A comparison of behavior of transitional-state foods under varying oral conditions

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Abstract

Transitional foods are under-utilized in the adult population as they may provide an opportunity to optimize eating pleasure and nutrition for individuals on a modified texture diet. Yet, little is known about the behavioral properties of transitional foods and no research to date has explored the dissolution of known transitional foods in adults. This study aimed to understand the extent of dissolution of 5 transitional snacks items in relationship to time, tongue pressure, and amount of saliva. Thirty individuals ages 50 to 88 participated in this study (10 with diagnosed xerostomia). The foods tested included shrimp chips, Baby Mum Mums, the EAT bar, and the Savorease cracker with and without dip. Each test food was placed in the mouth for 5 seconds or 12 seconds with or without tongue pressure and then expectorated. Benchtop preparation via the International Dysphagia Diet Standardization Initiative (IDDSI) protocol was also completed. An IDDSI fork pressure test was then performed on all samples. Significant differences between snacks were found in degree of dissolution, with Savorease crackers dissolving more consistently than all others and Baby Mum Mums dissolving least frequently than all others. Tongue pressure positively influenced the dissolution of some foods, particularly those with decreased rates of dissolution. Differences also existed between testing conditions. Overall, there was a wide variability in degree and speed of dissolution across different transitional foods and testing methods. These findings support the need for individual testing to explore post-oral processing consistency when determining the clinical utility of transitional foods.

Introduction

Despite the extremely limited literature on the effectiveness of texture-modified foods for facilitating safe and efficient consumption [1,2], the modification of food textures and diets has become a fundamental aspect of dysphagia management [3-7]. With a key goal of reducing the risk of choking and/or asphyxiation, recommendations are often made to modify solid foods to be more cohesive and moist (e.g., less likely to scatter) and/or to require less chewing for easier manipulation in the oral cavity [2,8]. Unfortunately, there exists great variability in the terminology used to describe solid foods and the delineation of these foods into multiple levels [8,9]. Further, objective and accessible methods for measuring texture-modified foods have received considerably less attention than their liquid counterparts [8].

To address the resulting need to improve safety, reliability, and quality of texture-modified foods and liquids, the International Dysphagia Diet Standardization Initiative (IDDSI) was created, providing a common, international taxonomy for terminology used for describing foods and liquids across the continuum [9]. Following a systematic review of the literature, surveys of current clinical practices, and expert discussions, an initial draft framework was developed and presented to international stakeholders for feedback. Of note, while the majority of respondents supported the number of food and liquid levels presented in the twin-pyramid framework, many clinicians indicated a need for the framework to also represent dissolvable solid foods, particularly those clinicians working with children and individuals with developmental disabilities. The final IDDSI framework incorporated this need by including a bar spanning the side of the food pyramid, labeled “transitional foods”.

The placement of this category alongside the pyramid served to represent the nature of transitional foods as solid foods that rapidly change texture in the presence of moisture or temperature change [e.g., 9]. Given the special textural properties of these foods, minimal chewing is required, with tongue pressure often being sufficient to break the solid apart in the right environment. The limited literature supporting, or suggesting, the clinical use of this texture has been primarily focused on children's development of mastication abilities. For example, currently only two articles are cited in the IDDSI Framework Evidence Statement [10] as being investigations of transitional foods in the literature. The two studies support that "transitional-like" solids are likely easier to consume and may be appropriate for use therapeutically with pediatric populations, particularly those with less mature or underdeveloped sensorimotor systems for mastication [11,12]. Similarly, more recent research supports that certain foods are appropriate even for an immature chewing motor system (e.g., Cheerios – a puffed, easily dissolvable solid cereal) whereas other foods may present a mismatch between the status of a young child's oral anatomic and motor system and the functional demands of the food itself (e.g., rice rusks – a solid cracker that requires higher fracture force and is often used as a teether for children) [13].

Interestingly, the risk factors for choking in the infant and toddler population are also found in various adult populations, including those with dysphagia. For example, both infants/toddlers and adults with partial to complete edentulism face a reduction in masticatory efficiency which creates difficulty in breaking down solid foods. Other risk factors that are found in adults with neurocognitive impairment, such as decreased tongue lateralization, coordination, and oral control, increased impulsivity, and poor safety awareness, parallel those seen in normal, early child development [14]. In the pediatric population, we attempt to minimize these risks through the use of soft, easy to swallow, bite-sized foods that do not require chewing in order to prevent choking, or foods that may fit the transitional criteria. Thus, adult populations with dysphagia could also benefit from such transitional state foods in their diet.

