-based thickeners exhibited superior sensory properties compared to starch-based thickeners. PraThick demonstrated similar sensory properties to ThickenUp Clear, highlighting its potential as a viable alternative. Considering the effect of sensory properties on patient compliance, it was concluded that these properties should be taken into account in the selection of thickeners.

Keywords: Dysphagia; sensory analysis; thickened liquid; starch based thickener; gum based thickener

ÖZET Amaç: Disfaji, malnütrisyon, dehidrasyon ve aspirasyon pnömonisi gibi komplikasyonlara yol açabilir. Sıvıların kıvamının artırılması, disfaji yönetiminde yaygın bir yaklaşımdır; ancak kıvam artırıcıların duyusal özellikleri, hastaların ürünü kullanmasına olan uyumunu etkileyebilir. Bu çalışma, yerli üretim bir kıvam artırıcı olan PraThick'in duyusal özelliklerini ithal ürünlerle karşılaştırmayı amaçlamaktadır. **Gereç ve Yöntemler:** Otuz yedi sağlıklı değerlendirici, 5 farklı kıvam artırıcı (PraThick, ThickenUp Clear, Nutilis Clear, Nutilis Powder, ThickenUp Powder) ile hazırlanan sıvıları değerlendirmiştir. Örnekler, üretici talimatlarına uygun şekilde hazırlanmış ve rastgele sırayla sunulmuştur. Her örnek, görünüm, koku, tat ve genel kabul edilebilirlik açısından 10 puanlık görsel analog skala kullanılarak puanlanmıştır. **Bulgular:** ThickenUp Clear ve yerli ürün PraThick, tüm kategorilerde en yüksek puanları almış olup, hiçbir parametrede aralarında anlamlı bir fark bulunmamıştır ($p>0,05$). Görünüm açısından ThickenUp Clear, PraThick hariç tüm ürünlerden; PraThick ise Nutilis Powder ve ThickenUp Powder'dan anlamlı olarak yüksek puan almıştır ($p<0,05$). Koku değerlendirmesinde, ThickenUp Clear, Nutilis Powder, Nutilis Clear ve ThickenUp Powder'dan anlamlı derecede daha yüksek puan almıştır ($p<0,05$); diğer ürünler arasında ise anlamlı bir fark görülmemiştir ($p>0,05$). Tat değerlendirmesinde ThickenUp Clear, PraThick hariç tüm ürünlerden ($p<0,05$); PraThick ise ThickenUp Powder'dan anlamlı şekilde yüksek puan almıştır ($p<0,05$). Genel beğeni açısından hem ThickenUp Clear hem de PraThick, diğer 3 üründen anlamlı olarak yüksek puan almıştır ($p<0,05$). **Sonuç:** Sakız bazlı kıvam artırıcılar, nişasta bazlı ürünlere kıyasla daha üstün duyusal özellikler göstermiştir. PraThick, ThickenUp Clear ile benzer duyusal özellikler sergileyerek, uygulanabilir bir yerli alternatif olma potansiyelini ortaya koymuştur. Duyusal özelliklerin hasta uyumu üzerindeki etkisi göz önünde bulundurularak, kıvam artırıcı seçimi yapılırken bu özelliklerin dikkate alınması gerektiği sonucuna varılmıştır.

Anahtar Kelimeler: Disfaji; duyusal analiz; koyulaştırılmış sıvı; nişasta bazlı koyulaştırıcı; sakız bazlı koyulaştırıcı

