From First Bite to Swallow Initiation: An Evidence-Informed Assessment Framework for Transitional Foods in Dysphagia Management

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Abstract

Transitional foods, foods that undergo textural transformation from one texture to another through moisture or temperature changes during consumption, represent a promising dysphagia management approach, yet systematic evaluation frameworks specifically addressing transformation mechanisms are lacking. Current texture-modified food assessment practices focus predominantly on initial texture properties and pharyngeal safety outcomes, with limited attention to oral-stage transformation processes that define transitional food effectiveness. This study developed an evidence-informed evaluation framework for transitional foods through rapid systematic review and thematic synthesis of texture-modified food assessment literature.

Systematic searches across four databases (PubMed, CINAHL, Cochrane Library, Scopus) identified 28 studies examining oral processing assessment approaches in texture-modified foods for adult populations. Data extraction systematically captured assessment components, methods, population characteristics, and quality indicators. Methodological quality was appraised using the Critical Appraisal Skills Programme tool and a purpose-developed assessment schedule, with thematic synthesis conducted using NVivo to identify patterns characterizing current assessment practices and gaps requiring framework specification. Systematic extraction identified 121 distinct parameters across nine conceptual domains. Assessment concentrated in rheological properties (43%), oral biomechanics (43%), and pharyngeal efficiency (43%), while transformation dynamics (29%) and saliva interaction (21%), the primary mechanisms distinguishing transitional foods from static texture-modified foods, remained substantially underrepresented. Quality appraisal revealed strong measurement practices (76% average measurement quality score) but design transparency gaps, with 82% of studies conducting reliability procedures yet only 18% reporting statistical reliability metrics. Only three studies specifically examined transitional foods as defined by IDDSI, necessitating framework development from broader texture-modified food literature.

Thematic synthesis revealed six overarching patterns: safety-focused assessment highlighting underdeveloped oral transformation measurement; rheological testing dominance with static

measurement bias; balanced method distribution masking functional imbalance across assessment stages; high-quality studies demonstrating methodological strengths alongside reporting gaps; multi-method triangulation concentrated in established domains with limited integration of transformation mechanisms; and IDDSI framework adoption primarily for texture classification (46% of studies) with limited application as a measurement tool for transformation assessment (14%). These synthesis findings directly informed development of an eight-domain Evidence-Informed Transitional Food Assessment Framework addressing identified gaps through accessible, evidence-based methods. The framework mandates pre/post texture comparison to validate transformation occurrence, incorporates gravimetric saliva interaction assessment using precision scales, operationalises IDDSI testing as transformation measurement applicable to expectorated bolus, and integrates patient-centred sensory evaluation alongside safety validation. The framework provides clinicians, researchers, and food industry stakeholders with evidence-based methods for systematic transitional food evaluation using globally accessible approaches, supporting evidence-informed food selection, prescription, and product development in dysphagia management.

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1. Chapter One: Introduction

Swallowing is a fundamental human function, essential for nutrition, hydration, and quality of life. When this function is impaired, known as dysphagia, it can lead to serious medical, emotional, and social consequences. Transitional food, a newer consideration in dysphagia management, holds promise for supporting mealtime that are more enjoyable for individuals with swallowing difficulties. Understanding this emerging food category is important for advancing the evaluation and management of dysphagia. This chapter introduces the clinical background, current management approaches, and emerging diet texture solutions, leading to the rationale for the present study, which focuses on transitional foods.

"For a dysphagic patient, eating is not less important than for a person without swallowing difficulties" (Amitrano, 2024): a reminder that food is not only nourishment but a source of identity, dignity, and social belonging.

1.1 Background

Dysphagia is a swallowing disorder, which may result from a range of underlying medical conditions (Sungsinchai et al., 2019). It refers to the impairment of the process of swallowing liquids and/or solid foods. This disorder represents a deviation from normal swallowing, which the International Classification of Functioning, Disability and Health (ICF, code b5105), defines as "the function of clearing food and drink through the oral cavity, pharynx and oesophagus into the stomach at an appropriate rate and speed" (World Health Organization, 2024).

Dysphagia is a widespread condition, and according to Cichero et al. (2013), it affects approximately 8% of the global population. More recent research indicates that the prevalence of oropharyngeal dysphagia (OD) may be even higher. Peñalva-Arigita et al. (2019) reported that approximately 1 in 17 people experience some form of dysphagia at some point of their lives. Furthermore, a systematic literature review and meta-analysis conducted by Rajati et al. (2022) found that the pooled prevalence of oropharyngeal dysphagia across 27 studies was 43.8%, with higher rates observed in certain regions and clinical populations. Supporting this, Kim (2025) notes that dysphagia occurs in 8–22% of adults over the age of 50, highlighting its prominence among older adults globally.

In New Zealand alone, recent projections estimate that dysphagia has affected 1.5% of the general population in 2020, with prevalence expected to rise to 2.6% by 2073 due to population ageing (Duncan et al., 2024). This trend signals a growing national healthcare concern that reflects broader global patterns, as ageing populations worldwide are contributing to an escalating prevalence of dysphagia (Duncan et al., 2024). These findings highlight the growing impact of Oropharyngeal Dysphagia, especially among vulnerable groups such as older adults, individuals with neurological conditions, and people living in aged-care settings.

Given the increasing prevalence of dysphagia both globally and within New Zealand, it is important to understand the underlying physiological mechanisms that contribute to impaired swallowing function and how they lead to clinically significant consequences. To fully grasp the clinical consequences of dysphagia, it is necessary to understand not just how frequently it occurs, but also how disruptions in the normal swallowing mechanism give rise to these outcomes.

Dysphagia can arise from neurological, muscular, or structural abnormalities. Neurological causes include stroke, traumatic brain injury, Parkinson's disease, multiple sclerosis, and dementia, which affect the neural control of swallowing. Muscular aetiologies encompass conditions such as myasthenia gravis, muscular dystrophy, and inflammatory myopathies that directly impair the strength and coordination of swallowing muscles. Structural abnormalities include head and neck cancers, oesophageal strictures, pharyngeal pouches, and congenital malformations that create physical barriers to safe swallowing. In addition, symptom- or behaviour-related presentations such as odynophagia (painful swallowing) and phagophobia (fear-based avoidance of swallowing) may coexist with or mimic dysphagia, further complicating assessment and management. Aetiologies may fall into one or more categories (Rommel & Hamdy, 2016). These underlying causes can give rise to serious swallowing-related complications.

Guénard-Lampron et al. (2021) note that aspiration may occur due to inadequate muscle coordination while swallowing, delays in swallow response, or food residue remaining in the mouth. This aspiration risk is heightened when combined with malnutrition and can progress to pneumonia. Given its high prevalence, complex physiological nature, and potential for serious complications, dysphagia represents a significant clinical challenge. Left untreated, it contributes to malnutrition, dehydration, aspiration pneumonia, prolonged hospital stays, and increased mortality and will negatively impact overall wellbeing and quality of life. As the global population ages, the healthcare burden associated with dysphagia is expected to rise considerably, highlighting the need for effective, accessible assessment and management strategies across clinical settings.

To understand the mechanisms underlying these complications, it is important to examine the normal physiology of swallowing, also known as deglutition. Deglutition is a complex, coordinated neuromuscular activity that allows for the safe and efficient transport of food and fluids from the mouth to the stomach. According to Logemann (1984) it can be divided into four phases: the oral preparatory phase, during which food is chewed and mixed with saliva to form a cohesive bolus; the oral phase, where the bolus is voluntarily (but often without conscious thought) propelled posteriorly; the pharyngeal phase, which is reflexive and involves airway protection and rapid bolus transit; and the oesophageal phase, where peristaltic contractions carry the bolus into the stomach. Each phase relies on precise timing, muscle coordination, and sensory feedback to ensure airway protection and effective transport of bolus. Disruptions in any of these phases, particularly the oral or pharyngeal phases can result in impaired swallowing efficiency or safety, leading to complications such as aspiration, residue, or delayed transit. However, the oral preparatory phase is particularly important as it establishes the foundation for all subsequent swallowing processes— inadequate oral processing directly compromises bolus formation, which leads to increased risks during the pharyngeal and oesophageal phases (Wieseke et al., 2008). Furthermore, the oral preparatory phase is especially significant for assessment purposes, as it provides the only phase where food properties and oral processing mechanisms can be directly observed and measured. This makes it a key focus for developing evidence-based evaluation protocols, particularly for transitional foods, where in-mouth texture transformation occurs through natural physiological processes.

1.2 Current Dysphagia Management Approaches

It is very important for these individuals with swallowing difficulties to consume foods that are easy to masticate and safe to swallow (Pedersen et al., 2016; Sungsinchai et al., 2019; Tokifuji et al., 2013). One of the primary management strategies for dysphagia is diet modification, with texture modified foods (TMF) being the most widely used intervention. These TMF refers to foods with altered textures, which may be modified by physical means or chemical processes. This approach is used across healthcare settings and is tailored to individuals' swallowing abilities as determined through clinical or instrumental assessments. These modified foods are intended to reduce the need for complex oral processing, minimise the risk of residue or choking, and promote safer, more comfortable swallowing for patients with impaired function (Cichero et al., 2013; Fiszman & Laguna, 2023).

Traditional texture modified foods include consistencies such as pureed foods, minced and moist meals, and soft foods that require minimal chewing effort. These diets are often accompanied by thickened liquids, which are designed to slow bolus flow and give individuals with delayed or uncoordinated swallow responses more time to protect the airway (Steele et al., 2015).

Su et al. (2018) describe the main rationale behind texture modification in dysphagia diets as the need for individuals to avoid low-viscosity liquids, hard and dry solid foods, and foods with low consistency and a lack of homogeneity. From a food science perspective, the rationale behind texture modification is grounded in rheology (the study of flow and deformation of materials) and food microstructure (Munialo et al., 2020). Accordingly, a crucial clinical intervention for individuals with dysphagia is dietary modification through prescribed texture-modified foods, including the use of thickened fluids, to support safe and effective swallowing (Wu et al., 2021).

However, previous standards for texture-modified foods faced significant theoretical and practical limitations. The inconsistency between international standards created fundamental challenges in cross-country comparisons and prevented food manufacturers from developing products suitable for global markets. Moreover, while rheology-based classification systems offered scientific rigor, they proved impractical for clinical application due to bedside usability issues and high measurement variability (Su et al., 2018).

Recognizing these challenges, the International Dysphagia Diet Standardisation Initiative (IDDSI) was developed to support consistency and safety in TMF preparation and classification (Cichero et al., 2013). This framework has been adopted globally in healthcare, aged care, and rehabilitation settings with implementation over 50 countries worldwide. The IDDSI framework provides a systematic, standardised method for classifying foods and liquids based on their textural and flow properties. It includes eight levels ranging from Level 0 (thin liquids) to Level 7 (regular/easy to chew). Intermediate levels such as minced and moist (level 5), pureed (level 4), and soft and bite-sized (level 6); are designed to accommodate varying degrees of chewing and swallowing ability, offering safer and more tailored options for individuals with dysphagia. Additionally, Level 7 (regular foods) is subdivided into Regular and Easy to Chew, allowing further refinement based on individual needs and oral processing capacity (IDDSI, 2019). The framework (Figure 1) also includes a side-bar category for transitional foods (traversing levels5 – 7), defined as items that undergo texture transformation in the mouth when exposed to saliva or temperature changes. This category was introduced following stakeholder advocacy, particularly for populations such as children and individuals with developmental disabilities (IDDSI, 2019). This framework helps clinicians, caregivers, and food service providers ensure that prescribed consistencies match the swallowing capabilities of individuals with dysphagia, thereby reducing risks of aspiration and nutritional deficits.

Figure 1: *International dysphagia diet standardization initiative framework*

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Despite these advances, IDDSI's treatment of texture modified foods remains largely descriptive. While the framework acknowledges their importance and provides simple testing methods (e.g., fork pressure test and the IDDSI flow test), much of IDDSI's development was consensus-driven (Barewal et al., 2021; Cichero et al., 2017), and empirical validation directly linking IDDSI levels to physiological swallowing outcomes is still emerging. Furthermore, although inexpensive and accessible, tools such as fork and spoons cannot reliably capture key aspects of oral processing, such as masticatory behaviour, bolus structure, and the mechanical or rheological properties of foods during transformation. This highlights a gap: although the framework successfully standardises classification, it does not yet provide a comprehensive theoretical foundation connecting food science, oral physiology, and clinical outcomes (Munialo et al., 2020).

1.3 Limitations of Current Approaches

Despite their widespread use, TMF have prompted growing concern among researchers, particularly regarding their nutritional adequacy and impact on patient satisfaction. Studies suggest that TMF may adversely affect the quality of life for individuals with swallowing disorders (van den Steen et al., 2025). While TMF are commonly prescribed to maintain nutritional status and hydration (Fiszman &

Laguna, 2023), their clinical effectiveness remains contested. Notably, Hansen et al. (2022) found no convincing evidence that thickened liquids or texture-modified diets prevent pneumonia or mortality, nor do they reliably improve quality of life, nutritional status, or oral intake in individuals with oropharyngeal dysphagia.

From a nutritional standpoint, Keller et al. (2012) argue that the production processes involved in TMF, particularly pureed foods, often result in reduced nutrient density compared to regular-textured meals. From a food science perspective, this reduction can be explained by processing methods that dilute nutrient density (e.g., addition of water or thickeners), alter microstructure, and reduce bioavailability of key nutrients (Munialo et al., 2020). This nutritional inadequacy may heighten the risk of malnutrition, compounding the health challenges faced by individuals with dysphagia.

Beyond physiological concerns, the consumption of TMF can also diminish the sensory and emotional experience of eating. Altered textures significantly reduce the pleasure associated with chewing and oral manipulation, which are integral to mealtime satisfaction (Hall & Wendin, 2008; Keller et al., 2012; Mioche et al., 2004).

The palatability and sensory aspects of TMF are key factors in patients experience of dysphagia management. Hall and Wendin (2008), describe the palatability of pureed foods as multidimensional. Research has identified several key sensory factors that contribute to the appeal and acceptability of pureed foods, including recognisable food appearance, visually and tastefully appealing presentation, firmer textures that facilitate bolus control, and robust flavours. Yet in practice, these foods often fall short—frequently appearing visually unappealing, offering limited variety, and lacking key sensory qualities such as aroma, vibrancy, and acoustic feedback (Karani & Pillay, 2021; Shune & Barewal, 2022).

Eating itself is a multisensory process in which visual, textural, and flavour cues interact with oral physiology to influence swallowing behaviour (Karani & Pillay, 2021; Loret, 2015; Spence, 2017; Spence & Shankar, 2010). Tailoring sensory properties beyond viscosity alone can improve swallowing safety and efficiency, highlighting the importance of understanding how patients engage with TMF beyond their assigned texture level (Loret, 2015). Acknowledging the comprehensive sensory experience of eating, from the physical sensations in the mouth to cognitive and emotional responses, can help in identifying solutions that promote both adequate intake and improved quality of life. Shune and Barewal (2022) emphasise that food is not merely a source of nutrition but a fundamental part of human experience, reinforcing the need for dysphagia interventions that preserve sensory and emotional enjoyment. Similarly, Liu et al. (2024) highlight the importance of considering patient preferences when developing TMFs. They argue that the palatability and sensory characteristics of these foods play a crucial role in patient acceptance and overall dietary intake. In addition, research indicates that exploring how the structural properties of foods influence oral processing is important for improving texture, enhancing sensory qualities, and supporting health-related outcomes such as dysphagia management (Guo, 2021).

Beyond the nutritional and sensory limitations, texture-modified foods significantly impact the social and psychological dimensions of eating, which are fundamental to human wellbeing and dignity. Mealtimes traditionally serve as important social occasions that foster communication, community bonding, and cultural expression (Dunbar, 2017). However, individuals consuming TMF often experience social isolation and embarrassment due to the stark visual and textural differences between their modified foods and regular meals consumed by others at the same table (Seshadri et al., 2018). This divergence can lead to self-imposed social withdrawal, where patients choose to eat alone rather than face the potential stigma associated with their altered diet.

Martino et al. (2010) has shown that acute and chronic patients with dysphagia differ in how they perceive and prioritise psychological consequences, and that these perceptions often diverge from those of caregivers and clinicians. In particular, patients emphasised the emotional and social toll of dysphagia and its complex interaction with nutritional and respiratory challenges. These insights suggest the need for greater clinician awareness of the psychosocial dimensions of dysphagia, and for management approaches that address both biomedical and emotional needs throughout the intervention process (Seshadri et al., 2018).