Yet, while little is known about oral processing and swallowing across different classes of solids [2], even less is known about transitional foods. “First finger foods,” which are frequently marketed to parents of toddlers, offer claims of safety due to them rapidly melting in the mouth and they are often presented to the public as a transitional food. However, when a variety of these products were tested, significant variability was found, with only a small proportion meeting all the safety criteria specified by the American Academy of Pediatrics [14]. Thus, it is not entirely clear how the definition of transitional foods should be operationalized and the impact the resulting definition will have on patient safety. The IDDSI guidelines indicate that transitional foods are solids that when tested as a shape no greater than 1.5 cmx 1.5 cm will squash, disintegrate, or melt (i.e., no longer resembles its original shape) after soaking in one mL of water for one minute and given the application of approximately 17 kPa of fork pressure [15]. However, such testing only accounts for the presence of one mL of water for an entire minute, which does not mimic saliva in enzymatic activity, oral quantities, and temperature nor typical oral preparation and transit times [16,17].

Further, compounding conditions of xerostomia pose additional risk for individuals with dysphagia due to loss of lubrication of food and increase in swallowing effort [18]. Xerostomia has been reported to occur in 57% of outpatients and 63% of hospitalized patients [19]. It is a common concern across a range of individuals with or at risk for dysphagia. Common etiologies for xerostomia are radiotherapy to the head and neck [20-22], use of certain xerogenic medications [23], Sjogren's syndrome [24], Alzheimer's disease [25] and diabetes [26]. Reduced saliva quantity and altered quality can certainly play a role in the dissolution properties of transitional foods and creates another layer of differentiation between the adult and pediatric populations. Thus, although transitional foods likely have utility as a diet option for individuals across the lifespan, it is questionable whether results in the pediatric population mirror those in the adult population.

Ultimately, transitional foods have great potential to play an increased role in our therapeutic approaches to dysphagia management. However, much remains unknown about the properties of these foods and the degree of variability that may exist between different marketed products, particularly under different oral environments such as given the presence of xerostomia. Therefore, the aims of the current study were to compare the presence of transition, or dissolution using the IDDSI fork pressure test criteria, across five known transitional, solid foam snack foods (a) across multiple in vivo testing methods given varying amounts of tongue pressure and time in the mouth and (b) utilizing standard benchtop testing methods as described by IDDSI for transitional foods.

Methods

Participants

Thirty community-dwelling adults were recruited from the general population via word of mouth and public flyers. Inclusion criteria remained broad and included all adults over the age of 50. Individuals were excluded if they had memory or cognitive issues that would make it difficult to follow study instructions. Individuals with dysphagia were only included if they were on a soft, bite-sized diet (IDDSI Level 6). Participants were assigned a positive score for dysphagia if this was previously diagnosed by a speech-language pathologist. However, no investigations were done to determine further information on etiology or type of dysphagia. In this study, individuals were identified as having xerostomia (or the subjective complaint of dry mouth [27]) if they were previously told it was a likely diagnosis by a physician or dentist and if they responded positively to the question "does your mouth usually feel dry". This latter question has been shown to have a high sensitivity for detecting hyposalivation [28]. In order to capture a wider range of participants, individuals were not excluded based on allergy status. However, given the nature of the food products being tested, any food allergies or food restrictions were identified prior to initiation of the study and led to a narrower testing sample for that individual if they had a shellfish allergy or lactose intolerance. The Institutional Review Board at the participating university approved the study and all participants signed written informed consent prior to participation.

In vivo task procedures

All data was collected over two consecutive weeks by three examiners. The examiners were trained on the IDDSI testing methods and observed each other in a number of test runs to minimize inter-operator variability. During data collection, each participant was seated in a semi-private booth. Prior to testing, participants calibrated their tongue pressure to the estimated thumb pressure used for the IDDSI fork test. Using the Iowa Oral Performance Instrument for biofeedback, participants were trained on obtaining approximately 17 kPa of tongue pressure over repeated trials. They were then instructed to apply this moderate tongue pressure with each transitional food trial when tongue pressure was required.