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Swallowing is a vital function involving the coordinated activity of the central and peripheral nervous systems and muscles. It enables the transport of saliva, liquids and food to the stomach, and any difficulty in this process is defined as a swallowing disorder or dysphagia.[1] Dysphagia may occur at all ages and can result from many causes, including neurological disorders, congenital anomalies, structural problems, head and neck cancer, chronic lung and digestive diseases, and age-related changes even without an underlying condition.[1,2] While the exact prevalence of dysphagia in our country is unknown, existing studies report rates ranging between 7.3-29.6% in the general population, with higher prevalence in conditions such as stroke, Parkinson's disease, traumatic brain injury, and head and neck cancer.[3,4] The prevalence of dysphagia is increasing due to improved survival in serious medical conditions, a growing elderly population, and the rise in diseases that contribute to dysphagia. As a common condition, dysphagia can lead to serious complications such as malnutrition, dehydration, aspiration pneumonia, prolonged hospitalizations, and even death.[4,5] In addition to these physical problems, it also has psychosocial impacts, including social isolation and reduced quality of life for both patients and caregivers.[6] Given the high prevalence and serious complications of dysphagia, early and appropriate interventions are crucial. The main goals are to ensure adequate nutrition and hydration, improve swallowing safety and efficiency, enhance quality of life, and reduce caregiver burden. Interventions vary depending on the underlying cause and severity, and they are typically categorized as compensatory or rehabilitative techniques.[4,7] Rehabilitative techniques aim to improve swallowing function through exercises and stimulation methods, while compensatory techniques focus on swallowing safety through postural adjustments and dietary modifications.[4] A commonly used dietary modification for swallowing safety is the use of thickening liquids, and various thickeners are available commercially and are categorized as starch-based or gum-based (Table 1).[8] These products improve swallowing safety by slowing bolus flow and allowing more time for airway closure before it reaches the entrance.[9] However, while they help maintain orally fluid intake, they may negatively affect sensory qualities such as taste, appearance, and odor which are key factors in user acceptance. These factors may negatively affect both acceptance and adherence to dietary recommendations in individuals with dysphagia.[9-12] Studies indicate that dissatisfaction with the sensory properties of thickeners may lead to reduced fluid intake and refusal to use them.[13]

TABLE 1: Types and properties of commercial thickeners used in dysphagia

Company	Product name	Origin	Starch	Gum	Bulking agent
Kıvampro	PraThick	Türkiye	-	Xanthan gum	Maltodextrin
Nestle	Resource ThickenUp Powder	Germany	Modified corn starch	-	
Precision Food Inc.	Thick It Original	USA	Modified corn starch	-	Maltodextrin
Walgreens	Thick Now	USA	Modified corn starch	-	Maltodextrin
Hormel	Thick & Easy	USA	Modified corn starch	-	Maltodextrin
Nutricia	Nutilis Clear	United Kingdom	-	Xanthan gum, Guar gum	Glucose syrup
Parapharma Tech	Purathick	USA	-	Tara gum	Maltodextrin, Calcium carbonate
Dr.MacLeod's	Quick Thik	Canada	-	Xanthan gum	Maltodextrin, Dextrose, Calcium phosphate
Supercol	Supercol	India	-	Guar gum	
Nestle	ThickenUp Clear	Germany	-	Xanthan gum	Maltodextrin, Potassium chloride
Precision Food Inc.	Thick It Clear Advantage	USA	-	Xanthan gum	Maltodextrin, Ascorbic acid
Hormel	Thick&Easy Clear	USA	-	Xanthan gum, Carrageenan	Maltodextrin, Erythritol
Nutricia	Nutilis Powder	Holland	Modified corn starch	Xanthan gum, Tara gum, Guar gum	Maltodextrin

Therefore, high-quality thickeners with favorable sensory properties that support fluid intake represent an important clinical need.[14]