Therefore, it is important to offer individuals with dysphagia a diet that closely resembles the visual characteristics and the flavour of regular food. In addition, the enjoyment and sensory appeal of texture modified foods should be taken into account to enhance consumer satisfaction and overall dining pleasure (Guénard-Lampron et al., 2021). Transitional foods offer a potential solution to these psychosocial challenges by providing options that more closely resemble regular foods in appearance and flavour, while being designed to transform with minimal or no chewing, relying primarily on moisture and temperature.

1.4 Transitional Foods as an Emerging Solution

Given these concerns regarding TMF, researchers are exploring alternative dietary approaches that better preserve both the sensory and functional aspects of eating. One such alternative is transitional foods. Transitional foods (TF), traditionally utilised as training food for children developing chewing skills, are now being considered as alternatives to traditional texture modified diets for adults with dysphagia (Barewal, 2025).

Transitional foods are defined by their ability to undergo a texture transformation more rapidly and with minimal oral effort (often requiring little or no chewing) during consumption, making them easier to chew and swallow for individuals with impaired oral and pharyngeal function. Some transitional foods start as firm solids and then become softer or dissolve in the mouth due to natural conditions like saliva, body temperature, or minimal oral pressure. For instance, ice cream melts rapidly at body temperature, transforming from a solid to a smooth liquid, while rice crackers and wafer biscuits break down into a puree-like consistency through saliva interaction. This adaptive behaviour allows them to mimic more typical eating experiences while maintaining the safety required for dysphagia diets.

According to IDDSI (2019), transitional foods are defined as “foods that start as one texture (e.g., firm solid) and change into another texture specifically when moisture (e.g., water or saliva) is applied, or

when a change in temperature occurs.” This definition captures the key feature that distinguishes transitional foods from other texture-modified options—their transformation occurs during the natural course of eating, rather than through mechanical or external food processing methods.
While transitional foods are not formally listed as a separate IDDSI level, they are described in IDDSI materials and guidelines due to their unique functional behaviour. Their inclusion under Levels 5 and 6 reflects the importance of both pre-consumption texture and in-mouth transformation in determining safe food options for individuals with dysphagia.
Considering all these factors, transitional foods represent an innovative category that bridges the gap between swallowing safety and sensory satisfaction by transforming texture in mouth through natural physiological processing. This unique ability makes them a promising solution in clinical contexts where patient comfort, dignity, and enjoyment of food are valued alongside swallowing safety, particularly because they enhance meal variety and sensory appeal—qualities often lacking in traditional texture-modified diets.
Current understanding of solid food processing indicates that oral processing behaviour is strongly influenced by food structure, yet establishing universal relationships between structure and processing remains challenging due to the considerable variation in the detailed structures of different food categories (Guo, 2021). This complexity highlights the need for more systematic research exploring oral processing across diverse solid food categories, with particular attention to both general and unique structural features (Guo, 2021). In light of these gaps in our understanding of conventional solid food processing, knowledge of transitional foods is even less developed (Barewal et al., 2021). Although transitional foods have long been used by children as first finger foods, research on their use in paediatric populations also remains limited. The IDDSI evidence statement cites only two supporting studies, both of which are based on paediatric data. In adult dysphagia management, the evidence base is even more sparse, with only a few researchers worldwide exploring transitional foods as a compensatory strategy (e.g., Barewal et al., 2021; Bruno et al., 2025; Mocchetti et al., 2025).

Despite the limited evidence base, transitional foods are gaining growing attention in clinical settings as a potential solution to the limitations of traditional texture-modified diets (Barewal et al., 2021). Clinicians and researchers are increasingly acknowledging the need for TMF options that support not only swallowing safety and nutritional adequacy but also the sensory and psychosocial aspects of eating (Barewal, 2025; Barewal et al., 2021; Bayne et al., 2022; Bruno et al., 2025; Guénard-Lampron et al., 2021; Shune & Barewal, 2022; Yu et al., 2023). This emerging interest reflects a broader shift in dysphagia care toward more holistic, patient-centred approaches that prioritise quality of life alongside clinical outcomes.

1.5 Problem Statement

While transitional foods show promise as a satisfying alternative to traditional texture modified foods, there remains a significant gap in clinical practice: the absence of standardised methods for evaluating their safety, function, and appropriateness for individuals with dysphagia. As transitional foods differ from other dysphagia-friendly textures in that they change during the oral preparatory phase of eating with minimal oral effort, clinicians face the unique challenge of how to systematically assess their behaviour from the initial bite through to the point of swallow initiation (Bruno et al., 2025).

Currently, no evidence-based framework exist to guide the evaluation of transitional foods in adult populations. Most available assessment tools, such as those developed for traditional TMF, are designed for static food textures and are not designed to capture the dynamic, in-mouth transformations that define transitional foods. This lack of validated assessment methods makes it difficult for clinicians to confidently recommend or monitor the use of these foods in therapeutic or daily care settings.

Furthermore, the oral processing phase, where transitional foods undergo their characteristic transformations, requires greater attention in current dysphagia assessment approaches. This phase encompasses all chewing activities contributing to bolus formation and swallowing, including jaw movements, muscle activity, tongue movements, and saliva secretion, during which food structure is irreversibly changed through particle size reduction, enzymatic hydrolysis, and wetting, softening, and clustering of food particles (Guo, 2021). It is during this stage that the texture changes occur in transitional foods, and any failure to adequately process the food could lead to safety risks such as choking, residue build-up, or premature spillage. While instrumental assessments focus primarily on pharyngeal and oesophageal function through hospital-based evaluations, limited attention is given to evaluating whether individuals can functionally complete the oral preparatory stage of swallowing (Lambert & Gisel, 1997). This gap is especially relevant in the context of transitional foods, as their therapeutic mechanism depends on successful oral processing, the very phase that existing assessment frameworks inadequately address.

This lack of clinical guidance presents a challenge for speech-language therapists, dietitians, and other professionals tasked with ensuring safe and enjoyable eating for individuals with dysphagia. Without a structured framework, it is difficult to identify suitable candidates for transitional foods, predict how these foods will behave in the mouth, or evaluate their effectiveness in real-world contexts.

Given the growing clinical interest in transitional foods and their potential to enhance patient experience, there is a clear need to develop reliable and practical evaluation tools. Addressing this gap will not only support safer and more effective dysphagia management but will also contribute to more person-centred care that values both nutritional and psychosocial wellbeing.

1.6 Theoretical Framework

This study is theoretically grounded in the principles of food rheology and tribology, which together explain the transformations that occur as foods are broken down, lubricated, and prepared for swallowing. Rheology refers to the study of how bulk food materials deform and flow under applied force, while tribology examines the friction, lubrication, and wear between interacting surfaces in relative motion (Titoria, 2017; Vieira et al., 2020). In simple terms, rheology tells us how thick, runny, or firm a food is when we move it, and tribology tells us how slippery or sticky it feels as it slides across the tongue and palate. These concepts provide the foundation for understanding how transitional foods behave during oral processing and influence swallowing safety.

Texture and mouthfeel play a central role in how consumers experience and accept food. Rather than relying solely on static properties of intact foods, current research emphasises the need to evaluate how these sensory attributes evolve during consumption (Gamonpilas et al., 2023). To address this, emerging approaches now focus on capturing the dynamic interactions that occur in the mouth, using rheology and tribology approaches, along with complementary tools like microscopy and particle size analysis (Titoria, 2017). This shift aligns with the broader understanding that texture perception is influenced by a transition from bulk material properties to interfacial friction and lubrication dynamics—that is, the resistance and lubrication effects occurring at the boundary between surfaces, such as between food particles and saliva or between the tongue and palate—during oral processing (Chen & Stokes, 2012; He et al., 2022; Sarkar et al., 2021; Stokes et al., 2013). Together, these perspectives provide a basis for evaluating whether a food is likely to be safe and manageable during oral processing and swallowing.

Food ingestion involves a complex interplay of forces and material transformations (Engmann & Burbidge, 2013). During oral processing, foods typically transition from a rheology-dominated phase, where bulk flow and deformation properties govern behaviour, to a tribology-dominated phase during swallowing, where surface friction and lubrication are more influential (Chen & Stokes, 2012; He et al., 2022; Sarkar et al., 2021; Stokes et al., 2013). The nature of this transition, however, varies with food structure and type (Sharma et al., 2022). Solid foods usually follow a sequential pathway, beginning with structural breakdown and comminution that produce rheology-driven sensory experiences, which later give way to tribology-driven effects as fragments aggregate into a bolus (Koç et al., 2013; Sharma et al., 2022; Stokes et al., 2013). By contrast, semisolid and texture-modified foods such as purees undergo little or no mechanical breakdown since their structure is already softened during processing. Instead, oral manipulation primarily involves mixing and shearing with saliva at the surface level, meaning that both rheological and tribological factors remain influential throughout consumption (Krop et al., 2019; Ningtyas et al., 2019).

For transitional foods, which undergo active transformation from solid to softer consistencies during oral processing with minimal oral effort, Rheological changes occur as the initial solid state softens through the influence of saliva, temperature, and minimal oral pressure, altering yield stress (the minimum stress required to initiate flow) and viscosity as the food breakdown. Concurrently, tribological properties evolve as the food's surface characteristics change during this transformation. How these dynamic changes compare to the static properties of TMFs, and whether they influence bolus formation, clearance or aspiration risk differently largely unexplored.

Rheology provides crucial insight into the link between food structure, physicochemical properties, and sensory texture, enabling quantification of yield stress, viscosity profiles, and fracture properties via standard rheometry (Vieira et al., 2020). However, key textural changes that occur during the late stages of mastication—such as lubrication, friction, and bolus cohesion—are not captured by rheometry, resulting in poor correlation with bolus characteristics just prior to swallowing (Marconati & Ramaioli, 2020; Vieira et al., 2020). This limitation underscores the importance of incorporating tribological perspectives alongside rheological measures, a combined approach that directly informs the framework developed in this study to link food material science with swallowing physiology.

1.7 Research Aim and Objectives

While this study focuses on transitional foods, limited research currently addresses transitional foods in adults with dysphagia. Therefore, this research draws more broadly on literature examining texture-modified food assessment, with careful consideration of relevance and applicability to transitional food evaluation.

Research Aim:

The primary aim of this study is to develop a clinically applicable, evidence-informed framework for evaluating the oral processing characteristics of transitional foods

Research objectives:

To achieve this aim, the study will pursue the following objectives :

Objective 1: Literature Identification

Conduct a focused systematic literature search across several databases to identify the components and methods used when texture modified foods are assessed in dysphagia management.

Objective 2: Quality Appraisal

Critically evaluate included studies for methodological quality, study rigour, and relevance to transitional food evaluation.

Objective 3: Evidence Synthesis

Synthesise evidence across identified studies to reveal patterns, gaps, and priorities in texture modified food assessment practices to inform transitional food assessment framework development.

1.8 Scope of the Study

This study focuses on the oral and oral preparatory phases of swallowing, with particular attention to how transitional foods behave from the initial bite through to swallow initiation. The research addresses three interconnected areas: (i) early oral processing activities such as biting, chewing, and bolus formation, (ii) the texture transformation and interaction with saliva during oral processing, and (iii) the identification of measurable features relevant to swallowing safety and the suitability of foods for dysphagia management.

To address these aims, the study adopts a literature synthesis approach, drawing evidence from multiple disciplinary sources relevant to oral processing and dysphagia. Literature is sourced from food science, tribology, rheology, sensory science, and clinical dysphagia research to inform the development of an evidence-based framework for evaluating transitional foods. The scope of the study is intentionally bounded to published literature, with no new data collection or clinical testing. The intended users of the resulting framework are researchers and clinicians involved in dysphagia management, particularly speech-language therapists/ speech and language pathologists, clinical dietitians, and members of multidisciplinary swallowing teams.

The expected deliverables include: a literature-informed framework describing measurable features of oral processing relevant to transitional foods, a practical, evidence based assessment guidance enabling clinicians to evaluate transitional food behaviour from bite to swallow initiation, and a theoretical foundation for future empirical research, including clinical trials and validation studies.

1.9 Significance and the contribution

This research enhances dysphagia management strategies by addressing the current gap in the evaluation of transitional foods. By developing a structured, literature-informed framework focused on oral processing, the study supports clinicians to make safer, more informed dietary recommendations. This directly contributes to improved patient safety, more personalised dysphagia care, and better quality of life for individuals requiring modified diets. Its significance extends across individual, clinical, and research levels. As a systematic effort to establish an evaluation framework for transitional foods, this research contributes to both clinical practice and academic discourse. It bridges concepts from food science, tribology, and clinical swallowing research, laying the groundwork for a more integrated and multidisciplinary approach to dysphagia care.
Furthermore, by establishing measurable parameters for transitional food consistency, the study advances theoretical understanding of the relationship between food texture properties and swallowing biomechanics. The proposed framework clarifies how specific rheological characteristics influence swallowing safety and efficiency, and may challenge current assumptions about texture modification. Beyond its immediate clinical utility, this framework will provide a foundation for future empirical work, including clinical trials and validation studies involving both typical and disordered swallowing populations.

1.10 Chapter Summary

This chapter introduced dysphagia, its clinical consequences, and the limitations of traditional texture modified foods. It also presented transitional foods as a promising alternative that may better support sensory, psychosocial, and functional needs in dysphagia management. The chapter outlined the theoretical foundations that guide the study, including concepts from rheology, tribology, and oral processing. It then identified a central gap in current practice: the limited evidence for evaluating transitional foods during the swallowing process. The research aim, objectives, and scope were described to establish the need for a structured and literature informed evaluation framework.

Chapter Two builds on this introductory overview by providing a detailed examination of the existing evidence related to texture modified foods, transitional foods, and oral processing. While Chapter One introduces the core concepts and explains why they matter for the present study, Chapter Two extends this by synthesising the literature, identifying patterns and gaps, and outlining the components and measures required to support the development of an evaluation framework for transitional foods.

2. Chapter Two: Literature Review

Understanding the relationship between swallowing physiology, food properties, and clinical management is important for developing effective interventions in dysphagia care. While Chapter One introduced the clinical problem, key concepts, and theoretical frameworks that underpin this study, this chapter extends that foundation by synthesising the literature in greater depth. This chapter presents a thematic review of literature from speech and language therapy, sensory science, and food sciences to provide a foundation for evaluating transitional foods - foods that transform into a different texture during oral processing in response to moisture, temperature, or gentle pressure. Transitional foods are increasingly recognized for their potential to enhance both swallowing safety and sensory experience of eating (Barewal, 2025; Barewal et al., 2021; Bayne et al., 2022; Bruno et al., 2025; Guénard-Lampron et al., 2021; Shune & Barewal, 2022; Yu et al., 2023). The chapter is organised around several key themes: dysphagia pathophysiology, current TMF strategies, the role of multisensory eating, oral processing mechanics, assessment methods, and food science principles such as rheology and tribology. Each section highlights knowledge gaps and supports the development of a structured, evidence-based framework to assess the oral processing characteristics of transitional foods. This narrative review examined literature from Google Scholar, PubMed, CINAHL, and Scopus using search terms such as "transitional foods", "texture-modified foods", "dysphagia", "oral processing", and related terminology with no time frame restrictions.

2.1 Swallowing and Dysphagia

Early research by Logemann (1984) outlined the sequential nature of swallowing across distinct phases, establishing a foundational model that continues to inform both clinical practice and research. Building on this foundation, more recent biomechanical studies have provided deeper insights into the neuromuscular coordination required for safe swallowing. For example, Farazi et al. (2015) developed a three-dimensional dynamic biomechanical model that highlights the complexity of oral, pharyngeal, and laryngeal integration during deglutition. These models highlight the remarkable precision and timing required for normal swallowing and provide an important framework for understanding how impairments in this process lead to dysphagia.

Dysphagia refers to any disruption in the swallowing process and may occur in one or more phases of deglutition (Sungsinchai et al., 2019). It is a significant concern because it compromises both nutritional intake and airway protection, with consequences ranging from dehydration and malnutrition to aspiration and reduced quality of life. Beck et al. (2018) highlighted that oropharyngeal dysphagia decreases the safety and efficiency of swallowing, increasing risks of aspiration, malnutrition, and related complications. Similarly, Guénard-Lampron et al. (2021) reported that impaired muscle coordination, delayed reflexes, or residual food in the mouth elevate aspiration risk, which, when combined with poor nutrition, can lead to aspiration pneumonia. Collectively, these findings demonstrate that dysphagia not only impacts physical health but also contributes to social withdrawal and a heightened healthcare burden (Seshadri et al., 2018).