Examiners then set five plates in front of the participants in random order. Each plate contained four 1.5 cm x 1.5 cm samples of a single food product, to simulate the size requirements prescribed for IDDSI transitional food testing. All plates were labeled by an alphanumeric identifier only. The transitional snacks included in this study were all dry, solid, foam snacks that begin at IDDSI level 7 at room temperature before the introduction of water. The commercially prepared transitional foods tested were selected from commercially available foam chips, including options provided as examples on the IDDSI website, as well as novel finger foods that are intended to satisfy primarily the adult palate. To reflect adult dietary preferences both savory and sweet choices were chosen. The testing stimuli were: a) Savorease carrot cracker (Taste for Life, LLC); b) Savorease carrot cracker with 5 mL of hummus (Taste for Life, LLC); c) shrimp chips (KC Commerce); d) Baby Mum Mum rice rusks (Want-Want Foods); and e) The EAT Bar (Nutraphagia) (Figure 1). As the Savorease crackers are intended to be eaten with dip to maximize nutrient content, both the transitional cracker and the transitional cracker with the dip were tested.

The samples of each product were placed in the mouth and then expectorated across four different time/pressure conditions designed to simulate potential oral conditions during eating across a range of typical oral transit times and including tongue-palate pressures [17, 29]: a) 5 seconds, no pressure; b) 5 seconds, with tongue pressure; c) 12 seconds, with tongue pressure; and d) 12 seconds, with pulsing tongue pressure. During the 5 seconds/no tongue pressure condition, participants positioned the sample on the dorsal surface of their tongue, held the sample in a closed mouth posture for a timed 5 seconds with no lingual-palatal pressure, and then expectorated. During the 5 and 12 seconds/tongue pressure condition, participants positioned the sample on the dorsal surface of their tongue, held the sample in a closed mouth posture for a timed 5 or 12 seconds with moderate tongue to palate pressure, and then expectorated. During the 12 seconds/pulsing tongue pressure condition, participants positioned the sample on the dorsal surface of their tongue, held the sample in a closed mouth posture for a timed 12 seconds with moderate pulsing lingual pressure against the palate, defined as approximately 17 kPa of mashing tongue pressure on the food against the hard palate every 2 seconds, and then expectorated. Between each sample, participants drank water to clear any remaining residue and then rested for 1 minute to allow saliva pH to normalize [30].

Immediately after the sample was expectorated, the examiner completed the IDDSI fork test on the sample [15]. During this testing, fork pressure was applied to the sample until the thumbnail was blanched to white. The results were classified as a "positive fork pressure test" if the sample squashed, fractured, and/or disintegrated to the point that it no longer looked like or returned to its original state after removing the fork. All samples were then photographed. Photographs of the samples were only used if there was any uncertainty on the fork pressure test results. In these cases, the photographs were shared with the other two examiners for independent confirmation of the initial fork pressure test results and consensus was then reached by all three examiners.

Benchtop testing

Samples of each product also underwent benchtop testing using the standard IDDSI fork test protocol [15]. Five 1.5 cm x 1.5 cm samples of each transitional food product were placed in 1 mL of water. After one minute, the samples were removed from the water and the fork pressure test was completed (see description above). The results were again classified as a "positive fork pressure test" if the sample squashed, fractured, and/or disintegrated to the point that it no longer looked like or returned to its original state after removing the fork. All samples were then immediately photographed.

Statistical analyses

A series of multilevel binomial logistic regression models, or generalized linear mixed models (GLMMs), with logit link functions and first-order autoregressive covariance structures were used to test whether dissolution rates varied by within-subject transitional snack type, within-subject testing method, and between-subject dry mouth status. Models were fit using SAS PROC GLIMMIX version 14.2 with residual pseudo-likelihood estimation [31]. The statistical models accounted for repeated measures nested within participants and included main effects of transitional snack type, testing method, or dry mouth status, depending on the research question. Least squares mean estimates were used to calculate odds ratios (ORs) for each planned within- and between-subjects contrast.

Results

Participants

The final sample ranged in age from 50 to 88 years old (M_{age} = 66.7 years, SD = 8.9 years) and included 13 males and 17 females. Twenty-eight participants were Caucasian, non-

Hispanic, and two (6.7%) were Caucasian, Hispanic. Ten were previously diagnosed with dry mouth (33.0%), 8 had dysphagia (26.7%; 4/8 had dry mouth), 1 had a dairy allergy (3.3%), and 2 had a crustacean allergy (6.7%).