Existing studies have evaluated the sensory properties of various thickeners in different liquids. Starch-based thickeners tend to alter taste and aroma more noticeably than gum-based ones, often suppressing the original flavor and adding bitter or metallic notes, along with a lumpy texture. In contrast, gum-based thickeners generally have a milder effect on taste but produce a more slippery mouthfeel.[15] (kaynak, 17) Oral processing is a complex and dynamic process that cannot be fully replicated by instrumental methods. Cultural differences also effect sensory perception, making it important to investigate these properties within the Turkish population.[16] However, only one national study has addressed this topic, evaluating 2 imported products solely in terms of taste.[17] Recently, the first and only domestically produced thickener became available. This thickener is significant for meeting the national need in dysphagia management and reducing dependence on imports. However, no study was found on the sensory properties of this domestic thickener. Given that individuals with dysphagia often exhibit sensory impairments (taste, smell) and constitute a heterogeneous population, conducting initial sensory evaluations with healthy and homogeneous participants is essential to minimize variability arising from sensory deficits and to ensure data reliability and consistency.[18] (kaynak, 33). Therefore, this preliminary approach provides a solid foundation for future studies involving patients with dysphagia, who are the primary users of these thickeners. The aim of this study is to compare the sensory properties of domestic and imported thickeners used in dysphagia.

We hypothesize that PraThick, as a gum-based thickener, would exhibit superior sensory properties compared to starch-based thickeners and demonstrate similar sensory properties to other commercial gum-based thickeners.

MATERIAL AND METHODS

This study was conducted at Aydın Adnan Menderes University, Department of Physiotherapy and Rehabilitation in collaboration with Harran University Department of Physiotherapy and Rehabilitation following the Declaration of Helsinki. The study protocol was approved by the non-interventional clinical research ethics committee (date: February 10, 2025; no: E-15189967-050.04-683631) at Aydın Adnan Menderes University Faculty of Health Sciences. The data collection for this experimental study, which employed a complete block (within-subject) sensory evaluation design, was conducted between March 3-28, 2025. The call for participation in the study was announced using billboards at the university. A personal interview was held with each interested individual, explaining the details of the study. Informed written consent was obtained from those who volunteered to participate.

PARTICIPANTS

A total of 37 untrained healthy university students were recruited for this study as assessors.[9] They were deliberately chosen to provide a consumer-oriented perspective, since the aim of the study was to evaluate the sensory properties of thickened liquids under conditions resembling real-life usage. Eligibility criteria included being between 18-65 years of age and having no diagnosis associated with swallowing disorders (neurologic disease, head and neck cancer, etc.). Individuals with any reported food allergies were excluded from participation.

PREPARATION OF THICKENED SAMPLES

The study utilized 5 commercially available powder thickeners, both imported and domestic. Nestle ThickenUp Clear, Nutricia Nutilis Clear, Nutricia Nutilis Powder, and Nestle ThickenUp Powder were used as imported thickeners, and KıvamPRO PraThick was used as a domestic thickener sample. The samples were selected from the product categories with the largest market presence.[10] Given the crucial importance of water intake in the dysphagia diet, the current study utilized water as to assess the sensory attributes of thickened beverages. The samples were prepared to the nectar consistency [International Dysphagia Diet Standardization Initiative (IDDSI) Level 2], by following the recipes and using the provided measuring spoons as specified on the product packaging for each thickener. The products

were allowed to thicken for the time specified in their instructions and were stirred again before serving.

SENSORY TESTS

Sensory Panel and Study Design

A single sensory panel was employed to assess the samples. The primary outcome measures of the study were the sensory evaluation scores for appearance, odor, and taste, while the secondary outcome measure was the overall acceptability score. The study utilized a complete block experimental design, where each participant evaluated a randomly assigned set of 5 thickener samples, which were identified using random 3-digit codes [ThickenUp Clear (593), Nutilis Clear (463), Nutilis Powder (746), ThickenUp Powder (735), PraThick (859)].[9]

Sample Serving Procedure

Each sample, an average of 30 ml, was served to the participants at room temperature together with a plastic spoon in clear plastic cups (Figure 1).[9,16] Plastic cups were employed to facilitate a more precise evaluation of the appearance and to minimize potential odor of paper cups.[10]

Sensory Evaluation Process

The participants recorded their evaluation scores on a special answer sheet using a 10-point visual analog scale. They were asked to rate appearance, odor, taste, and overall acceptability, where 1 indicated "extreme difference" and 10 "no difference" from the reference sample.[15,19] For appearance, the participants assessed samples at eye level to observe color, clarity, or cloudiness.[10] For odor, they performed a sensory evaluation by smelling the samples carefully. For taste assessment, participants compared the flavor of each sample (one spoonful) with water as a reference. For overall acceptability, they also tasted the samples, rinsing their mouths with water between evaluations to avoid carryover effects.[16] Water was selected as the reference sample, and participants were asked to record on an answer sheet how much the other 5 samples differed from the reference sample in their assessment. For all evaluated parameters, higher scores mean better sensory properties.