To reduce these risks, people with dysphagia are often advised to consume foods that are easier to chew and safer to swallow (Pedersen et al., 2016; Sungsinchai et al., 2019; Tokifuji et al., 2013). However, dietary modification represents only one aspect of management. Current clinical practice incorporates both compensatory strategies (e.g., postural adjustments, altered textures, and thickened liquids) and rehabilitative approaches (e.g., swallowing exercises, sensory stimulation, and neuromuscular training) (Easterling, 2018). Together, these approaches aim to enhance swallowing safety, maintain nutrition, and improve quality of life. Within this context, texture modified foods (TMF) and thickened fluids have emerged as key compensatory strategies, and the following section reviews their role in dysphagia management.

2.2 Current management strategies

Texture modified foods (TMF) are defined as foods that have been altered through physical or chemical processes to minimize the risk of choking and aspiration (Cichero et al., 2013; Fiszman & Laguna, 2023). Although texture modification has long been applied in food science, its adoption as a clinical strategy in dysphagia management is relatively recent (de Villiers et al., 2020).

The recommendation to use TMF for dysphagia management has often relied more on clinical best practices than on robust systematic reviews of evidence base (Beck et al., 2018). This reliance on experience and tradition rather than high-quality trials highlights an important concern: TMFs are widely prescribed, yet the strength of supporting evidence remains limited (Hansen et al., 2022). Despite this, significant progress has been made in standardising practice. The introduction of the International Dysphagia Diet Standardisation Initiative (IDDSI) addressed longstanding inconsistencies in terminology and classification (Cichero et al., 2017; Cichero et al., 2013). This global framework has been positively received by healthcare providers, industry stakeholders, and caregiving communities, and has now been adopted in over 50 countries for dysphagia management (Su et al., 2018). IDDSI has therefore facilitated more systematic implementation of TMFs across healthcare systems worldwide.

Nevertheless, despite their global uptake, several notable limitations of TMF have been repeatedly identified. These limitations fall into three interconnected domains: sensory appeal, nutritional adequacy, and adherence. Adherence in this context refers to the degree to which individuals are willing or able to comply with prescribed texture modified diets (Krekeler et al., 2018; Nagshabandi et al., 2023). Pureed or heavily modified textures are often perceived as unappetizing, reducing mealtime enjoyment and negatively affecting adherence (Hall & Wendin, 2008; Keller et al., 2012; Mioche et al., 2004). Wu et al. (2021) further note that extended meal durations, fatigue from prolonged chewing or swallowing, and increased reliance on feeding assistance may exacerbate low adherence, particularly in individuals with cognitive or physical impairments. Nutritional concerns have also been raised as blending, sieving, and thickening processes can reduce nutrient density and compromise dietary adequacy (Fiszman & Laguna, 2023; Keller et al., 2012). Taken together, challenges across all three domains—sensory, nutritional, and adherence—have been shown to compromise patient outcomes and quality of life.

van den Steen et al. (2025) observed that while TMFs are widely used among individuals with oropharyngeal dysphagia (OD), their use is frequently associated with poor nutritional status and diminished quality of life, factors that in turn heighten aspiration risk in vulnerable populations. Similarly, O'Keeffe (2018) have raised concern about the delicate balance between safety and quality of life, noting that restrictive and poorly accepted diets may compromise long-term therapeutic goals. Shune and Barewal (2022) emphasised the severity of the issue, stating that texture-modified foods carry a "high biopsychosocial cost," contributing simultaneously to malnutrition and quality of life. Taken together, these findings demonstrate that the limitations of TMF have important clinical implications.

Beyond clinical outcomes, TMF are also associated with economic and practical challenges. From an economic standpoint, the cost of thickening agents and modified diet preparation is considerable, and questions have been raised about the cost-effectiveness of such interventions given their unproven clinical benefits (O'Keeffe, 2018). On a practical level, studies have identified multiple barriers to implementation across healthcare settings, including inconsistent food quality and portion sizes, lack of standardisation in meal distribution and feeding assistance, inadequate dining environments, communication breakdowns between staff, time pressures, and limited staffing resources (Hill et al., 2022; Ullrich et al., 2014; Wu et al., 2022). Collectively, these challenges compromise adherence and reduce the effectiveness of TMFs in real-world practice.

Despite these substantial limitations, texture modified foods remain a cornerstone of dysphagia management. Their widespread ongoing use reflects longstanding clinical familiarity, limited alternative options, and the perception that they improve swallowing safety based on plausible pathophysiological rationale including evidence that TMF can reduce penetration and aspiration, enhance mealtime efficiency, and support individuals with dental or masticatory challenges (Coyle et al., 2009; McCurtin & Healy, 2017; Mocchetti et al., 2025; O'Keeffe, 2018; Rofes et al., 2011). However, recommendations for TMF should be made cautiously, with careful consideration of timing and appropriateness. Equally important is ensuring transparent discussion with patients and families, with informed consent actively obtained to support shared decision making (O'Keeffe, 2018).

Given the well-documented nutritional, sensory, adherence, economic, and practical challenges associated with TMF, there is growing recognition that alternative approaches may be necessary. While texture modified foods have traditionally been the standard intervention, the emergence of transitional foods presents one such promising alternative that warrants further exploration.

2.3 Emergence of transitional food

In response to the limitations of TMFs, researchers across various disciplines including speech-language therapists, food scientists, and nutritionists have begun exploring alternative dietary options. Efforts have also been made to improve existing TMF by enhancing visual appeal, optimising flavours, and incorporating innovative texture-modifying agents such as xanthan gum, enzymes, and gelling agents. These modifications have shown some early success in improving safety outcomes and increasing oral intake (Okkels et al., 2018; Pu et al., 2021; Vilardell et al., 2016; Wu et al., 2022). Additionally, recent research highlights the need to assess TMF characteristics beyond traditional parameters such as bolus volume, viscosity, and temperature (van den Steen et al., 2025). This emerging focus on exploring alternative textural properties within existing TMF categories has also sparked broader interest in fundamentally different approaches to texture modification, including foods that undergo dynamic transformation during oral processing. Among these approaches, transitional foods have emerged as a promising alternative .

Transitional foods are defined by IDDSI (2019) as “foods that start as one texture (e.g., firm solid) and change into another texture specifically when moisture (e.g., water or saliva) is applied, or when a change in temperature occurs.” Unlike TMF, their transformation occurs naturally during oral processing with minimal oral effort rather than through external manipulation, aligning more closely with the physiological process of eating. With these unique dissolution properties, transitional foods show great potential as a clinically viable alternative to pureed foods for individuals requiring texture modification (Bruno et al., 2025). Building on this potential, originally introduced to support chewing development in children, transitional foods are now being considered as an alternative to standard TMFs for managing dysphagia in adults (Barewal, 2025; Bruno et al., 2025; Mocchetti et al., 2025).

While paediatric and adult populations differ clinically, the theoretical basis for this extrapolation lies in the shared principles of oral processing, bolus formation, and safe swallowing mechanics, which are central to both populations. However, the evidence base remains limited, with only a small number of studies worldwide investigating their role in adults with dysphagia.

Recent studies have explored both the sensory and physiological properties of transitional foods. Bayne et al. (2022) investigated sensory-enhanced, fortified transitional snacks in nursing home residents and found that these foods could improve nutrient intake while offering palatability benefits. Yu et al. (2023) explored the development of transitional foods using hydrophilic colloids (water-absorbing food texture modifiers) and 3D printing with fish paste, demonstrating that transitional foods can balance safety and palatability. Expanding on behavioural aspects, Barewal et al. (2021) examined the dissolution and breakdown of transitional foods under varying oral conditions such as tongue pressure, saliva production, and time. Their findings underscored that transitional food behaviour is highly individualized, influenced by both physiological and sensory factors, and not yet fully understood in adults with dysphagia. This highlights the need for individualized evaluation protocols and stronger evidence on post-oral processing outcomes. In terms of swallowing physiology, Mocchetti et al. (2025) compared transitional foods, purees, and regular solids using FEES and found that transitional foods were associated with greater swallowing efficiency and reduced pharyngeal residue. Bruno et al. (2025) examined oropharyngeal swallowing during video-fluoroscopic assessment and reported that transitional solids did not increase risk compared to pureed foods, supporting their potential as a safe and, as framed by the authors, a "bridge" consistency in dysphagia management. Shune and Barewal (2022) highlighted the importance of sensory-enhanced snacks in improving intake, particularly in nursing home residents, emphasising that food enjoyment and emotional satisfaction can influence nutritional outcomes. While these studies provide encouraging preliminary evidence, several limitations must be acknowledged. Many investigations were conducted with small or convenience samples, often in homogeneous populations, limiting generalizability. The foods tested were typically restricted to a single type of transitional or control food, and study protocols differed from standardised conditions, which may have influenced outcomes. Individual factors such as salivary flow, xerostomia, dentition, taste preferences, and prior snack experiences could also affect oral processing, swallowing performance, and overall acceptability (Barewal et al., 2021; Bayne et al., 2022; Bruno et al., 2025; Mocchetti et al., 2025; Shune & Barewal, 2022; Yu et al., 2023). Additionally, inconsistencies in sensory descriptor usage and evaluation methods across studies have been highlighted, indicating a need for standardised approaches (Guénard-Lampron et al., 2021).

Taken together, while transitional foods show potential for enhancing swallowing efficiency, palatability, and nutritional intake, their clinical utility remains insufficiently understood because the existing evidence base is still small and fragmented. Current studies vary widely in design, populations, and outcome measures, making it difficult to draw firm conclusions about how transitional foods influence swallowing physiology, sensory experience, or nutritional intake. Greater conceptual and methodological clarity is needed before transitional foods can be confidently integrated into adult dysphagia care or used to guide clinical recommendations.

To deepen this understanding, the following section considers the multisensory nature of eating and its relevance to dysphagia care.

2.4 Eating as a multisensory experience

For individuals with dysphagia, the multisensory aspects of eating remain just as important as they are for those without swallowing difficulties (Amitrano, 2024). Eating is widely regarded as one of the most multisensory human experiences, involving sight, smell, taste, texture, and sound. These sensory cues play a crucial role in food enjoyment, selection, and intake (Karani & Pillay, 2021; Spence, 2017; Spence & Shankar, 2010). Beyond hedonic value, palatability, visual appeal, aroma, taste, and texture also influence food intake regulation by shaping behaviour before, during, and after eating (McCrickerd & Forde, 2016). These sensory cues guide expectations before eating, influence bite size and oral processing behaviour during eating, and determine satisfaction and willingness to continue intake after eating.

Evidence suggests that the influence of sensory cues on swallowing may differ between typical and dysphagic populations. Loret (2015) emphasised these differences and highlighted the need for systematic research to better understand the contribution of multisensory factors to safe and efficient swallowing. In dysphagia care, preserving sensory qualities is associated with improved satisfaction and adherence to modified diets, particularly among vulnerable populations such as infants and older adults, who may have specific sensory and nutritional needs. For example, Karani and Pillay (2021) reported that altering auditory cues, such as enhancing chewing sounds to resemble a crisp or crunchy texture, can change how individuals perceive food texture, even when the physical properties of the food remain unchanged. This demonstrates that auditory information can shape texture perception and may offer ways to enhance the acceptability of texture-modified foods in dysphagia care.

However, conventional texture-modified foods, while effective for safety, often compromise multisensory elements, leading to reduced pleasure, intake, and long-term compliance. Schwartz et al. (2018) emphasise that food design for dysphagia must go beyond safety alone to also incorporate hedonic and psychosocial aspects, as this balance is critical for supporting adherence and quality of life. Transitional foods may offer unique advantages over conventional TMFs by preserving or reintroducing sensory qualities that are often lost during texture modification. Because of their initial structure and how they break down with saliva interaction, body temperature and minimal oral effort, transitional foods can provide enhanced visual, auditory, textural, and taste cues compared to TMFs. These features may increase willingness to consume modified diets, support nutritional adequacy, and improve overall quality of life (He et al., 2022).

To understand these potential benefits more fully, it is important to examine the mechanics of oral processing, particularly as transitional foods undergo texture transformation during this phase.

2.5 Oral processing Mechanics

Oral processing refers to the dynamic and multifaceted sequence of actions that transform food from its initial state into a swallow-ready bolus (Titoria, 2017). It begins with the grip and initial bite, followed by the first stage of transportation, chewing and mastication, second stage transportation, bolus formation, and eventually swallowing. These actions can occur sequentially, such as biting, transport, and chewing or simultaneously, as in oral selection, bolus manipulation, and second stage transport (Chen, 2009; He et al., 2022; Liu et al., 2017; Lucas et al., 2002; Wang & Chen, 2017). Effective food management during oral processing ensures that food is broken down into a size, shape, and consistency that is safe for swallowing, while also allowing full sensory appreciation of texture and flavour. This complex process involves decision-making and coordinated oral movements, the sequencing of which is important for safe and efficient eating (Chen, 2009).

Each of these stages plays a crucial role in transforming food into a cohesive and swallowable form, with variations depending on food texture and individual oral physiology.

The sequential and interconnected nature of these oral processing stages is effectively illustrated in the comprehensive framework developed by Lucas et al. (2002) as shown in Figure 2.

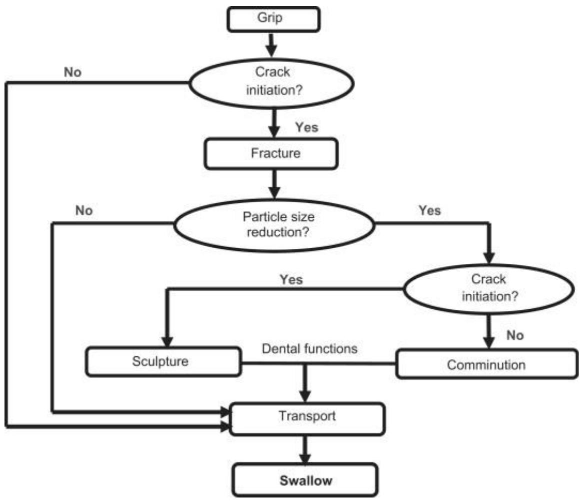

Figure 2: *Overview of food processing as a sequence of events.*

Decision boxes are shown as ovals while process boxes are rectangular. Adapted from Lucas et al. (2002)

Food texture (or sometimes mouthfeel) is a sensory reflection of the structural, mechanical, and surface properties of the food. However, texture perception is, in principle, influenced by two main factors: the properties of the food and the individual's oral physiology. This highlights the interplay between food physics and oral physiology in texture perception during oral processing (He et al., 2022). Unlike conventional texture-modified foods that maintain static properties, transitional foods must be engineered to respond predictably to the mechanical forces and conditions present during oral processing. As such, understanding the mechanical and sensory properties of food is important particularly for transitional foods, where in-mouth transformation depends on both food physics and individual oral function, which will be further explored in the following section on food rheology and tribology.

2.6 Role of Food Rheology and Tribology

The integration of rheological and tribological principles in clinical settings represents a paradigm shift toward evidence-based food design for therapeutic purposes, addressing both safety and nutritional needs of patients with compromised oral processing abilities (Gamonpilas et al., 2023; Vieira et al., 2020).

These transitions are highly relevant in dysphagia care. For example, if a food lacks sufficient cohesiveness or yields inconsistent lubrication, it may form a fragmented bolus or stick to oral/pharyngeal surfaces, raising the risk of residue and aspiration. Clinical studies have shown that viscosity, cohesiveness, and adhesiveness are key rheological parameters for bolus formation and transit, while tribological qualities like slipperiness or friction impact comfort and efficiency during swallowing. As such, rheology and tribology provide vital insight into the safety, efficiency, and sensory acceptability of foods used in dysphagia management (Gamonpilas et al., 2023). Recognizing these physical parameters is particularly important in dysphagia assessments, where clinicians must evaluate the safety and effectiveness of foods tailored to impaired swallowing, especially in transitional foods where in-mouth transformation is expected.