Dissolution rates by transitional snack type

In vivo testing. Table 1 summarizes the dissolution rates (i.e., percentage of positive fork pressure test) for each transitional snack type within each in vivo testing condition, with the bottom row indicating the overall dissolution rates for each snack across the conditions. We first conducted a GLMM to compare these dissolution rates via fork pressure test between snacks across all conditions. Table 2 summarizes the odds ratios (ORs) for each within-subjects contrast. Significant differences in dissolution rates emerged for all pairwise contrasts except the Savorease carrot cracker versus the Savorease carrot cracker and hummus (p = .25) and the shrimp chip versus the EAT Bar (p = .14). For example, the odds of dissolution with fork pressure test at 5 or 12 seconds with or without tongue pressure for the Savorease carrot cracker were 53.6 times higher than for the shrimp chip (95% CI = 16.34-175.99, p < .0001), 127.1 times higher than for the Baby Mum Mum (95% CI = 37.16-434.89, p < .0001), and 32.1 times higher than for the EAT Bar (95% CI = 9.65-106.87, p < .0001).

Table 1. Dissolution rates via fork pressure test at 5 and 12 seconds with and without tongue pressure.

	Transitional Snack Type					
Condition	**Savorease Cracker**	**Savorease Cracker & Dip**	**Shrimp Chip**	**Baby Mum Mum**	**The EAT Bar**	***Total***
5 seconds, no TP	0.87	0.97	0.00	0.00	0.20	*0.43*
5 seconds, with TP	1.00	1.00	0.32	0.07	0.45	*0.58*
12 seconds, with TP	1.00	1.00	0.39	0.30	0.55	*0.66*
12 seconds, pulsing TP	1.00	1.00	0.80	0.44	0.63	*0.77*
Total	*0.96*	*0.99*	*0.32*	*0.17*	*0.45*	*0.59*

Note. TP = tongue pressure

Table 2. Generalized linear mixed model (GLMM) results comparing dissolution rates via fork pressure test at 5 or 12 seconds with or without tongue pressure by snack type.

Snack 1		**Snack 2**	**Odds Ratio [95% CI]**	***p*-value**
Savorease Cracker	vs.	Savorease Cracker & Dip	0.24 [0.02,2.74]	.2545
Savorease Cracker	vs.	Shrimp Chip	53.63 [16.34,175.99]	<.0001*
Savorease Cracker	vs.	Baby Mum Mum	127.13 [37.16,434.89]	<.0001*
Savorease Cracker	vs.	The EAT Bar	32.12 [9.65,106.87]	<.0001*
Savorease Cracker & Dip	vs.	Shrimp Chip	220.77 [24.21,2013.02]	<.0001*
Savorease Cracker & Dip	vs.	Baby Mum Mum	523.32 [56.11,4880.64]	<.0001*
Savorease Cracker & Dip	vs.	The EAT Bar	132.24 [14.39,1214.81]	<.0001*
Shrimp Chip	vs.	Baby Mum Mum	2.37 [1.15,4.87]	.0201*
Shrimp Chip	vs.	The EAT Bar	0.60 [0.31,1.17]	.1367
Baby Mum Mum	vs.	The EAT Bar	0.25 [0.12,0.53]	.0004*

Note. * indicates a statistically significant *p*-value

Benchtop testing. We also compared benchtop dissolution rates across transitional snack types. Dissolution rates were 100% for the Savorease carrot cracker, 100% for the Savorease carrot cracker and hummus, 80% for the shrimp chip, 20% for the Baby Mum Mum, and 100% for the EAT Bar. Table 3 provides the ORs comparing dissolution status by snack type. Results indicated generally higher odds of benchtop dissolution for Savorease carrot cracker, Savorease carrot cracker and hummus, and the EAT Bar compared to the shrimp chip and Baby Mum Mum.

Table 3. Contingency table analysis results comparing benchtop dissolution by snack type.