STATISTICAL ANALYSIS

Effect size (Cohen's f) was determined as 0.63 in the "post hoc" analysis using G*Power version 3.1 using the overall acceptability data of 37 participants. The power of the study was greater than 95% in the power analysis with this effect-size. Statistical analyses were performed using the SPSS software version 25 (SPSS Inc., Chicago, IL, USA). The variables were investigated using graphical (histograms, probability plots) and analytical methods (Shapiro-Wilk test, Skewness and Kurtosis) to determine whether they distributed normally. Visual appearance and overall acceptability variables were normally distributed, while odor and taste variables were not. Friedman tests and repeated measures analysis of variance (ANOVA) were conducted to test whether there is a significant difference between sensory variables. The Wilcoxon test and paired samples t-test were performed to test the significance of pairwise differences using Bonferroni correction to adjust for multiple comparisons (Bonferroni correction for multiple comparisons: 0.05/10=0.005). An overall 5% Type I error level was used to infer statistical significance.

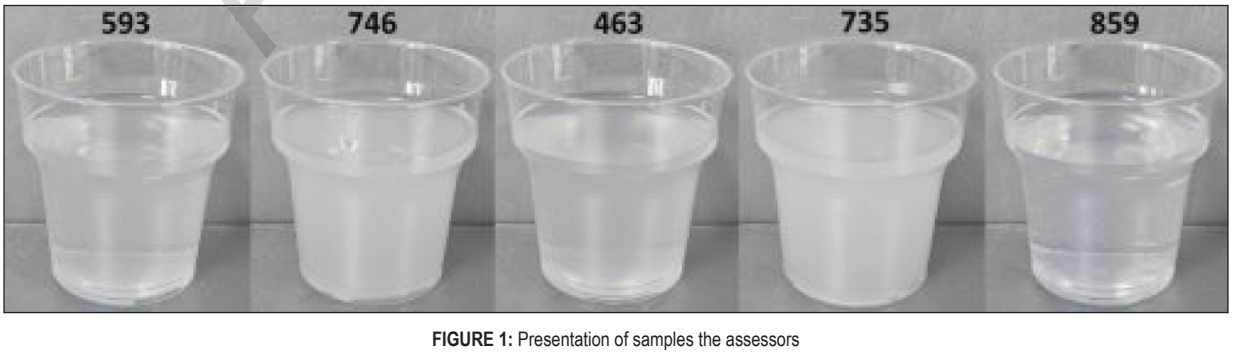

FIGURE 1: Presentation of samples the assessors

TABLE 2: Descriptive statistics of sensory properties

	Visual appearance VAS (n=37) $\bar{X}$±SD (minimum-maximum)	Odor VAS (n=37) $\bar{X}$±SD (minimum-maximum)	Taste VAS (n=37) $\bar{X}$±SD (minimum-maximum)	Overall acceptability VAS (n=37) $\bar{X}$±SD (minimum-maximum)
PraThick	6.76±1.53 (3-10)	8.17±1.48 (1-10)	5.68±2.63 (1-10)	5.25±2.78 (1-10)
ThickenUp Clear	7.08±1.36 (3-10)	8.62±0.99 (4-10)	7.01±1.56 (2-10)	5.56±2.88 (1-10)
Nutilis Clear	6.22±1.36 (4-10)	7.75±1.57 (3-10)	4.91±2.14 (1-8)	3.50±2.29 (2-10)
Nutilis Powder	2.92±2.02 (1-7)	7.34±1.69 (2-10)	4.19±2.06 (1-8)	3.11±2.29 (2-10)
ThickenUp Powder	1.89±2.02 (1-7)	7.03±2.17 (1-10)	3.38±2.55 (1-10)	2.53±1.87 (2-10)