Emerging evidence supports this perspective. Mocchetti et al. (2025) demonstrated that transitional foods achieved better swallowing efficiency than both solid and puréed textures, highlighting their potential clinical utility. The study suggests that the initial solid-like structure of transitional foods promotes the formation of a more cohesive bolus, while their subsequent softening facilitates smoother transport through the oropharynx. By contrast, low-viscosity purées such as applesauce may lack sufficient cohesion, spreading unpredictably in the oral cavity and leading to greater pharyngeal residue. These findings directly illustrate how transitional foods leverage rheological changes (from solid-like matrices to cohesive, lower-viscosity boluses) and tribological advantages (enhanced lubrication during transport) to support safer and more efficient swallowing.

This highlights the need to understand dysphagia management through a cross-disciplinary lens, integrating knowledge from fields such as food science, medical science, and material science. Food science plays an essential role in the management of oropharyngeal dysphagia (OD), offering tools to objectively formulate, assess, and optimize the physical, chemical, and sensory properties of food. As Fiszman and Laguna (2023) argue, addressing swallowing impairments effectively requires an interdisciplinary approach, one that merges clinical insights with the analytical precision of food science. This collaboration is crucial not only for improving safety and functionality but also for enhancing the sensory experience of modified diets through measurable and replicable methods.

Considering the multifaceted nature of oral processing, including rheological transformations, tribological interactions, and sensory perception it is important to explore how current instrumental and non-instrumental clinical tools measure these dynamics and where further development is needed to capture transitional food behaviours.

2.7 Clinical Evaluation Tools and Gaps

Due to the high prevalence of dysphagia and its wide ranging health, emotional, social, and economic consequences, early identification through systematic screening is important for improving patient outcomes. This underscores the need for standardised, reliable, and valid screening and assessment tools for dysphagia (Speyer et al., 2022; Swan et al., 2019).

Swallowing assessments can be instrumental, non-instrumental, or both (Cordier et al., 2023b). Often referred to as a clinical swallowing evaluation, non-instrumental assessments are typically performed by a dysphagia expert at the bedside, in a clinic, or at home, involve collecting medical history, patient-reported symptoms, and conducting a physical examination with clinical observations of oral motor, sensory evaluation; and (mostly) inferred outcome of laryngeal, pharyngeal and oesophageal swallow functions (Andrews & Pillay, 2017; Rumbach et al., 2018). These methods aim to identify potential causes of swallowing difficulties, evaluate swallowing safety, guide feeding decisions, and determine the need for further testing. While valuable, non-instrumental methods cannot directly visualize the internal swallowing mechanisms (Cordier et al., 2023; Speyer et al., 2022; Swan et al., 2019).

In cases requiring more detailed physiological analysis, instrumental assessment may be warranted. These methods can identify aspiration, including silent aspiration, and other physiological problems in the pharyngeal phase. Two widely used gold standard instrumental assessments are the Fiberoptic Endoscopic Evaluation of Swallowing (FEES) and the Videofluoroscopic Swallowing Study (VFSS) (Cordier et al., 2023a; Cordier et al., 2023; Speyer et al., 2022; Swan et al., 2019).

Each of these modalities offers distinct advantages and limitations. FEES provides bedside or clinic-based visualization of pharyngeal anatomy, bolus residue, penetration, and aspiration events without radiation exposure, making it portable and accessible (Allen et al., 2021). However, it cannot assess oral phase coordination and is limited by the transient "white-out" during swallowing, which prevent continuous visualization of the swallow sequence (Cordier et al., 2023; Helliwell et al., 2023; Speyer et al., 2022).

In contrast, VFSS enables dynamic visualization across oral, pharyngeal, and upper oesophageal phases, allowing for measurement of kinematic parameters such as oral transit time, swallow initiation, and bolus flow (Wu et al., 2024). Despite these strengths, VFSS involves radiation exposure, requires frame-by-frame analysis with external software for detailed measurements, and often uses snapshot sequences that may miss intermittent swallowing deficits. Furthermore, VFSS cannot visualize mucosal tissues or vocal fold movement (Cordier et al., 2023; Helliwell et al., 2023; Speyer et al., 2022).

Although indispensable in clinical practice, both FEES and VFSS share methodological inconsistencies, including variability in protocols, bolus consistencies, and frame rates, while lacking standardised, psychometrically validated visuoperceptual scoring systems that rely heavily on clinician interpretation (Cordier et al., 2023; Helliwell et al., 2023; Speyer et al., 2022). More importantly, neither method is designed to capture quantitative measures of the oral-preparatory phase, where foods undergo rheological and tribological transformations essential for safe swallowing. This makes them insufficient for addressing key questions about texture modification, lubrication, and oral sensory processing in dysphagia management.

To complement FEES and VFSS, researches have investigated other modalities such as ultrasound and electromagnetic articulography to examine oral-preparatory and oral stage of swallowing (Allen et al., 2021; Huckabee et al., 2012; Wu et al., 2024). While these approaches offer promising insight, they remain largely research tools requiring further development, standardisation, and validation (Allen et al., 2021; Fuentes et al., 2018; Steele & Van Lieshout, 2004; Wu et al., 2024). Similarly, technique such as cervical auscultation and manometry have shown potential but are still limited by a lack of standardised protocols, normative data, and clinical validation (Allen et al., 2021; Wu et al., 2024).

Importantly, none of these existing assessments, including FEES, VFSS, EMA, US, manometry, and cervical auscultation comprehensively evaluate oral-phase dynamics, including texture transformation, lubrication, and sensory aspects of oral processing. This gap underscores the need for robust, standardised criteria and tools capable of assessing oral-preparatory and oral stages of swallowing and sensory dynamics of oral processing in dysphagia evaluation. This is particularly relevant for transitional foods, where evidence-based assessment of safety and efficiency must be grounded in both clinical outcomes and food material science principles.

Thus, advancing transitional foods as a therapeutic option requires new integrative assessment tools that capture both swallowing physiology and the rheological/tribological transformations that occur during oral processing.

2.8 Rationale for the Study

Emerging research into transitional foods suggests promise for their use in dysphagia management, particularly given their potential to balance safety, nutrition, and patient acceptability (Barewal et al., 2021; Bayne et al., 2022). However, the evidence base remains limited and fragmented. Few studies have systematically investigated the oral processing behaviour of transitional foods, especially in relation to texture change, dissolution, and the interaction with individual oral physiology (Barewal et al., 2021; Bruno et al., 2025; Mocchetti et al., 2025; Shune & Barewal, 2022). Sensory dimensions such as lubrication, mouthfeel, and taste which is important for swallowing safety and adherence, also remain underexplored in this context (Schwartz et al., 2018).

Adjusting texture and viscosity alone does not guarantee safe swallowing or improved quality of life. Instead, a more holistic approach is needed, one that incorporates rheological, tribological, and sensory properties of food alongside clinical swallowing assessments (Poursani & Razavi, 2023). Current clinical assessments such as FEES, VFSS, EMA, US, manometry, articulography and cervical auscultation provide valuable insight into swallowing physiology (Allen et al., 2021; Cordier et al., 2023a; Helliwell et al., 2023; Speyer et al., 2022; Wu et al., 2024) and can be complemented by methods that specifically capture the oral-processing dynamics and in-mouth textural transformations that are unique to transitional foods.

Instrumental techniques from food science, such as rheological and tribological testing, are powerful for characterising material properties. Yet, they cannot fully replicate or predict the sensory experiences perceived by patients during oral processing (Chen, 2020; Nishinari et al., 2019). This highlights the need for cross-disciplinary integration: food science methods can define measurable properties of transitional foods, while clinical and sensory sciences provide critical insights into their real-world safety, functionality, and acceptability (Fiszman & Laguna, 2023; Loret, 2015; Schwartz et al., 2018).

At present, no structured clinical framework exists to bring these dimensions together. The current evidence base for transitional foods is much smaller than that for texture-modified diets, and this imbalance must be acknowledged. Rather than assuming established efficacy, it is important to recognise transitional foods as a developing area where foundational research is still emerging.

This study therefore addresses this gap by conducting a structured, literature-informed investigation into the oral processing components of transitional foods. Through systematic evidence mapping and critical synthesis, it develops an evidence-informed framework that integrates food science, sensory science, and clinical perspectives. While preliminary in scope and based on existing literature rather than new clinical data, the framework provides a foundational resource to guide future research, clinical education, and potential translation into practice.

By situating transitional foods within an interdisciplinary assessment model, this study contributes to the development of safer, more effective, and patient-centred dysphagia management strategies, while also identifying the areas where further empirical work is needed.

2.9 Chapter summary

This chapter reviewed the existing evidence on dysphagia, texture-modified foods, transitional foods, and oral processing to provide a deeper foundation for the present study. It explored how swallowing physiology, sensory experience, food structure, and oral processing interact, and examined emerging research that positions transitional foods as a potential alternative to traditional TMFs. The chapter also discussed relevant concepts from sensory science, food rheology, tribology, and clinical swallowing assessment to highlight how these interdisciplinary perspectives contribute to understanding transitional food behaviour. Together, this review outlines the broader evidence landscape and clarifies why transitional foods require more focused, structured evaluation in adult dysphagia care.

Chapter Three will outline the methodological approaches used in the present study to support the development of an evidence-informed evaluation framework.

3 Chapter Three: Methodology

This chapter outlines the methodological approaches used to develop a clinically applicable, evidence-informed framework for evaluating the oral processing characteristics of transitional foods. A multiphase research design, informed by qualitative evidence-synthesis principles, was adopted to ensure methodological rigour and coherence. Each phase is described in detail, including its rationale, procedures, and contribution to the development of the transitional food assessment framework. Data collection and analysis strategies are also presented to demonstrate how rigour, transparency, and clinical relevance were maintained throughout the research process.

3.1 Research Aim:

The primary aim of this study was to develop a clinically applicable, evidence-informed framework for evaluating the oral processing characteristics of transitional foods

3.2 Objectives:

Objective 1: Literature Identification

A focused systematic literature search was conducted across several databases to identify the components and methods used when texture modified foods are assessed in dysphagia management.

Objective 2: Quality Appraisal

Included studies were critically evaluated for methodological quality, study rigour, and relevance to transitional food evaluation.

Objective 3: Evidence Synthesis

Evidence was synthesised across identified studies to reveal patterns, gaps, and priorities in texture modified food assessment practices to inform transitional food assessment framework development.

3.3 Research design:

A qualitative evidence synthesis design was employed, combining systematic review methods with framework development to create an evidence-based framework for assessing transitional foods in dysphagia management. The study proceeded in three sequential phases:

2 Phase 1: Literature Identification – focused rapid systematic search of peer-reviewed literature and clinical guidelines to identify the components and methods used when texture modified foods are assessed in dysphagia management.

3 Phase 2: Quality Appraisal and Evidence Synthesis – Systematic content analysis and quality appraisal of included studies, followed by thematic synthesis of findings and gap identification.

4 Phase 3: Framework Development and Integration – Interpretive Integration of evidence into a draft assessment framework using a best-fit approach, ensuring clinical applicability and contextual adaptability.

3.4 Study Phases

3.4.1 Phase 1: literature identification

3.4.1.1 Purpose :

The purpose of Phase 1 was to conduct a focused and systematic search for existing literature on assessment methods for transitional foods in dysphagia management. Specifically, this phase sought to identify all relevant studies examining assessment approaches for texture-modified foods (including transitional foods) in adult dysphagia populations and capture the full range of methodological approaches currently used, including both established and emerging techniques. The phase aimed to establish a comprehensive evidence base to inform the subsequent critical analysis and synthesis phases while minimising the risk of omitting important studies through systematic, reproducible search procedures. Additionally, the phase sought to document the search process transparently to enable replication and validation of findings. The broader texture-modified food search scope ensured capture of methodological approaches applicable to transitional food assessment, recognizing that TF evaluation builds upon established TMF assessment foundations.

3.4.1.2 Search Strategy :

A focused literature search was conducted across multiple databases to maximise coverage of peer-reviewed and guideline-based literature. Searches were performed in PubMed, CINAHL, the Cochrane Library, and Scopus, representing biomedical, allied health, clinical, and multidisciplinary research sources relevant to food texture assessment and dysphagia. Studies published between 2000 and 2025 were included.

A staged, iterative search approach was employed, beginning with broad controlled-vocabulary terms (e.g., MeSH, CINAHL Headings), followed by combined controlled-vocabulary and free-text strategies, and concluding with highly targeted searches for emerging terms such as "transitional food". Citation tracking was also conducted through Scopus to identify additional relevant studies. Search terms combined keywords and controlled vocabulary to account for variability in terminology. Terms reflected the key concepts of dysphagia, oral processing, mastication, bolus formation, food texture and rheology, texture-modified diets, transitional foods, and assessment or evaluation. Boolean operators (AND, OR) and truncation were used to combine concepts and broaden retrieval while maintaining conceptual specificity. This search strategy encompassed both transitional foods and the wider category of texture-modified foods to ensure all potentially relevant methodological literature was captured.

Complete database-specific search strings, staged search attempts, and search decisions are provided in Appendix A (Search Log).

The eligibility criteria were defined a priori to ensure consistency and transparency. Studies were included or excluded based on the following criteria:

Inclusion Criteria :

Studies were included if they met the following criteria:

- Population: Adults (18+ years) or mixed adult/paediatric populations.
- Focus: Assessment methods, tools, or protocols for transitional foods or texture-modified foods relevant to oral processing, texture behaviour, or swallowing biomechanics.
- Methodology: Studies developing or validating assessment methods, including instrumental, sensory, rheological, biomechanical, or multimodal approaches.
- Publication Type:
    - Peer-reviewed journal articles (full text available)

    - Clinical practice guidelines from recognised professional organisations
    - Consensus statements from dysphagia or speech-language pathology associations
    - Conference proceedings with full-text papers
- Language: English publications, or English-language abstracts where key methodological elements could be identified.
- Time Frame: Studies published between 2000 and 2025, ensuring contemporary methodological relevance while allowing inclusion of foundational literature.

It is important to note that while systematic procedures were applied, this method does not constitute a full scoping review.

Exclusion Criteria :

Studies were excluded if they met any of the following criteria:

- Exclusively paediatric populations.
- Research not involving food texture assessment (e.g., liquids-only studies; For clarity, studies examining IDDSI Level 3 (Liquidised) and Level 4 (Pureed) foods were included, as these are classified as texture-modified foods within the IDDSI framework. Only studies assessing liquids alone (Levels 0–2), without any food texture component, were excluded.).
- Non-peer-reviewed literature (e.g., opinion pieces).
- Publications not available in English.
- Product formulation and food development studies (e.g., 3D-printing formulation optimisation).
- Patient assessment or screening tools.
- Food-only physicochemical characterisation without human assessment or methodological development.
- Qualitative studies without instrumental or measurable food assessment methodology.
- Clinical case reports, population studies, or clinical comparisons lacking methodological contribution to TF/TMF assessment.

These exclusion criteria aligned directly with the documented exclusion clusters identified during full-text review (Appendix A).

Search Management and Documentation :

All retrieved references were imported into EndNote for reference management, duplicate removal, and preliminary screening. Titles and abstracts were screened for relevance, followed by full-text review against the established inclusion and exclusion criteria. To enhance methodological rigour, a second reviewer independently verified the final set of included studies to ensure alignment with the predefined criteria, with any disagreements resolved through discussion and consensus.

The search process was documented in accordance with PRISMA (Page et al., 2021) guidelines to ensure transparency and reproducibility. Documentation included a detailed search log recording databases searched, search terms, staged search attempts, dates, and the number of records retrieved at each stage. A PRISMA flow diagram (Figure 3) was constructed to illustrate the number of studies identified, screened, excluded, and included. Reasons for exclusion were recorded during full-text review to ensure transparency in decision-making. This structured approach established a defensible and reproducible evidence base for subsequent phases of the study.