Snack 1		**Snack 2**	**Odds Ratio [95% CI][a]**
Savorease Cracker	vs.	Savorease Cracker & Dip	NA
Savorease Cracker	vs.	Shrimp Chip	2.25 [1.08,4.67]
Savorease Cracker	vs.	Baby Mum Mum	6.00 [1.00,35.91]
Savorease Cracker	vs.	The EAT Bar	NA
Savorease Cracker & Dip	vs.	Shrimp Chip	2.25 [1.08,4.67]
Savorease Cracker & Dip	vs.	Baby Mum Mum	6.00 [1.00,35.91]
Savorease Cracker & Dip	vs.	The EAT Bar	NA
Shrimp Chip	vs.	Baby Mum Mum	4.00 [0.66,24.37]
Shrimp Chip	vs.	The EAT Bar	0.44 [0.21,0.92]
Baby Mum Mum	vs.	The EAT Bar	0.17 [0.03,1.00]

Note. NA = odds ratio cannot be computed given 100% overall dissolution rate. [a] None of the expected cell counts in the contingency table were greater than 5 (only 5 tests/snack type); therefore, chi-square test statistics and associated *p*-values were not calculated.

Dissolution rates by in vivo testing method

A separate GLMM was estimated to compare dissolution rates via fork pressure test across all transitional snack types by in vivo testing method (see Table 1 for overall rates by testing method). Table 4 summarizes the odds ratios (ORs) for each within-subjects contrast. Results indicated significantly lower odds of dissolution for the 5 seconds/no tongue pressure condition versus the 12 seconds/pulsing tongue pressure condition (OR = 0.27, 95% CI = 0.10-0.75; *p* = .01). No other pairwise contrasts were statistically significant.

Table 4. Generalized linear mixed model (GLMM) results comparing dissolution rates via fork pressure test across snacks by testing method.

Condition 1		**Condition 2**	**Odds Ratio [95% CI]**	***p*-value**
5 seconds, no TP	vs.	5 seconds, with TP	0.55 [0.23,1.31]	.1850
5 seconds, no TP	vs.	12 seconds, with TP	0.42 [0.17,1.00]	.0548
5 seconds, no TP	vs.	12 seconds, pulsing TP	0.27 [0.10,0.75]	.0138*
5 seconds, with TP	vs.	12 seconds, with TP	0.75 [0.31,1.81]	.5275
5 seconds, with TP	vs.	12 seconds, pulsing TP	0.48 [0.17,1.35]	.1678
12 seconds, with TP	vs.	12 seconds, pulsing TP	0.64 [0.23,1.81]	.4028

Note. TP = tongue pressure. * indicates a statistically significant *p*-value

Dissolution rates by dry mouth and dysphagia status across transitional snack types

Finally, we examined the influence of oral environment and swallowing status on dissolution as these two variables likely impact in vivo testing methods. GLMM results comparing dissolution rates between participants with and without dry mouth across all snacks at 5 seconds with and without tongue pressure revealed a trend for improved dissolution in subjects without dry mouth (53% dissolution versus 45% dissolution; OR = 0.77, 95% CI = 0.60-1.01; *p* = .06). This trend did not emerge at 12 seconds (67% dissolution versus 64% dissolution; OR = 0.88, 95% CI = 0.47-1.65; *p* = .69). Overall rates of dissolution across the products also varied among the individuals with dry mouth; Table 5 summarizes the results at 5 seconds with and without tongue pressure for these individuals.

Table 5. Dissolution rates via fork pressure test at 5 seconds with and without tongue pressure for participants with dry mouth (*n* = 10).

	Transitional Snack Type				
Condition	**Savorease Cracker**	**Savorease Cracker & Dip**	**Shrimp Chip**	**Baby Mum Mum**	**The EAT Bar**
5 seconds, no TP	0.80	0.90	0.00	0.00	0.00
5 seconds, with TP	1.00	1.00	0.25	0.00	0.17

Note. TP = tongue pressure

GLMM results comparing dissolution rates between participants with and without dysphagia across all snacks at 5 seconds and 12 seconds did not reveal any significant differences (51% dissolution versus 47% dissolution at 5 seconds (*p* = .25) and 65% dissolution and 69% dissolution at 12 seconds (*p* = .68) for individuals without and with dysphagia, respectively). Overall rates of dissolution across the products also varied among the individuals with dry mouth; Table 6 summarizes the results at 5 seconds with and without tongue pressure for these individuals.

Table 6. Dissolution rates via fork pressure test at 5 seconds with and without tongue pressure for participants with dysphagia (n = 8).