VAS: Visual Analog Scale (1-10); SD: standard deviation

RESULTS

A total of 37 assessors, 22 female and 15 male, with mean age of 22.2±1.08 years participated in this study. The mean and standard deviation values of the visual appearance, odor, taste and overall acceptability scores of the thickeners are given in Table 2. According to the results of repeated measures ANOVA and Friedman tests, significant differences were found between thickeners in the visual appearance, odor, taste, and overall acceptability parameters (Table 3).

The highest scores for appearance were ThickenUp Clear (7.08±1.36) and PraThick (6.76±1.53), respectively (Table 2). The repeated measures ANOVA showed that ThickenUp Clear had significantly higher scores than all other products except PraThick in terms of visual appearance ($p<0.05$). There was no significant difference between PraThick and ThickenUp Clear ($p>0.05$) but PraThick obtained a significantly higher score than Nutilis Powder and ThickenUp Powder ($p<0.05$) (Table 4).

ThickenUp Clear (8.62±0.99) and PraThick (8.17±1.48) received the highest scores for the odor sensory property, respectively (Table 2). In the pairwise comparisons of the odor sensory property, ThickenUp Clear had a significantly higher score than Nutilis Powder, Nutilis Clear, and ThickenUp Powder ($p<0.005$), but there was no significant difference between ThickenUp Clear and PraThick ($p=0.038$, Bonferroni correction, a significance level of $p<0.005$). Also, no significant differences were found among the other thickeners ($p>0.005$) (Table 5).

The highest scores for taste were obtained for ThickenUp Clear (7.01±1.56) and PraThick (5.68±2.63), respectively (Table 2). ThickenUp Clear obtained a significantly higher score than all other products except PraThick in terms of taste ($p<0.005$). There was no significant difference between PraThick and ThickenUp Clear ($p=0.01$, Bonferroni correction, a significance level of $p<0.005$). PraThick achieved a significantly higher taste score compared only to ThickenUp Powder ($p<0.001$; Bonferroni correction, significance level $p<0.005$) (Table 5). All other pairwise comparisons showed no significant differences ($p>0.005$) (Table 5).

ThickenUp Clear (5.56±2.88) received the highest overall acceptability score, followed by PraThick

TABLE 3: Comparison of thickeners based on sensory properties

	Mean square	F	Partial eta squared	x^2	p value*
Visual appearance	211.67	127.37	0.78	-	<0.001[a]
Odor	-	-	-	47,275	<0.001[b]
Taste	-	-	-	58,968	<0.001[b]
Overall acceptability	64.7	13.68	0.28	-	<0.001[a]

*$p<0.05$; [a]Repeated measures analysis of variance; [b]Friedman test

TABLE 4: Pairwise comparisons using repeated measures ANOVA

Product 1-2	Visual appearance difference	p value*	Overall acceptability difference	p value*
ThickenUp Clear-Nutilis Powder	-4.16	**<0.001**	2.44	**0.001**
ThickenUp Clear-Nutilis Clear	-0.86	**0.010**	2.05	**0.004**
ThickenUp Clear-ThickenUp Powder	-5.18	**<0.001**	3.02	**<0.001**
ThickenUp Clear-PraThick	-0.32	1	0.3	1
Nutilis Powder-Nutilis Clear	3.29	**<0.001**	-0.38	1
Nutilis Powder-ThickenUp Powder	-1.02	**0.010**	0.58	1
Nutilis Powder-PraThick	3.83	**<0.001**	-2.13	**0.003**
Nutilis Clear-ThickenUp Powder	-4.32	**<0.001**	0.972	0.240
Nutilis Clear-PraThick	0.54	0.760	-1.75	**0.001**
ThickenUp Powder-PraThick	4.86	**<0.001**	-2.72	**<0.001**