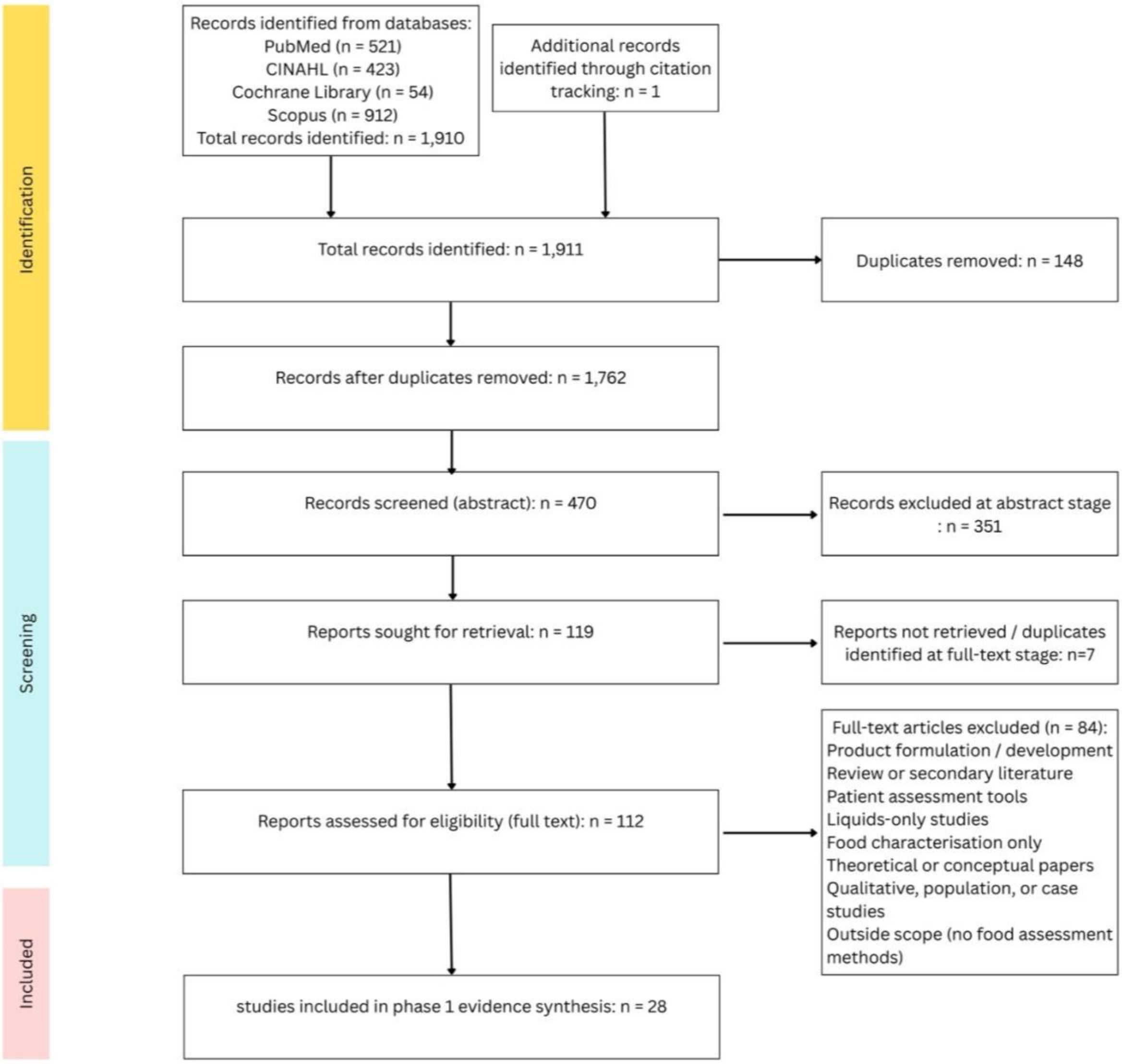

Figure 3: *PRISMA flow diagram*

displaying the search and screening process for Phase 1 - The diagram illustrates the total number of records identified (n = 1,910), duplicates removed (n = 148), records screened (n = 470), records excluded (n = 351), full-text articles assessed for eligibility (n = 112), full-text exclusions with reasons (n = 84), and the final number of studies included in the Phase 1 synthesis (n = 28).

3.4.1.3 Literature Extraction and Data Organisation

Systematic data extraction was conducted across all included studies using a purpose-developed literature extraction tool designed specifically for this study (Appendix B). The extraction process captured study identification details (author(s), year, country, study type), population characteristics (sample size, demographics, health or clinical group specifications), study aims and focus areas, and comprehensive assessment-related information. For each study, all components related to oral processing or swallowing assessment were systematically identified and recorded, including specific measurement parameters, assessment methods, tools employed, and outcome measures.

Component and Parameter Identification:

The extraction process identified both *what* studies assessed (component measurements) and *how* these assessments were conducted (methods and tools). Component descriptions were first extracted as reported by study authors. Overlapping or synonymous terminology was then consolidated to avoid duplicate counting. Components were subsequently mapped to their measurable units and assessment conditions. This process sometimes expanded the parameter inventory when a broadly described component represented multiple distinct measured variables, and in other cases consolidated several descriptions into fewer parameters when they reflected the same construct under similar measurement conditions.

Domain Organisation:

Identified parameters were grouped into conceptual domains based on their functional role within oral processing and swallowing. These domains were generated inductively through iterative analysis of the extracted data, with parameters clustered according to the swallowing phase they primarily addressed (e.g., oral preparatory, oral transport) and the type of measure they represented (e.g., structural, sensory, behavioural). Domain labels and boundaries were refined through repeated comparison and re-organisation to ensure they meaningfully represented the range of assessment approaches identified in the literature. This domain-based organisation provided a structured way to examine where assessment emphasis occurred across different stages of the eating and swallowing process.

Method Categorisation:

Assessment methods and tools were categorised to support systematic comparison of methodological approaches across the evidence base. Grouping methods into broader categories enabled identification of distribution patterns and highlighted the range of assessment techniques currently applied in texture-modified food evaluation.

The purpose-developed extraction tool ensured consistency in data capture across all studies, with key findings recorded alongside methodological strengths and limitations as reported by original authors. The completed extraction table formed a comprehensive evidence matrix that supported subsequent quality appraisal and thematic synthesis phases.

3.4.2 Phase 2 : Quality Appraisal and Evidence Synthesis

3.4.2.1 Purpose :

The purpose of Phase 2 was to conduct an in-depth, systematic examination of the studies identified in Phase 1, followed by evidence synthesis. This combined phase aimed to appraise the methodological quality and credibility of each included study while identifying and categorising the types of assessment methods reported for transitional foods. The phase sought to evaluate the strengths and limitations of current assessment approaches in terms of clinical applicability, reliability, and validity, and to identify recurring themes and patterns in the assessment of transitional foods. Additionally, the phase aimed to highlight important methodological strengths that could be adapted to a new framework, detect consistent gaps, limitations, and areas where evidence was lacking, and highlight methodological gaps that could inform the development of a systematic framework. Finally, the phase sought to map the relationship between current evidence and the practical requirements of clinical dysphagia management.

3.4.2.2 Methodological Approach

This phase combined systematic content analysis with thematic synthesis methodologies (Thomas & Harden, 2008). The content analysis involved extracting detailed information about study characteristics, assessment methods, outcome measurements, and key findings from all included studies. Studies were coded and categorised according to the type of assessment methods used such as instrumental approaches, sensory evaluation techniques, and in vivo testing procedures. Following this systematic examination, a thematic synthesis approach (Thomas & Harden, 2008) was employed to integrate findings into coherent evidence themes that would inform subsequent framework development .

3.4.2.3 Dual Quality Appraisal Framework

This phase combined the use of the Critical Appraisal Skills Programme (CASP) checklists (Critical Appraisal Skills Programme, 2018) with a purpose-developed methodological appraisal schedule (Appendix C). The CASP checklists were employed to assess overall study validity, clarity, and applicability, while the methodological appraisal schedule was intend to capture the specific methodological considerations relevant to swallowing and oral processing research.

CASP was not applied to include in-vitro studies, as its criteria are designed for studies involving human participants and do not align with laboratory-based experimental work. In-vitro studies lack participant-related constructs such as recruitment, ethical approval, or real-world applicability, making CASP inappropriate for evaluating their methodological quality.

To address this, the methodological appraisal schedule was applied across all studies. This schedule evaluated methodological rigour using criteria tailored to swallowing and oral-processing research, ensuring that all study types—clinical, instrumental, sensory, and in-vitro—were appraised consistently.

To enhance appraisal rigour, a second reviewer independently rated all 28 included studies using both the CASP checklist (for human studies) and the purpose-developed methodological appraisal schedule (for all study types). The second reviewer conducted a full, item-by-item appraisal to verify scoring consistency and ensure that judgements were not shaped by a single evaluator. Ratings from both reviewers were compared, and any discrepancies were resolved through discussion, re-examination of the study, and consensus agreement.

Purpose-Developed Methodological Appraisal Schedule:

The purpose-developed appraisal schedule was designed to complement CASP by enabling appraisal across both human participant studies and in-vitro experimental studies. It provided a structured and systematic means of evaluating methodological quality, measurement rigour, and clinical adaptability across diverse study types. Two versions—a summary and a detailed format—were created to balance efficiency with comprehensive appraisal.

The schedule assessed three core domains:

- Measurement Quality: clarity of operational definitions, standardisation of procedures, reporting of reliability or calibration processes.
- Study Design Quality: sample justification (where applicable), inclusion/exclusion criteria, procedural transparency, and consistency of framework implementation.
- Adaptation Potential: feasibility, clinical usability, relevance to dysphagia management, and transferability to healthy adult research.

The schedule included simple scoring criteria that allowed studies to be categorised as high, moderate, or low methodological quality. Key strengths, limitations, and considerations for framework adaptation were documented for each study to inform the subsequent synthesis process.

3.4.2.4 Analysis Strategy and Categorisation

Following quality appraisal, the categorised extraction data were reviewed to support systematic comparison of assessment approaches across studies. Both the method categories and component domains established during extraction were used as analytic structures for Phase 2.

Studies were examined within each method category (instrumental, sensory/perceptual, clinical/observational, and in-vivo approaches) to identify methodological patterns, strengths, and areas of inconsistency. In parallel, the component domains were used to interpret which aspects of oral processing or swallowing were most frequently assessed, how consistently these components were measured across studies, and where evidence relating to transitional food assessment was lacking.

This combined method-and-component categorisation enabled higher-level interpretation of methodological trends, highlighted areas of convergence and divergence, and provided the structured basis for the subsequent thematic synthesis.

NVivo 15 (QSR International Pty Ltd, 2024) was used to organise and code extracted data following quality appraisal, supporting the categorisation of assessment components and methods (see Appendix D for full coding framework and matrices).

Data extracted from included studies were imported into NVivo as individual case nodes, with each study represented as a discrete unit of analysis. Coding followed a structured three-level hierarchical framework: parent categories captured the overarching analytical domains (Components Assessed, Methods Used, Populations, Study Quality); axial codes grouped conceptually related features within each domain; and substantive codes captured specific measurement parameters and procedural details (Appendix D1).

Assessment parameters were organised using a dual-categorisation approach, in which each parameter was classified according to both the method used (e.g., rheological testing, clinical assessment) and the component being assessed (e.g., transformation dynamics, bolus formation, swallowing safety).

To interrogate these relationships systematically, two matrix coding queries were conducted—one examining associations between components and methods, and another exploring interactions between methodological approaches and study quality (Appendix D2). These queries supported cross-study comparison, highlighted where different methods targeted similar constructs, and identified gaps or inconsistencies in measurement emphasis across study types, all of which informed the subsequent synthesis.

3.4.2.5 Thematic Synthesis

The content and thematic synthesis followed a structured three-stage approach. First, extracted data were coded to capture all relevant aspects of assessment approaches, including measurement focus, methodological characteristics, and transitional-food–related considerations. Second, the codes were grouped into descriptive themes that reflected recurring patterns across studies, such as commonly assessed components, frequently used methodological approaches, and areas with inconsistent or limited measurement detail. Finally, analytical themes were developed to interpret how these patterns related to the broader requirements of transitional food assessment, highlighting where current methods were well aligned with clinical needs and where important conceptual or methodological gaps remained. This synthesis provided the interpretive foundation for identifying priority areas to inform framework development.

Gap Analysis:

A structured gap analysis was applied to the synthesised evidence to determine how well existing assessment approaches addressed the needs of transitional food evaluation. This involved comparing evidence patterns across method categories and component domains to identify areas of strength—such as components that were consistently measured or methods with strong methodological reporting—as well as areas where evidence was limited, inconsistent, or absent. The analysis also considered methodological limitations identified during appraisal, including variability in measurement procedures, lack of standardisation, and limited reporting of reliability. These identified gaps directly informed decisions about which assessment elements would require refinement, adaptation, or development in the subsequent phase of framework construction.

3.4.3 Phase 3: Framework Development

3.4.3.1 Purpose

The purpose of Phase 3 was to translate the synthesised evidence from Phases 1 and 2 into a structured, clinically meaningful assessment framework for evaluating the oral processing characteristics of transitional foods. Rather than producing a prescriptive protocol, this phase focused on identifying essential constructs, organising them into functional domains, and proposing an evidence-informed structure that could guide future clinical tool development and potential pilot testing.

3.4.3.2 Methodological Approach

Framework development was grounded in a qualitative evidence synthesis approach, drawing directly from:

- the extracted components and methods identified in Phase 1
- the methodological appraisal and thematic findings from Phase 2
- interpretive coding and conceptual grouping undertaken in NVivo during Phase 2

A best-fit framework synthesis approach (Carroll et al., 2013) informed the interpretive process—not by applying an existing external framework, but by using its principles to organise empirical findings into a structured, conceptually coherent model. Evidence was iteratively compared, grouped, and refined to identify functional domains of transitional food assessment.

This approach allowed the framework to remain evidence-led, clinically relevant, and flexible, without imposing pre-existing theoretical structures that may not reflect the unique characteristics of transitional foods.

3.4.3.3 Framework Development Process

The development process occurred in three analytic steps, closely aligned with the study objectives:

Step 1: Consolidation of Evidence Constructs

All coded findings including components, parameters, methods, strengths, and limitations were reviewed to identify recurring constructs across studies. This step clarified what the literature consistently measured, where variation existed, and which constructs were most relevant to transitional food assessment.

Step 2: Domain Formation

Using iterative NVivo coding and constant comparison, constructs were clustered into functional domains. Domain boundaries were informed by:

- oral processing physiology
- measurement behaviour of transitional foods
- patterns observed in the evidence base
- gaps identified in Phase 2

This resulted in a set of domains that represented the essential dimensions of transitional food evaluation.

Step 3: Organisation of Assessment Methods

Within each domain, the available methods were organised according to:

- purpose (what the method measures)
- mechanism (how it measures the construct)
- feasibility (resource considerations, accessibility, clinical relevance)

This structure ensured that the framework captured both what should be measured and how it can be measured.

3.4.3.4 Outcome

Phase 3 resulted in the development of an evidence-based transitional food assessment framework comprising the key oral processing domains identified in Phases 1 and 2, along with their associated constructs and relevant assessment method categories. The framework provides a structured representation of how transitional foods representation of the evidence-informed best practice for evaluating transitional foods clinically and conceptually. It serves as a foundation for the subsequent discussion chapter, where its applicability, methodological strengths, and implications for future clinical tool development are explored.

Overview of Study Design

STUDY PHASES	Phase 1	Phase 2	Phase 3
Objectives	Literature Identification	Quality Appraisal and Evidence Synthesis	Framework Development
Activities	• Database searching (PubMed, CINAHL, Cochrane, Scopus) • Eligibility screening (n=28 studies included) • Data extraction using purpose-developed tool • Component and parameter identification • Initial domain organization	• Dual quality appraisal (CASP + purpose-developed schedule) • Independent second reviewer verification • NVivo coding (3-level hierarchical framework) • Matrix coding queries (Components × Methods; Quality × Methods) • Thematic synthesis and gap analysis	• Evidence construct consolidation • Domain formation through iterative coding • Assessment method organization • Best-fit framework synthesis
Output	List of Included studies, Identified components & methods	Themes, gaps, methodological patterns	Evidence-informed framework

***Figure 4**: Overview of the study design across the three research phases*

3.5 Methodological Rationale and Study Design Justification

The selection of a qualitative evidence synthesis with framework development was based on the need to produce a clinically relevant, literature-informed framework within a reasonable timeframe while ensuring methodological rigour. Alternative approaches, including Delphi studies, systematic reviews alone, or primary data collection, were considered but deemed less appropriate for the present research objectives.

3.5.1 Implementation Science Foundation

This study design represents an implementation science approach, which emphasises the importance of developing interventions with built-in considerations for real-world application. Implementation evaluation frameworks identify key outcomes such as acceptability, feasibility, and appropriateness that should be addressed from the design phase rather than as post-hoc considerations (Nilsen, 2015). This approach aligns with established evaluation framework principles, ensuring that the developed framework considers not only clinical effectiveness but also factors critical for successful adoption, implementation, and maintenance in healthcare settings.

3.5.2 Alternative Methodology Considerations

Why not a Delphi study?