	Transitional Snack Type				
Condition	**Savorease Cracker**	**Savorease Cracker & Dip**	**Shrimp Chip**	**Baby Mum Mum**	**The EAT Bar**
5 seconds, no TP	0.75	1.00	0.00	0.00	0.00
5 seconds, with TP	1.00	1.00	0.29	0.00	0.25

Note. TP = tongue pressure

Discussion

The goals of the current study were to compare dissolution across five different commercially available “transitional-like” solid products utilizing (a) different in vivo and (b) benchtop testing methods. Overall results suggested the presence of wide variability in the extent and speed of dissolution across different commercially available transitional products, especially when tested in the oral environment. Notably, product dissolution was more consistent under benchtop testing methods as compared to intra-orally, with dissolution rates in the in vivo testing ranging from 0-100% across products and testing conditions.

It was clear that not all products behaved the same, using both in vivo and benchtop testing methods. In fact, the one product tested that is currently marketed as a first safe finger food, the Baby Mum Mum, performed significantly poorer with respect to dissolution across all testing conditions and particularly among individuals with xerostomia. Unlike the other products tested, Baby Mum Mums are also targeted as a teether (advertised by the manufacturers as the “original rice teething biscuit brand in North America”), which may have contributed to the decreased dissolvability of the crackers. However, this was not the only product tested that remained hard with a majority of the product in its original form after the fork pressure test, despite being commercially marketed as or suggested to be (e.g., via IDDSI guidelines) a transitional-state food. In fact, outside of the Savorease products, testing of the remaining foods resulted in a positive fork pressure test less than 50% of the time in most of the intra-oral conditions and less than 25% of the time for individuals with self-reported xerostomia during the 5-second conditions. Yet, for many of these products, there was a positive effect of increased time in the oral cavity and the addition of pulsing tongue pressure. Notably, solid foams in the transitional food category possess the characteristic “crunchy” texture, but differ in their efficiency of absorption of moisture. This distinguishing feature is likely largely responsible for the variance in dissolution seen in this study. As we continue to explore the clinical utility of transitional-state foods, the importance of these variability findings cannot be understated. First, it is clear that not all self-described transitional-state foods will indeed act as expected in the oral cavity for every patient to the same degree. As this initial data indicates that there was no statistically significant difference in dissolution at 5 and 12 seconds between participants with self-identified dysphagia and those without, it would seem rational to at least begin with more rapidly dissolving transitional foods for those individuals experiencing greater oral phase difficulties. However further clinical trials are required to validate this assumption. Second, it may be necessary to not only consider the food texture allowed or presented, but to also consider the method of consumption and whether the therapeutic instruction of specific techniques, such as the introduction of a more mashing tongue pattern, would be beneficial. Novel transitional foods have been created to broaden the transitional food category and offer more choices to individuals with dysphagia. However this preliminary study has shown that dissolution is also affected by oral conditions. Thus, it is recommended in clinical practice to assess transitional foods for each individual within the mouth itself in order to identify the most ideal oral behaviors.

In addition to differences across products, there were clear differences between the in vivo and benchtop testing methods. The increased dissolution rates using the standard IDDSI preparation procedures as compared to intra-oral preparation procedures suggest that using the standard IDDSI protocol alone may not accurately represent a given individual's performance with a particular product. These individual differences are likely a by-product, at least in part, of changes in salivary flow and swallowing physiology, particularly as these are not captured in the standard IDDSI testing protocol. Saliva is a biofluid composed predominantly of water, but it also contains various electrolytes, small organic substances, proteins, peptides, and polynucleotides [32]. Salivary secretion can increase up to 1.5-2.3 ml/min with a food stimulus, but this amount could be drastically reduced in the presence of xerostomia [16]. Further, a one-minute liquid bath is lengthier than typical oral transit times, or the time gap between the complete capture of the bolus and the reflex firing of swallowing, which varies typically between 1 second and 12.8 seconds for solid foods in a healthy adult population [17]. While there is great value to having a standard protocol for initially classifying products that may fall into the transitional food category, these findings clearly highlight the importance of testing transitional foods as part of standard evaluation practices with individual patients to determine appropriateness. Further, these findings suggest that in determining the clinical utility of any given food we likely need to consider the post-oral processing consistency which is ultimately what is swallowed.