*p-values are Bonferroni-adjusted; a significance level of p<0.05; ANOVA: Analysis of variance

TABLE 5: Wilcoxon signed-rank test statistics for paired comparisons

Product 1-2	Odor z value	Odor r value	Odor p value*	Taste z value	Taste r value	Taste p value*
Nutilis Powder-ThickenUp Clear	-4.191	0.68	<0.001	-5.289	0.86	**<0.001**
Nutilis Clear-ThickenUp	-4.087	0.67	<0.001	-4.020	0.66	**<0.001**
ThickenUp Powder-ThickenUp Clear	-4.228	0.69	<0.001	-4.762	0.78	**<0.001**
PraThick-ThickenUp Clear	-2.076	0.34	0.038	-2.592	0.42	0,010
Nutilis Clear-Nutilis Powder	-1.821	0.29	0.069	-1.821	0.29	0.069
ThickenUp Powder-Nutilis Powder	-1.259	0.20	0.208	-2.141	0.35	0.032
PraThick-Nutilis Powder	-2.838	0.46	0.005	-2.297	0.37	0.022
ThickenUp Powder-Nutilis Clear	-2.573	0.42	0.010	-3.404	0.55	**0.001**
PraThick-Nutilis Clear	-1.634	0.26	0.102	-1.443	0.23	0.149
PraThick-ThickenUp Powder	-3.273	0.53	0.001	-3.954	0.65	**<0.001**

*With Bonferroni correction; a significance level of p<0.005; r: Effect size

(5.25±2.78) (Table 2). Both PraThick and ThickenUp had significantly higher scores compared to other three thickeners (Nutilis Clear, Nutilis Powder, ThickenUp Powder) in terms of overall acceptability ($p<0.05$). However, there was no significant difference between PraThick and ThickenUp Clear, and no significant difference between Nutilis Clear, Nutilis Powder, and ThickenUp Powder in terms of overall acceptability ($p>0.05$) (Table 4).

DISCUSSION

This is the first study to evaluate and compare PraThick, the only domestically produced thickener used in dysphagia management, with other commercially available thickeners in terms of sensory properties (appearance, odor, taste, and overall acceptability). The present study demonstrated that there were significant differences among the thickeners across all sensory parameters. In all sensory properties, ThickenUp Clear and PraThick obtained the highest scores, respectively. In addition, it was found that ThickenUp Clear and PraThick showed similar sensory scores across all parameters.

Visual characteristics, which determine the first impression in sensory evaluation, are very important in dysphagia management as they directly affect the likelihood of patients accepting the thickener.[20] In our study, gum-based thickeners (PraThick, ThickenUp Clear, Nutilis Clear) were found to have a better appearance compared to starch-based products (Nutilis Powder and ThickenUp Powder). In the study by Ong et al., which examined the sensory properties of thickeners, the starch-based product ThickenUp Powder was described as "cloudy" and "grainy".[9] Addi-

tionally, it has been reported in the literature that xanthan gum-based products are transparent, shiny, and clear, whereas starch-based products tend to be lumpy (lumpiness), cloudy, matte, and opaque.[9,15] In this context, the findings of our study regarding the appearance parameter are consistent with the literature. It has also been stated that the lumpy texture of starch-based products, due to their granular structure at the microscopic level, negatively affects the perception of appearance and texture.[21] The potential of gum-based products to achieve the desired consistency without creating cloudiness or opacity provides a significant visual advantage (color, brightness, lumpiness, etc.) in the liquids they are used in. Xanthan gum and Carboxymethyl Cellulose, as hydrophilic gums, have been reported to form clear, transparent, and light-transmitting structures, which contribute to a higher visual acceptability.[22] The fact that PraThick has a similar visual profile to ThickenUp Clear suggests that the gum-based structure in its formulation may have contributed to its clarity.