While Delphi studies are valuable for achieving expert consensus, they rely heavily on subjective opinion, which can be influenced by individual bias, disciplinary perspectives, or geographic representation. This subjectivity can limit generalisability, particularly in a diverse and globally relevant field such as dysphagia management (de Meyrick, 2003; Shang, 2023). In contrast, an evidence synthesis approach systematically evaluates empirical research from a global and diverse range of researchers, providing a more objective and reproducible foundation for framework development. Furthermore, Delphi processes often require substantial time commitments from participants across multiple survey rounds, which can delay the study completion (Shang, 2023).

Why not a systematic review alone?

Although systematic reviews are effective for summarising evidence, they typically stop short of producing an applied, structured framework for clinical use. The present study extended beyond evidence collation by translating findings into a practical assessment framework. This required additional methodological steps including thematic analysis, gap identification, and integration into a best-fit framework to ensure that results are actionable and adaptable to clinical practice (Carroll et al., 2013).

Why not base the study on primary data collection?

The decision to focus on secondary evidence synthesis rather than immediate primary data collection reflects the developmental sequence of evidence-building required in this area. These steps were : foundational methodology development; breadth of evidence integration; and implementation orientation.

Foundational Methodology Development: before empirical studies could be meaningfully conducted, there was a need for a structured, evidence-informed framework that defined what, how, and why specific aspects of transitional food assessment should be measured. This study provided that methodological foundation, upon which future in-person studies could reliably build.

Breadth of Evidence Integration: synthesising findings across diverse research designs allowed for the capture of a wider range of approaches and contexts than a single-site or single-sample primary study could achieve. This broad perspective strengthened the relevance and generalisability of the resulting framework.

Implementation Orientation: by collating and analysing evidence from multiple contexts, this study could anticipate barriers and facilitators to adoption, producing a framework designed for real-world feasibility. Primary data collection alone would risk producing insights that were context-bound and less transferable.

3.5.3 Methodological Positioning

This design was a strategic and necessary step in the research trajectory. By combining systematic evidence synthesis with framework development, the study balanced objectivity and comprehensiveness with clinical applicability. It delivered a framework that was scientifically grounded, implementation-ready, and positioned to guide subsequent empirical investigations. The methodology represented a foundational contribution that would enable future researchers to conduct methodologically sound primary data collection studies with evidence-based assessment procedures.

3.6 Data Management

Data management was carried out systematically to ensure accuracy, transparency, and ease of retrieval. Reference management was conducted using EndNote 21 (Clarivate, 2024). Key methodological and outcome data were extracted using structured Excel templates to support consistency across studies. Extracted qualitative data were coded and organised using NVivo to support thematic analysis and pattern identification. All data were stored securely on password-protected institutional servers with automated backups.

3.7 Quality Assurance

To ensure rigour, transparency, and reproducibility, several quality assurance strategies were implemented. A detailed chronological audit trail was maintained documenting search strategies, selection decisions, coding processes, and analytical steps. A reflexivity journal was also kept as a structured record of assumptions, positionality, interpretive decisions, and potential researcher influences throughout the analytic process. The reflexive process was guided by the principles of Reflexive-Inspirational Interpretation (RII), which emphasises critical self-awareness, epistemic humility, and the deliberate examination of researcher privilege in knowledge production (Pillay, 2003, 2009). To enhance the credibility of study selection, a second reviewer independently verified the final set of included studies against the eligibility criteria. This process ensured that no studies were included or excluded based solely on a single evaluator's judgement. The second reviewer also checked the consistency of coding across the extraction tool, confirmed methodological categorisations, and validated the correct application of both appraisal frameworks (CASP and the purpose-developed schedule). And any differences were resolved through discussion.

3.8 Methodological Limitations

While the multi-phase, qualitative evidence synthesis approach allowed for a comprehensive and structured development of the assessment framework, several potential limitations were anticipated. The study's dependence on existing literature meant that it relied solely on published, peer-reviewed research and existing clinical guidelines, and as a result, any gaps or biases present in the literature inevitably influenced the findings. Language restrictions limited inclusion to studies published in English, which may have excluded relevant research conducted in other languages. The exclusion of unpublished data meant that grey literature, conference abstracts without full reports, and unpublished studies were excluded, potentially omitting valuable insights. These limitations were acknowledged when interpreting the findings and in the development of the final framework, with an emphasis on transparency and the identification of areas requiring further research.

3.9 Mitigation strategies

The developing framework was refined through iterative supervisory feedback to enhance clarity and coherence. Although this did not constitute a formal internal review process, these discussions supported refinement of structure and alignment with the evidence base, consistent with the reflective-inspirational interpretation (RII) approach (Pillay, 2003, 2009).

3.10 Ethical Considerations

This study did not involve direct interaction with human participants or the collection of identifiable personal data. All data were obtained from publicly available, peer-reviewed literature and existing clinical guidelines. In accordance with Massey University research ethics policy, the study was classified as low-risk and did not require formal review by the Human Ethics Committee. Nonetheless, the research was conducted in line with ethical principles of integrity, transparency, and respect for intellectual property, including appropriate attribution and citation of all sources.

3.11 Chapter Summary

This chapter outlined the methodological approaches that were used to develop an evidence-based assessment framework for transitional foods in dysphagia management. A multi-phase, qualitative evidence synthesis design was presented, detailing the purpose, rationale, and methodological procedures for each of the three sequential phases: literature identification, quality appraisal and evidence synthesis, and framework development and integration. Data management strategies, quality assurance measures, and justifications for the chosen research design were described to ensure transparency, rigour, and reproducibility. The chapter outlined anticipated limitations and ethical considerations, positioning the study to produce a clinically applicable and contextually adaptable assessment framework that could inform best practice in diverse healthcare settings.

4 Chapter Four: Results

The following results, extracted from the rapid systematic review, were synthesized to inform the development of a framework for transitional food assessment. The findings are organised by research objectives to reflect the progression from evidence identification to framework formulation.

4.1 Objective 1: Literature Identification of Components and Methods

4.1.1 Overview

A systematic review was conducted to identify oral processing components and assessment methods used in transitional food (TF) and texture-modified food (TMF) research. The search identified 28 studies meeting inclusion criteria, of which 3 studies (11%) explicitly investigated IDDSI-classified transitional foods (Barewal et al., 2021; Bruno et al., 2025; Mocchetti et al., 2025) and these form the core evidence base for transitional food assessment. Twenty-five studies (89%) examined broader texture-modified foods and these supporting studies provided relevant evidence on oral processing components and measurement approaches applicable to TF assessment, though they were not designed specifically for TF validation.

Systematic extraction across all 28 studies identified the range of components measured and methods employed, establishing the current evidence base for TF assessment framework development.

Table 1: List of Included Studies

Study ID	Study (Author, Year)
1	Yoshikawa et al. (2025)
2	van den Steen et al. (2025)
3	Mocchetti et al. (2025)
4	Ismael-Mohammed et al. (2025)
5	Bruno et al. (2025)
6	Ismael-Mohammed et al. (2024)
7	Ihrke et al. (2024)
8	Aii et al. (2024)
9	Wong et al. (2023)
10	Stading et al. (2023)
11	Ismael-Mohammed et al. (2023)
12	Sharma et al. (2022)
13	Peh et al. (2022)
14	Mihnea et al. (2022)
15	Bandini et al. (2022)
16	Stading (2021)
17	Kwak et al. (2021)
18	Barewal et al. (2021)
19	Park et al. (2020)
20	Merino et al. (2020)
21	Matsuno et al. (2017)
22	Momosaki et al. (2013)
23	Sugimoto et al. (2012)
24	Iida et al. (2011)
25	Wendin et al. (2010)
26	Saitoh et al. (2007)
27	Kim and Han (2005)
28	Takahashi et al. (2026)

4.1.2 Components and Methods Identified

Systematic extraction identified 95 component measurements across the 28 studies. When these components were broken down into their specific measurable units and overlapping terms were combined, the dataset resulted in 121 distinct parameters. These parameters were then grouped into conceptual domains (see Appendix E for complete inventory)

Component assessment was concentrated across three dominant domains assessed in 43% of studies each: rheological properties (n=12 studies, 20 parameters), oral biomechanics (n=12 studies, 18 parameters), and pharyngeal efficiency (n=12 studies, 12 parameters). These were followed by bolus formation (39%, n=11 studies, 13 parameters) and texture properties (36%, n=10 studies, 15 parameters). Moderate coverage domains included transformation dynamics (29%, n=8 studies, 13 parameters), swallowing safety (29%, n=8 studies, 7 parameters), sensory evaluation (29%, n=8 studies, 16 parameters), and saliva interaction (21%, n=6 studies, 11 parameters).

To organise this diverse measurement landscape, components were grouped into 9 conceptual domains based on their functional role in TF transformation, swallowing assessment, and acceptability evaluation:

Table 2: Component Domains with Aligned Parameters and Assessment Methods (n=28)

Domain	Definition	studies (n)	Studies %	Study IDs	Parameters Measured	Assessment Methods/Instruments	Method Category
1. Rheological Properties	Flow and deformation behaviour measured instrumentally	12	43%	4,7,10, 11,12, 13,16, 20,22, 25,27, 28	• Viscosity (mPa·s)	• Rotational rheometer	Rheological/ Texture Testing
					• Apparent viscosity (mPa·s)	• Rotational rheometer (multiple shear rates)	
					• Shear rate (s^{-1})	• Controlled shear rheometer	
					• Flow curve behaviour	• Rotational rheometer	
					• Shear thinning index	• Rheometer (flow curve analysis)	
					• Storage modulus G′ (Pa)	• Oscillatory rheometer	
					• Loss modulus G″ (Pa)	• Oscillatory rheometer	
					• Phase angle δ (°)	• Oscillatory rheometer	
					• Loss tangent tan δ	• Oscillatory rheometer (G″/G′ calculation)	
					• Consistency index K ($Pa{\cdot}s^n$)	• Power-law rheological modelling	
					• Flow index n	• Power-law modelling	
					• Yield stress (Pa)	• Stress-controlled rheometer	
					• Thixotropy (Pa/s)	• Hysteresis loop via rheometer	
					• Cohesive energy density (J/m^3)	• Oscillatory rheology (energy calculations)	
					• Viscoelastic spectrum	• Frequency sweep rheometry	
					• Zero-shear viscosity (Pa·s)	• Low-shear rheology	
					• Time-dependent viscosity change (%)	• Time sweep rheometry	
					• Pre/post oral viscosity change (%)	• Rheometer + oral processing protocol	
					• Rheological stability (CV%)	• Time sweep rheometer	

					• Frequency sweep response	• Oscillatory rheometer (frequency sweep)	
2. Oral Biomechanics	Forces, movements, and muscle activity during mastication	12	43%	2,4,6, 9,10, 15,16, 18,21, 23,24, 27	• Chewing cycles (count)	• Video recording + manual counting	Biomechanical/ Physiological
					• Chewing rate (cycles/second)	• Video + timing analysis	
					• Oral preparation time / Chewing duration (s)	**• Video timing / Stopwatch / Frame-by-frame VFSS (food entry to swallow)**	
					• Chewing sequence structure (pattern)	• Video analysis (chewing side patterns, sequence regularity)	
					• Jaw kinematics (mm, degrees)	• Jaw tracking systems (optoelectronic/electromagnetic)	
					• Bite force (N)	• Force transducer / Bite force sensor	
					• EMG amplitude (µV)	• Surface EMG (masseter, temporalis muscles)	
					• EMG timing (onset/offset, ms)	• Surface EMG + synchronization	
					• EMG frequency (Hz)	• EMG signal frequency analysis (FFT/power spectrum)	
					• Tongue pressure (kPa)	• IOPI (Iowa Oral Performance Instrument) / MAIP	
					• Tongue–palate contact duration (ms)	• Pressure sensors / Electropalatography	
					• Lingual movement (range/pattern, mm)	• VFSS / FEES / Ultrasound imaging	
					• Posterior tongue-palate seal (rating)	• VFSS / FEES (seal adequacy via spillage observation)	
					• Oral transit time - OTT (seconds)	• VFSS / FEES (timed frame-by-frame from oral prep to swallow)	
					• Bolus transport timing (ms)	• VFSS (oral stage bolus movement timing)	
					• Stage 2 transport frequency (count)	• VFSS (number of premature pharyngeal entries)	
					• Stage 2 transport degree (scale)	• VFSS (severity/extent of premature spillage)	

					• Posterior spillage timing (ms)	• VFSS / FEES (timing of premature pharyngeal entry)	
3.**Pharyngeal Efficiency**	Post-swallow outcomes and clearance	12	43%	1,2,3, 5,8,9, 17,19, 22,24, 26,27	• Pharyngeal residue (severity scale)	• FEES / VFSS (Yale Pharyngeal Residue Severity Rating Scale or NRRS)	Imaging + Clinical Assessment
					• Vallecular residue (severity/volume)	• FEES / VFSS (residue rating in valleculae)	
					• Pyriform sinus residue (severity/volume)	• FEES / VFSS (residue rating in pyriform sinuses)	
					• Number of swallows (count)	• VFSS / FEES / Clinical observation (swallows per bolus)	
					• Swallow efficiency rating (composite score)	• Clinical rating scale (e.g., efficiency index)	
					• Pharyngeal transit time - PTT (ms)	• VFSS timing (UES opening to closure)	
					• Hypopharyngeal transit time (ms)	• VFSS timing (bolus tail through hypopharynx)	
					• Oropharyngeal transit time (ms)	• VFSS timing (oral prep completion to UES closure)	
					• Clearance score (rating)	• Pooling score / Clinical rating (bolus clearance efficiency)	
					• Residue management (effectiveness rating)	• FEES (clearing swallows effectiveness)	
					• Bolus flow speed (mm/s or cm/s)	• VFSS (bolus velocity measurement)	
					• Oral-pharyngeal coordination (rating/timing)	• VFSS (timing between oral and pharyngeal phases)	
4. **Bolus Formation**	Characteristics of prepared bolus ready for swallow	11	39%	6,8,9, 10,11, 15,16, 18,21, 23,24	• Bolus cohesion (0-2 scale or ratio)	• Visual rating scale / TPA (cohesion testing)	Biomechanical/Physiological + IDDSI Framework Use
					• Bolus aggregation (score/rating)	• Visual assessment / TPA	
					• Mixing ability (mixing index)	• Bolus imaging + mixing index calculation	

					• Bolus homogeneity (uniformity score)	• Image analysis (variance/distribution analysis)	
					• Particle size distribution (mm)	• Sieving method / Digital image analysis	
					• Median particle size (mm)	• Sieving / Digital imaging + size measurement	
					• Grinding ability (reduction ratio)	• EMG + particle size outcome (pre/post comparison)	
					• Bolus shape compactness (circularity)	• Image analysis (shape descriptors)	
					• Bolus stickiness (adhesiveness, N·s)	• Texture Analyzer (adhesion test)	
					• Bolus moisture content (%)	• Gravimetric moisture test	
					• Bolus firmness (N)	• Texture Analyzer (compression test on expectorated bolus)	
					• Internal structural integrity	• Microscopy (microstructure examination)	
					• Bolus boundary definition (clarity)	• VFSS / Imaging (bolus edge detection/contrast)	
5. Texture Properties (TPA)	Mechanical texture characteristics from instrumental testing	10	36%	4,6,7, 11,13, 17,19, 20,22, 24	• Hardness (N)	• Texture Profile Analysis - TPA (first compression peak)	Rheological/ Texture Testing + IDDSI Framework Use
					• Cohesiveness (ratio, 0-1)	• TPA (work cycle 2 / work cycle 1)	
					• Adhesiveness (N·mm or mJ)	• TPA (negative area under force-time curve)	
					• Springiness (mm or ratio)	• TPA (height recovery between cycles)	
					• Gumminess (N)	• TPA (calculated: hardness × cohesiveness)	
					• Chewiness (N·mm or mJ)	• TPA (calculated: gumminess × springiness)	
					• Resilience (%)	• TPA (upstroke energy / downstroke energy)	
					• Fracturability (N)	• TPA (force at first significant break)	