Despite the current variability in product performance and testing options, the clear value transitional foods can add to the diets of adults with dysphagia supports continued clinician and researcher exploration of these products. This value can be realized from both a psychoemotional and a biologic/physiologic standpoint. All of the transitional foods tested were solid foams, which offer a crunchy texture that is often lost when an individual is on a modified texture diet. The majority of the general population's preferential eating pattern has been shown to be that of a "cruncher" [33]. Food texture is one key sensory property that contributes to flavor and palatability [34,35]. It is of no surprise that individuals on modified texture diets miss the mouth feel of their familiar foods and miss the texture that contributes to taste [36]. The transition to a modified diet can result in individuals eating solely as a matter of necessity and hunger, forgoing enjoyment and pleasure [37]. Thus, transitional foods have the capacity to offer a stronger link for individuals with dysphagia to their premorbid food preferences, thereby improving the eating experience and increasing quality of life.

Consumers of modified texture diets are also at increased risk for malnutrition, consuming less energy (calories) and nutrients [38-41]. Thus, transitional-state foods may also provide a viable option for increasing food consumption and nutritional intake. Transitional foods, including those tested in the current study, typically fall into the category of snack foods. Snack times are not regularly targeted as a key opportunity to increase nutritional intake in the elderly. It is only recently that attention has focused on snacks in the elderly population as a potential valuable source of food energy [42,43]. Further, as demonstrated in the current study, transitional foods do not require chewing to dissolve in the mouth, which markedly increases safety during consumption. However, a natural response to a finger food is to masticate. Thus, even minimal chewing of a safe-to-eat transitional food could have a direct therapeutic benefit, both on masticatory muscle strengthening and potentially also on cognition [44]. Further research into these potential biopsychoemotional outcomes is warranted.

The limitations of the current investigation are important to consider. As a preliminary pilot investigation, the number of participants – particularly those with self-reported xerostomia and dysphagia – was relatively small, participants were relatively healthy, and the range of ages of participants did not fully cover all potential adults (i.e., younger adults and the oldest-old). Xerostomia was not validated with measures of stimulated and unstimulated salivary flow rates and was based on self-report. Consideration was not given to the circadian rhythms in human salivary flow rate, pH level and salivary mineral composition, which could all have an effect on dissolution of transitional foods [45]. In addition, saliva flow has been shown to be stimulated in animal studies with citric acid, sodium chloride and sucrose [46]. Citric acid is one ingredient in the Savorease dip used and sugar is a key ingredient in Baby Mum Mums and the EAT bar. Participant taste and smell preferences can also affect salivary flow rates [47]. Although total saliva quantities are lowered in xerostomia, salivary flow rate can be further affected by ingredients in the foods and the subjective assessment of taste. Therefore, as many transitional foods require moisture to break down, there is a potential for wide ranging inter-person variability in performance based on quantity and quality of saliva available to perform that task. Further, no specific instructions were given related to the method of expectoration. It

is possible that additional oral processing occurred, at least for some participants, as the material moved anteriorly out the oral cavity. Given the goals of this pilot, the study was conducted in an extremely controlled experimental setting, which may further limit generalizability given differences in individual behavior. Notably, we also relied on self-report for determining dysphagia status and did not directly assess swallowing status or have the capabilities to differentiate between levels of dysphagia severity and underlying pathophysiologies (e.g., related to oral, oropharyngeal, and/or esophageal dysphagia).
As such, we could not determine the impact of dysphagia or the behavior of the transitional foods from oral processing through the swallow, which will be important next steps to determining clinical viability. Thus, future work with a wider range of participants using instrumental assessment to examine timing and degree of dissolution as well as swallowing and residue patterns is needed. While not the intended target of the current investigation, further research also needs to be conducted on measuring emotional response and nutritional intake to transitional-state foods as compared to soft texture foods. Overall, as a preliminary investigation, the current study importantly provided an initial first step into the systematic investigation of transitional-state snacks and foods by highlighting necessary considerations for continued research exploration and clinical use.

Conclusion

As the commercial market for transitional-state foods continues to grow, we must continue to explore the properties of these foods to ensure clinical safety. Yet, the potential significance of these products cannot be understated, and ultimately supports these continued investigations. This preliminary study offers the first insights into the dissolution of transitional foods in the mouth and the influence of saliva quantity and time. Expanding our knowledge of transitional foods will improve our understanding of use with the goal of improving patient engagement and outcomes.

Figure 1. Transitional-state products prepared in 1.5 cm x 1.5 cm stimuli including: A) Savorease cracker (savory flavor); B) Savorease cracker with dip in cup, added just before oral conditioning (savory flavor); C) shrimp chip (savory flavor); D) Baby Mum Mum (sweet flavor); E) Nutraphagia Eat Bar (sweet flavor).

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