In the odor parameter, both starch-based and gum-based products were found to have high scores. When the thickening agents were compared, ThickenUp Clear was rated significantly higher than all other products except PraThick. In our study, ThickenUp Clear was the most positively evaluated product in terms of odor, while no significant differences were found among the other products. Odor is a critical sensory parameter that influences the initial perception of the product among individuals with dysphagia. It has been reported that gum-based components such as xanthan gum form transparent, odorless, and neutral solutions, minimizing the impact on odor perception.[14] In the study conducted by Bylaite et al., it was indicated that hydrogel structures like xanthan gum suppress the release of volatile aroma compounds, thereby reducing odor perception.[23] This can be considered as one of the factors that increase the preferability of gum-based formulations. It has been reported that starch-based products contain off-flavor components (bitter, metallic, astringent, etc.), and this negatively affects both taste and odor perception.[15] The interaction of the components in starch-based products with aroma molecules can lead to the emergence of undesirable olfactory characteristics. The fact that ThickenUp Clear has a better odor profile than other gum-based products, can be explained by differences in formulation. Previous studies have reported that products containing different types of gums exhibit variability in odor and taste perception.[10,24] This can be attributed to the formulation of ThickenUp Clear (xanthan+maltodextrin), which results in a lower olfactory load compared to other gum-based products.

In terms of taste, gum-based products scored higher than starch-based products, but gum-based products were also found to negatively affect taste to varying degrees. In the present study, ThickenUp Clear had more favorable taste scores compared to other products. Although there was no statistically significant difference in taste between ThickenUp Clear and PraThick, this difference can be interpreted as clinically significant. When the literature is considered, it is seen that our current study results are consistent with the results of previous studies. Baixauli et al. also reported that gum-based products were more neutral in terms of taste, whereas starch-based products were characterized by negative qualities such as pronounced starch aroma, astringent taste and persistent aftertaste.[21] Similarly, Ong et al. compared xanthan gum- and cornstarch-based thickeners within the IDDSI framework. In their study, cornstarch-based samples were characterized by attributes such as “grainy”, “chalky”, and “bitter”, while xanthan gum-based samples were more frequently described as “sweet”, “slippery”, and “clear”. This can explain why in our study starch-based products were rated significantly lower in taste compared to gum-based ones, and why gum-based formulations such as PraThick and ThickenUp Clear achieved higher acceptability in terms of taste.[9] This difference can be explained by the fact that starch-based thickeners tend to leave a “starchy” taste in the mouth and are broken down by salivary amylase, leading to changes in structure that negatively affect taste and aroma perception.[15,25,26] Conversely, the better taste profiles of PraThick and ThickenUp Clear can be attributed to their gum-based compositions, which form more stable structures with salivary enzymes and present a more neutral taste profile.[27] Although Nutilis Clear is a gum-based product, it did not show a significant su-

periority in taste compared to Nutilis Powder in our study. This may be associated with the presence of flavor additives or specific gum combinations that could negatively impact taste perception.[28]