					• Firmness (N)	• Texture Analyzer (single compression peak force)	
					• Stiffness (N/mm)	• Texture Analyzer (slope of force-displacement curve)	
					• Penetration force (N)	• Texture Analyzer (penetration/puncture test)	
					• Work of shear (mJ)	• Texture Analyzer (shear blade - area under curve)	
					• Work of compression (mJ)	• Texture Analyzer (compression - area under curve)	
					• Deformation at break (mm or %)	• Texture Analyzer (displacement at fracture)	
					• Structural breakdown force (N)	• Texture Analyzer (multi-cycle compression test)	
					• IDDSI level - initial (0-7 scale)	• IDDSI testing protocols (fork drip, spoon tilt, spoon tilt)	
6. Transformation Dynamics	Pre/post texture comparison or dissolution assessment	8	29%	6,10,11,12,16,18,27,28	• Dissolution time (s)	• Standard timed dissolution protocol; stopwatch/video timing	Rheological/ Texture Testing + Biomechanical + IDDSI Framework Use
					• Dissolution rate (g/s or %/s)	• Timed dissolution test with repeated mass measurements; gravimetric tracking	
					• Hydration (% moisture - absolute)	• Gravimetric moisture analysis (total moisture content)	
					• Moisture uptake (Δ% - change)	• Gravimetric analysis (moisture post – moisture pre)	
					• Pre/post viscosity change (% or Pa·s)	• Rheometer (pre/post oral processing measurement)	
					• Pre/post hardness change (N or %)	• Texture Analyzer (pre/post compression)	
					• Softening rate (N/s or %/min)	• Time-lapse Texture Analyzer (repeated compression)	

					• Breakdown kinetics (particle size/time)	• Chewing-cycle video analysis; EMG-regulated mastication; Particle size distribution; TA (multi-cycle)	
					• Oral processing time to swallow (s)	• Video observation + timing (mastication duration)	
					• Bolus lubrication (friction coefficient μ)	• Tribometer / Friction testing rig	
					• Particle swelling (% diameter increase)	• Microscopy + Image analysis	
					• Matrix disintegration pattern	• Visual inspection / Photography / Video	
					• State transition (solid→gel→liquid)	• Pre/post rheology/texture assessment + visual observation	
					• Pre/post IDDSI level change (scale units)	**• IDDSI testing (initial food + expectorated bolus comparison)**	
7. **Swallowing Safety**	Airway protection and aspiration risk	8	29%	1,2,3, 5,8,9, 17,22	• PAS score (1-8 ordinal scale)	• FEES / VFSS + PAS rating scale	Imaging + Clinical Assessment
					• Penetration (present/absent or depth)	• FEES / VFSS (bolus entry to laryngeal vestibule)	
					• Aspiration (present/absent or severity)	• FEES / VFSS (bolus entry below vocal folds)	
					• Laryngeal invasion (rating/depth)	• FEES (depth of bolus entry into larynx)	
					• Delayed swallow initiation (timing, ms)	• VFSS frame-by-frame (bolus position at trigger)	
					• Incomplete airway closure (rating)	• FEES (vocal fold closure adequacy)	
					• Cough reflex response (present/absent)	• Clinical observation (spontaneous/reflexive cough)	
8. **Sensory Evaluation**	Subjective perceptions and	8	29%	9,12, 13,14, 15,19, 20,25	• Perceived firmness (ordinal/VAS)	• QDA / VAS scale	Sensory & Acceptability
					• Perceived cohesiveness (ordinal)	• QDA / Trained sensory panel	

	acceptability ratings				• Perceived adhesiveness (ordinal)	• QDA / Trained sensory panel	
					• Melting perception (rate/extent)	• QDA / VAS (trained panel or consumer)	
					• Creaminess (ordinal)	• QDA / Trained sensory panel	
					• Wobbliness (ordinal)	• QDA / Trained sensory panel	
					• Graininess (ordinal)	• QDA / Trained sensory panel	
					• Roughness (ordinal)	• QDA / Trained sensory panel	
					• Ease of swallow (VAS or ordinal)	• VAS scale / Consumer rating	
					• Perception of particles (intensity)	• QDA / Trained sensory panel	
					• Homogeneity perception (ordinal)	• QDA / Trained sensory panel	
					• Mouthfeel (overall texture sensation)	• QDA / Trained sensory panel	
					• Flavour intensity (ordinal/VAS)	• Sensory panel (trained or consumer)	
					• After-swallow residue perception (VAS)	• VAS scale / Consumer self-report	
					• Sensory smoothness (ordinal)	• QDA / Trained sensory panel	
					• Chew resistance (ordinal/VAS)	• QDA / Consumer rating	
9. **Saliva Interaction**	Saliva incorporation and effects on texture	6	21%	10,12, 16,18, 27,28	• Salivation rate (mL/min or g/30min)	• Spitting method (30 min collection) + pre/post weighing	Biomechanical/ Physiological
					• Saliva incorporation volume (mL or g)	• Gravimetric difference (bolus weight gain)	
					• Bolus moisture ratio (% or ratio)	• Pre/post moisture analysis (gravimetric)	
					• Oral dryness perception (score)	• Questionnaire (VAS/ordinal scale) or visual inspection	
					• Lubrication coefficient	• Tribometer (lubrication effectiveness)	
					• Friction coefficient μ (dimensionless)	• Tribometer (sliding friction testing)	

					• Adhesion to mucosa (N or Pa)	• Probe-tack adhesion test / Texture Analyzer	
					• Detachment stress (Pa)	• DMA (Dynamic Mechanical Analysis) + probe-tack rig	
					• Saliva-induced viscosity drop (% or Pa·s)	• Rheometer (pre/post saliva addition)	
					• Structural change with saliva	• Rheometer + Microscopy (microstructure observation)	
					• Saliva mixing efficiency (index/%)	• Imaging analysis / Conductivity tests	

Note: Studies assessed multiple domains using multiple methods. Percentages represent studies measuring ≥1 parameter within each domain. Domains ordered by assessment frequency (highest to lowest). Total distinct parameters: 121 across 9 domains (see Appendix F for glossary)

4.1.3 Summary

Literature identification revealed 121 distinct parameters organised into 9 core domains, assessed using 6 primary method categories across 28 studies. Measurement activity was not evenly distributed across domains. Instead, three domains accounted for the largest proportion of reported parameters and study frequency; rheological properties (43%, 20 parameters), oral biomechanics (43%, 18 parameters), and pharyngeal efficiency (43%, 12 parameters). These were followed by bolus formation (39%, 13 parameters) and texture properties (36%, 15 parameters). Transformation dynamics (29%, 13 parameters), swallowing safety (29%, 7 parameters), sensory evaluation (29%, 16 parameters), and saliva interaction (21%, 11 parameters) showed moderate to lower representation. It is important to distinguish between the conceptual domains described above, which represent the properties or processes being assessed, and the method categories in this section, which describe the tools and procedures used to measure those properties. Although some labels overlap (e.g., 'rheological'), they refer to different classification levels (WHAT vs HOW).

Assessment methods were predominantly rheological/texture testing (64%) and biomechanical measurement (50%), with moderate use of imaging (50%), IDDSI framework (46%), sensory & acceptability evaluation (29%), and clinical assessment methods (25%). The evidence base comprises 3 TF-specific studies providing direct evidence and 25 supporting TMF studies providing broader context on oral processing assessment approaches applicable to TF evaluation.

4.2 Objective 2: Quality Appraisal

4.2.1 Overview

Methodological quality appraisal was conducted using two complementary tools: the Critical Appraisal Skills Programme (CASP) checklist for general research quality (n=26 studies) and a purpose-developed schedule for oral processing-specific measurement and design quality (n=28 studies).

CASP was applied to 26 studies, excluding 2 in vitro method-development studies (Studies 7, 28) which lack human-subject design elements. The purpose-developed schedule assessed all 28 studies, evaluating measurement quality (instrumentation validity, procedural standardisation, precision, reliability documentation) and design quality (sampling strategy, sample size, controls, blinding, randomization). For in vitro studies, adapted criteria focused on technical rigor and procedural clarity.

This dual approach enabled comprehensive assessment of both general research validity and discipline-specific methodological rigor relevant to TF assessment framework development.

4.2.2 Overall Quality Distribution

Quality appraisal revealed that the overall methodological quality of the evidence base was acceptable, with the majority of studies achieving high or moderate ratings. Based on the combined CASP and purpose-developed schedule's assessments, 50% of studies (n = 14) were rated as high quality, 43% (n = 12) as moderate quality, and 7% (n = 2) as low quality. High-quality studies typically demonstrated clear aims, validated measurement tools, systematic procedures, and appropriate analytical approaches. In contrast, moderate- and low-quality studies showed gaps in reliability reporting, sample size justification, or study design rigor.

Table 3: Quality Distribution Across Evidence Base (n=28)

Quality Rating	Studies (n)	Studies %	CASP Characteristics	Purpose-Developed Schedule's Score Range
High Quality	14	50%	9-11 'Yes' ratings; minimal 'Can't tell'	19-22/25
Moderate Quality	12	43%	8-9 'Yes' ratings; some methodological gaps	16-19/25
Low Quality	2	7%	8 'Yes' ratings; limited design rigor	14-15/25

Analysis of the purpose-developed schedule subscores (Table 3) revealed a consistent pattern: measurement quality (mean: 11.4/15, 76%) exceeded design quality (mean: 7.4/10, 74%) across all studies. This indicates that researchers prioritized instrumentation validity and procedural standardisation over sampling strategy, comparison groups, and blinding. These gaps in design elements limit the critical for causal inferences that can be made.

4.2.3 Quality of Transitional Food-Specific Evidence

All three TF-specific studies (100%) achieved high overall quality ratings, providing a strong methodological foundation for TF-specific assessment framework development (Table 4).

Table 4: Quality Assessment of Transitional Food-Specific Studies

Study	CASP Rating	Tool's Score (Total)	Measurement Quality	Design Quality	Overall Rating	Key Quality Features
Study 3 (Mocchetti 2025)	High (9Y/0N/2CT)	21/25	13/15	8/10	High	Excellent reliability (ICC 0.84–0.91; κw 0.78–0.94); validated VFSS protocols
Study 5 (Bruno 2025)	High (11Y/0N/0CT)	17/25	11/15	6/10	High	Power analysis conducted; validated multi-component tools (MBSImP, PAS, IDDSI-FDS)
Study 18 (Barewal 2021)	High (10Y/0N/1CT)	21/25	13/15	8/10	High	IDDSI validation on expectorated bolus; operator training documented; ecologically valid

Both the CASP ratings (9-11 Yes) and the combined purposed- developed schedule's scores (17-21/25) were high for all three TF studies. Studies 3 and 18 showed particularly strong measurement quality (13/15) with excellent reliability documentation and validated protocols. Study 5 achieved the highest CASP rating (11Y/0N/0CT) and was the only study reporting formal power analysis, though measurement quality was slightly lower due to single-rater assessment.

4.2.4 Methodological Quality Indicators

Analysis of specific quality indicators revealed consistent patterns of methodological strengths and limitations across the evidence base (Table 5).

Table 5: Key Methodological Quality Indicators (n=28)

Quality Indicator	Description	Studies (n)	Studies %
METHODOLOGICAL STRENGTHS			
Clear aims and methods	Study purpose, research questions, and procedures explicitly stated	28	100%
Validated measurement tools	Use of established, validated instruments (PAS, IDDSI, TPA, MBSImP, standardised scales)	20	71%
Standardised protocols	SI units, validated procedures, systematic data collection protocols	20	71%
Appropriate statistical analysis	Suitable tests for data type and research questions; effect sizes or confidence intervals reported	25	89%
Ethical approval documented	Ethics committee clearance and informed consent procedures stated	24	86%
Multiple measurement methods	Triangulation using ≥2 distinct assessment methods	19	68%
Quantitative metrics with units	Reproducible measurements with SI units (mPa·s, N, kPa, seconds, ordinal scales)	25	89%
Participant characteristics described	Clear inclusion/exclusion criteria; demographic and clinical characteristics reported	23	82%

Quality Indicator	Description	Studies (n)	Studies %
METHODOLOGICAL LIMITATIONS			
No sample size justification	Absence of power calculation, sample size rationale, or adequacy discussion	22	79%
Small sample size (n<20)	Potentially underpowered for detecting moderate effects	12	43%
No formal reliability statistics	Absence of ICC, Kappa, CV, or test-retest coefficients	23	82%
Single rater/assessor only	No inter-rater reliability testing despite subjective rating components	8	29%
No control or comparison group	Absence of baseline or comparator condition	20	71%
Limited population generalizability	Narrow inclusion criteria, homogeneous samples, or single-site recruitment	18	64%
Methodological translation barrier	VFSS radiation exposure limits healthy adult validation studies	7	25%
No blinding reported	Potential for assessor bias in subjective outcome measurement	15	54%

The pattern demonstrates strong performance in measurement precision and instrumentation validity but consistent weaknesses in reliability reporting, sample size adequacy, and experimental design rigor. Notably, 82% of studies conducted reliability-enhancing procedures (e.g., replicated measurements, rater training) but only 18% reported formal reliability coefficients (ICC, Kappa, CV), creating a transparency gap between practice and reporting.

4.2.5 Summary

Quality appraisal using Critical Appraisal Skills Programme and the purposed-developed schedule revealed acceptable overall methodological quality (50% high, 43% moderate), with all 3 TF-specific studies achieving high quality ratings (100%). This provides a strong foundation for TF-specific framework development.

Key methodological strengths included validated instrumentation (71%), quantitative reproducible metrics (89%), multi-method triangulation (68%), and appropriate statistical analysis (89%). However, critical limitations emerged: insufficient reliability transparency (only 18% reported formal statistics despite 82% conducting reliability procedures), lack of sample size justification (79%), absence of control groups (71%), and no longitudinal or test-retest assessment (100%).

The consistent pattern of measurement quality exceeding design quality (11.4/15 vs. 7.4/10) indicates that while measurement techniques are technically sound, study designs require strengthening through adequately powered samples, comparative designs, blinded assessment, and transparent reliability reporting for comprehensive TF framework validation.

4.3 Evidence Synthesis

4.3.1 Synthesis Approach

The thematic synthesis identified six overarching themes that describe how TMF assessment approaches can inform development of the TF assessment framework. These themes are presented below in the order they emerged through analysis:

1. Theme 1: Safety-Focused Assessment Highlights Underdeveloped Oral Transformation Measurement
2. Theme 2: IDDSI Framework Use Demonstrates Both Classification Strength and Measurement Potential
3. Theme 3: Rheological Testing Dominance With Static Measurement Bias
4. Theme 4: Balanced Method Distribution Masks Functional Imbalance
5. Theme 5: High-Quality Studies Still Show Methodological Gaps
6. Theme 6: Multi-Method Triangulation Concentrated in Established Domains

4.3.2 Assessment Approach Patterns

Theme 1: Safety-Focused Assessment Highlights Underdeveloped Oral Transformation Measurement

Pharyngeal outcomes (pharyngeal efficiency 43%, swallowing safety 29%) were the most comprehensively assessed areas, with 8 studies using PAS scales and 12 studies examining residue or transit times. This pattern was further supported by the use of imaging methods (50%, n=14) and clinical assessments (25%, n=7), both of which primarily evaluate post-swallow airway protection and pharyngeal clearance.

In comparison, transformation dynamics, the core characteristic of transitional foods, were evaluated in only 29% of studies, supported by limited sensory (11 references), IDDSI (7 references), and biomechanical (1 reference) data. Saliva interaction was assessed in 21% of studies and showed no cross-method triangulation, indicating that although measurable, it remains methodologically isolated within the literature.

This pattern indicates that current research places primary emphasis on confirming swallowing and/or airway safety after the bolus enters the pharynx, while oral-stage transformation and oral safety behaviours, although present in some studies, remain less consistently measured. These findings suggest the field prioritises verifying that food are safe post transformation rather than understanding how transformation enables safety.

Theme 2: IDDSI Framework Use Demonstrates Both Classification Strength and Measurement potential

IDDSI framework use demonstrated a critical implementation gap. While 46% of studies (13/28) employed IDDSI for texture classification (Objective 1, Table 2), only 14% (4/28) used IDDSI testing protocols as empirical measurement methods, a 3:1 (13:4) imbalance between classification and measurement. Synthesis coding showed IDDSI had the highest cross-domain integration (10 references for standardised protocols, 9 for swallowing safety, 7 for transformation dynamics), yet this frequency primarily reflected labelling (e.g. "Level 4 foods tested") rather than quantitative testing outcomes ("fork-drip test = X seconds").