In terms of overall acceptability, gum-based products were found to be superior to starch-based products, with ThickenUp Clear and PraThick receiving higher preference scores compared to the other products. However, it is noteworthy that despite the higher scores of gum-based products in terms of appearance, taste, and odor, their overall acceptability was relatively lower. Overall acceptability is one of the key outcomes that reflects the combined effect of all sensory parameters and determines the practical usability of the product.[16] Ong et al. emphasized that taste, texture, appearance, and particularly "after-feel" are the main factors influencing overall acceptability.[9] One study demonstrated that gum-based thickeners with higher shear-thinning properties are associated with lower mouthcoating and stickiness, which can make them perceived as less disturbing and easier to drink by consumers.[29] This finding supports the higher overall acceptability scores of ThickenUp Clear and PraThick in our study. Additionally, it has been reported that xanthan gum-based products are more readily accepted by individuals with dysphagia due to their stable viscosity and more balanced sensory profiles in terms of aroma and texture.[21,27,30] In contrast, starch-based products tend to negatively impact overall acceptability due to sensory issues such as mouth stickiness, grainy texture, and residue formation.[31] Martínez et al. reported that healthy assessors found gum-based products smoother, more homogeneous, and easier to swallow, while starch-based products were perceived as sticky and leaving residues in the mouth.[16] Furthermore, it was stated that the ability of gum-based thickeners to maintain their viscosity upon contact with saliva contributed to their stability and made them more favorable for consumption.[32] These sensory characteristics can influence how products are perceived by consumers and, indirectly, determine their overall acceptability. The positive evaluation of PraThick, ThickenUp Clear, and Nutilis Clear can be attributed to the advantageous sensory profiles provided by their gum-based formulations. In a study conducted by Kim et al., it was indicated that the viscosity level of gum-based thickeners played a decisive role in sensory acceptance. In particular, the study showed that medium-viscosity xanthan gum solutions were evaluated most positively in terms of taste, odor, and overall acceptability.[10] The similar high acceptability observed for PraThick and ThickenUp Clear in our study suggests that these products may have well-balanced formulations in terms of sensory properties.

Although Nutilis Clear is classified as a gum-based thickener, in our study it did not show a clear superiority over Nutilis Powder in terms of the taste parameter but rather exhibited an "intermediate" sensory profile. This may be related to the formulation differences between the 2 products. Nutilis Clear contains xanthan gum, guar gum, and glucose syrup, while Nutilis Powder is based on modified corn starch and also contains xanthan gum, tara gum, guar gum, and maltodextrin (Table 1). The literature reports that gum-based components provide clarity, neutral odor, and higher stability, while starch-based products negatively affect sensory perception due to their cloudy appearance, granular structure, and starch taste.[9,14,15,21,22] It has been noted that formulations containing maltodextrin alter mouthfeel and taste perception, as well as aroma release.[28] Similarly, the glucose syrup in the Nutilis Clear formulation may enhance sweetness perception or mask the perception of volatile compounds, thereby affecting the sensory profile.[33] The inclusion of carbohydrate derivatives (glucose syrup or maltodextrin) in addition to gum-based components in both products may explain their similarity in terms of taste and odor, leading to Nutilis Clear not scoring as high as pure gum-based products, but also not being evaluated as negatively as pure starch-based products.

One strength of this study is the comparison of 5 widely used commercial thickening agents, both gum- and starch-based, using the same sensory criteria relevant to dysphagia management. Focus on products that are widely used in the literature enhances the clinical relevance of the findings, making them directly applicable to real-world settings. Furthermore, the use of a consumer-based sensory panel in the evaluation process is a significant advantage as it reflects real consumer experiences. The focus on

four key sensory properties (appearance, odor, taste, overall acceptability) enabled the collection of targeted and interpretable data. This approach allowed for the evaluation of fundamental factors that directly affect patient compliance, rather than broader but clinically less impactful parameters commonly addressed in previous studies.

However, this study has some limitations. Since the assessors were healthy individuals, the results may not fully reflect the sensory perceptions of individuals with dysphagia. Additionally, evaluations were limited to a single liquid (water), whereas thickeners may exhibit different sensory characteristics when used in other types of beverages. Future research should involve individuals with dysphagia, include a variety of liquids and temperatures, and explore time-related changes in sensory properties. Examining additional attributes like mouthfeel, slipperiness, and ease of swallowing is also recommended to guide product improvement.

CONCLUSION

In conclusion, the findings of this study revealed that gum-based thickeners have more favorable sensory properties compared to starch-based ones. Particularly, ThickenUp Clear and the domestically produced PraThick stood out with their homogeneous appearance, neutral odor, and taste profiles, achieving higher scores in terms of overall acceptability. Considering that sensory properties significantly impact patient compliance and the acceptability of thickening agents, we emphasize the importance of taking sensory properties into account when selecting thickeners for dysphagia management.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

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