Only 7% of studies (2/28) used IDDSI tests on expectorated bolus, representing a missed opportunity, given that IDDSI methods are low-cost, globally accessible, and designed for both initial texture and transformed bolus assessment. Despite 46% adoption of the framework, systematic measurement of transformation using IDDSI remains limited. The synthesis showed that IDDSI often appeared alongside transformation dynamics (7 references) and standardised protocols (10 references), indicating that researchers recognise its relevance even though measurement implementation is inconsistent.

This pattern suggests that, although IDDSI is predominantly used for classification, existing studies demonstrate that IDDSI protocols can generate quantifiable, transformation-relevant data when applied as measurement methods—highlighting an underused opportunity within current assessment practices.

Theme 3: Rheological Testing Dominance With Static Measurement Bias

Rheological and texture testing methods were most prevalent (64%, n=18 studies; Objective 1), with synthesis showing rheological properties received 33 total method references across categories—the highest of any domain. However, cross-analysis revealed a fundamental disconnect: while initial texture characterization was strong (rheology 43%, texture properties 36%; Table 1) and pharyngeal outcomes well-covered (pharyngeal efficiency 43%, swallowing safety 29%), only 29% of studies assessed transformation dynamics through pre/post comparison.

This creates a "static measurement bias" whereby researchers extensively characterize what foods are (initial rheology, TPA properties) but rarely measure what foods become (post-oral processing texture). Despite rheological testing appearing in 64% of studies and biomechanical measures in 50%, synthesis matrix showed transformation dynamics received only 11 sensory references and 7 IDDSI references—substantially lower than the 17 sensory references for rheological properties alone. This indicates that even when multiple methods are used, they characterize the same static properties rather than capturing dynamic transformation across the oral processing continuum.

Theme 4: Balanced Method Distribution Masks Functional Imbalance

Although method categories appeared numerically balanced—rheological/texture testing (64%), biomechanical measures (50%), imaging methods (50%), and IDDSI framework use (46%)—synthesis showed this balance does not translate into functional coverage across domains. Imaging and clinical assessment methods were predominantly applied to pharyngeal outcomes, with synthesis showing 4 clinical method references each for swallowing safety and pharyngeal efficiency. In contrast, oral transformation mechanisms received minimal assessment, with only 2 clinical references for oral biomechanics, 1 for transformation dynamics, and none for saliva interaction.

Similarly, while biomechanical measures were used in 50% of studies, synthesis coding showed their application concentrated on general oral movement (10 references for oral biomechanics) rather than transformation-specific processes (1 reference for transformation dynamics; 0 for saliva interaction). This pattern indicates that while multiple method categories demonstrate capability to assess across different stages of the swallowing process, their application in the literature concentrated predominantly on pharyngeal outcomes and initial properties, with oral-stage transformation assessment representing an emerging but less-established application area.

Theme 5: High-Quality Studies Still Show Methodological Gaps

Integration of quality ratings (Objective 2) with method patterns showed that methodological limitations persisted even in high-quality studies. All three TF-specific studies achieved high overall quality (100%; Objective 2, Table 4), yet analysis of purpose-developed schedule subscores revealed that measurement quality (mean: 11.4/15, 76%) consistently exceeded design quality (mean: 7.4/10, 74%). This indicates that studies frequently demonstrated strong procedural and instrumentation quality, such as use of validated tools (71%) and standardised protocols (71%; Objective 2, Table 5), but continued to show weaknesses in design features including comparison groups (71% single-group designs), small sample sizes (43% n<20), and lack of blinding (54% no blinding reported).

The synthesis matrix further confirmed a universal reporting gap: reliability metrics were absent across all method categories, despite 82% of studies conducting reliability procedures (Objective 2). Even methodologically sophisticated studies did not report reliability coefficients, indicating a consistent lack of transparency across the evidence base.

Notably, clinical assessment methods (25% of studies) showed four references to standardised protocols, demonstrating that established clinical scales provide validated measurement structures within the TMF literature. However, the synthesis also showed that despite the availability of validated tools, reliability metrics were still not reported, reflecting the broader conduct-reporting gap observed across the evidence base. This pattern suggests that while validated clinical tools exist and are being used, reporting practices remain inconsistent, limiting the transparency and comparability of assessment outcomes.

Theme 6: Multi-Method Triangulation Concentrated in Established Domains

Although 68% of studies used more than one method, synthesis showed that triangulation was not evenly distributed across domains. Rheological properties demonstrated the highest triangulation with 33 method references across rheological, sensory, and standardised protocol categories. Swallowing safety (13 references) and pharyngeal efficiency also showed strong cross-method coverage supported by imaging, clinical tools, and IDDSI classifications.

Moderate triangulation was observed for oral biomechanics (10 method references), standardised protocols (11 references), and sensory evaluation (8 studies). These domains demonstrated integration across multiple method types, though less consistently than rheological and pharyngeal-focused domains.

In contrast, transformation-related domains showed limited triangulation. Transformation dynamics were represented across sensory (11 references), IDDSI (7 references), and biomechanical methods (1 reference), indicating that although cross-method assessment is possible, it is infrequently applied. Bolus formation similarly showed minimal integration, with only six cross-method references.

Saliva interaction had no triangulation, with all assessments relying on a single method category and no cross-method validation.

This pattern indicates that although multiple method categories are available and widely used, triangulation is concentrated in established domains, while transformation-specific areas,particularly saliva interaction, remain methodologically isolated.

4.3.3 Summary

Evidence synthesis integrating Objectives 1 and 2 revealed six key patterns across the 28-study dataset. First, assessment practices were predominantly pharyngeal-focused, with strong coverage of pharyngeal efficiency (43%) and swallowing safety (29%), supported by extensive use of imaging (50%) and clinical assessments (25%). In contrast, oral-stage transformation, including transformation dynamics (29%) and saliva interaction (21%), was less consistently assessed and showed limited cross-method integration.

Second, the analysis demonstrated an IDDSI classification–measurement gap. Although 46% of studies used IDDSI for texture classification, only 14% applied its testing methods as empirical measures, and only 7% used IDDSI tests on expectorated bolus. This reflects high recognition of IDDSI within the literature but comparatively limited use of its measurement potential.

Third, patterns showed a static measurement bias, with dominant attention to initial texture (64% rheological testing; 43% rheological properties) and pharyngeal outcomes, while pre/post changes and dynamic oral processing measures were less commonly applied.

Fourth, although method categories appeared numerically balanced (64% rheological/texture testing, 50% biomechanical, 50% imaging, 46% IDDSI), their functional use was uneven. Methods were mostly used for pharyngeal and initial property assessment, with minimal application to oral transformation mechanisms.

Fifth, integration of study quality findings showed that measurement procedures were often strong, but design elements (e.g., sample size, control groups, blinding, reliability reporting) were inconsistently documented. Reliability metrics were absent across all method categories despite most studies conducting reliability checks.

Finally, triangulation patterns showed that multi-method approaches were clustered in established domains such as rheology (33 references), swallowing safety (13 references), and pharyngeal efficiency, while transformation-specific domains, particularly saliva interaction (0 triangulated references) and transformation dynamics, remained methodologically isolated.

Collectively, these patterns demonstrate that while diverse assessment methods exist and are widely used, their application is concentrated in established areas. Oral transformation processes, central to understanding transitional foods, are less consistently assessed and show limited methodological integration across the current evidence base.

5 Chapter Five: Discussion

5.1 Overview

This systematic review aimed to develop an evidence-informed evaluation framework for transitional foods (TFs) in dysphagia management by synthesizing current texture-modified food (TMF) assessment practices. Through analysis of 28 studies examining oral processing characteristics of texture modified food, three research objectives were addressed: (1) identification of assessment components and methods used for TMFs, (2) quality appraisal of TMF assessment literature, and (3) thematic synthesis revealing patterns and gaps in TMF assessment practices. These objectives informed development of a TF-specific evaluation framework addressing identified gaps while maintaining practical accessibility.

This discussion interprets the review's findings in relation to broader dysphagia assessment practices, examines their implications for evaluating TFs, and outlines how synthesised results underpin the Evidence-Informed Transitional Food Assessment Framework as the primary output of the study. The framework operationalises findings from TMF assessment practices to address systematic gaps specifically relevant to TF evaluation while ensuring feasibility across diverse resource settings.

5.2 Objective 1

5.2.1 Assessment Domain Concentration

Initial literature searches identified only six studies explicitly focused on transitional foods as defined by IDDSI. However, only three met inclusion criteria for this review (Studies 3, 5, 18). The three excluded papers addressed TF-adjacent topics outside the scope of comprehensive swallowing assessment: one used 3D printing technology to develop TF prototypes from fish paste (Yu et al., 2023). one examined fortified TF snacks for nutritional enhancement in nursing homes (Bayne et al., 2022), and one was a narrative review synthesising sensory texture descriptors across the purée–to-TF continuum (Guénard-Lampron et al., 2021). Because TF-specific evidence was limited, the review incorporated broader texture-modified food (TMF) assessment literature to establish evaluation approaches applicable to TFs, resulting in a final evidence base of 28 studies (three TF-specific and 25 TMF studies).

Systematic extraction across these 28 studies identified 121 distinct parameters organised into nine conceptual domains. Assessment was heavily concentrated in three domains: rheological properties (43%, n=12), oral biomechanics (43%, n=12), and pharyngeal efficiency (43%, n=12). This represented balanced attention to initial texture characterisation, oral processing mechanics, and pharyngeal outcomes. This pattern reflects established dysphagia assessment priorities: rheology provides foundational texture classification; oral biomechanics captures functional processing capability; and pharyngeal measures validate swallowing safety.

Despite this breadth, the concentration within these three domains highlights a critical imbalance. Researchers measure initial food properties and post-oral swallowing outcomes, yet comparatively few studies examine the transformation process during oral handling, the defining characteristic of transitional foods. Transformation dynamics were assessed in only 29% of studies (n=8), and saliva interaction—the primary driver of transformation—was examined in only 21% (n=6). This under-representation suggests methodological momentum towards established, well-validated domains and insufficient attention to emerging areas central to TF evaluation. This aligns with broader dysphagia literature that has historically prioritised pharyngeal-phase safety over oral-stage processes, leading to an underemphasis on chewing, bolus preparation, and oral sensory–motor function (Cichero, 2020).

Notably, among the three TF-specific studies, only one (Study 18) directly assessed oral-stage transformation mechanisms. The remaining two TF studies focused on pharyngeal outcomes, further underscoring the oral transformation assessment gap the framework developed in this study aims to address.

5.2.2 The Transformation Assessment Gap

The underrepresentation of transformation-focused domains constitutes the most significant evidence gap identified in this review. Transformation dynamics (29%) and saliva interaction (21%) collectively represent the core oral processing mechanisms that distinguish transitional foods (TFs) from static texture-modified foods. Yet their assessment frequency remained substantially lower than that of rheological properties (43%) and texture properties (36%). This gap reflects broader challenges in dysphagia assessment where static properties measured ex vivo predominate despite recognition that in vivo oral processing fundamentally alters food characteristics. This pattern aligns with Cichero (2020) observation that oral preparatory processes such as biting, chewing, saliva incorporation, and bolus readiness assessment are often under-assessed despite their central role in swallowing safety.

The limited transformation assessment may reflect multiple factors: methodological complexity requiring pre/post comparison protocols, lack of standardised transformation measurement approaches, emphasis on safety outcomes (pharyngeal efficiency, swallowing safety) overshadowing transformation mechanisms, and established research paradigms prioritizing initial texture characterization. For transitional foods, defined by their capacity to transform during oral processing, this assessment gap is particularly problematic.

Without systematic transformation validation, the capacity of foods to safely transform from initial texture to swallow-ready bolus remains inadequately characterized across the evidence base. This assessment gap perpetuates trial-and-error approaches to TF provision, as systematic understanding of the physical and physiological principles underpinning bolus formation is essential for evidence-based food development and dysphagia care (Chen et al., 2013)

Across the 28-study evidence base, nine studies (32%) conducted pre/post comparison assessments: textural properties (Studies 6, 12), rheological changes (Studies 10, 11, 16, 28), moisture uptake (Studies 10, 16, 27), and tribological properties (Study 28). Only Study 18 and 15 applied IDDSI testing protocols to expectorated bolus for transformation validation, representing a distinct methodological approach within the transformation assessment literature.

5.2.3 Method Category Distribution and Accessibility

Assessment methods in the TMF literature concentrated in rheological/texture testing (64%) and biomechanical measurement (50%), with moderate representation of imaging methods (50%), IDDSI framework use (46%), sensory evaluation (29%), and clinical assessment tools (25%). This distribution reflects a strong methodological emphasis on laboratory-based metrics, particularly rheology and instrumental texture analysis, which require specialized equipment and technical expertise. While this concentration reinforces the technical rigor of TMF assessment, it limits accessibility and feasibility in typical clinical or low-resource environments.

Although the IDDSI framework appeared in 46% of studies, closer examination revealed a critical implementation gap. In most cases, IDDSI served only as a classification tool to describe sample textures (e.g., "tested at Level 4"). Very few studies used IDDSI tests as empirical measurement procedures. Only 14% of studies (4/28: Studies 7, 12, 15, 18) implemented IDDSI protocols, such as fork-drip testing, spoon tilt, or flow testing, as part of their data collection, creating a 3:1 classification-to-measurement imbalance.

While this pattern may suggest underutilisation, it is also important to consider the distinction between clinical and research applications. IDDSI procedures were intentionally developed as practical, standardised tools to support clinical decision-making, rather than to replace more precise, instrument-based measurement methods commonly used in research settings. Therefore, the limited use of IDDSI as a measurement tool in research may reflect this research–practice distinction, rather than solely a methodological gap.

This pattern, explored in the evidence synthesis (Objective 3, Theme 2), contributes to the broader transformation validation gap by overlooking IDDSI's potential as an active measurement tool beyond its labelling function.

5.3 Objective 2 :

5.3.1 Methodological Quality Patterns

Quality appraisal demonstrated consistently strong performance across foundational methodological domains. All included studies (100%) articulated clear research aims, aligned their study designs appropriately with stated objectives, and used data collection procedures suited to the outcomes measured. Sample and material descriptions were robust, with 96% providing adequate characterization, and appropriateness of data analysis methods was likewise nearly universal (96%). These patterns indicate that the TMF evidence base is methodologically sound at the level of study design and procedural execution.

Despite this overall strength, several systematic gaps in reporting transparency were identified. Although 82% of studies conducted reliability procedures, such as inter-rater agreement checks or test-retest assessments, only 18% reported reliability metrics (e.g., ICCs, kappa values, coefficients of variation). This discrepancy of 82% conduct vs. 18% reporting suggests that reliability processes are often carried out during research but fail to reach publication. Potential explanations include journal word-limit restrictions, disciplinary norms that deprioritize measurement reliability reporting, or an implicit assumption that reliability is less critical for food-texture studies. However, the absence of reported reliability metrics limits the capacity to evaluate measurement precision across studies and constrains future meta-analytic synthesis, where reliability data are essential for weighting study quality.

A similar underreporting pattern was observed for study limitations and broader implications. While 54% of studies acknowledged methodological limitations, only 32% discussed the wider value implications of their findings, such as implications for clinical dysphagia management, feasibility of implementation, or future research directions. This underreporting suggests a missed opportunity to contextualize findings within the broader field—particularly important for TF assessment, which sits at the intersection of clinical practice, food technology, and patient-centred care. Limited emphasis on real-world relevance may impede the translation of TMF research into practical TF assessment protocols.

5.3.2 Implications of Quality Patterns for TF Assessment

The methodological patterns observed in the quality appraisal have direct implications for the development of a transitional food (TF) assessment framework. While the included studies demonstrated strong foundational quality such as clear aims, appropriate designs, and robust data collection, persistent gaps in reliability reporting and contextualisation limit the interpretability, reproducibility, and clinical applicability of current TMF assessment practices.

The low rate of reliability reporting (18%) presents a significant barrier to standardising TF evaluation. Transformation-related measures including bolus formation and saliva interaction are highly sensitive to procedural variability. Without documented reliability metrics, it is not possible to determine whether observed differences arise from true food transformation behaviour or from inconsistent measurement practices. For TFs, which rely on quantifying subtle changes in dissolution, moisture uptake, and bolus texture, reliability underpins clinical decision-making and cross-study comparison. Thus, the framework developed in this study places strong emphasis on standardised, replicable assessment protocols that can be implemented with clear reliability procedures.

Similarly, the limited reporting of limitations and broader implications (32%) suggests a lack of translation between laboratory measurement practices and real-world dysphagia management. Many TMF studies remained focused on mechanical characterisation or pharyngeal-stage outcomes without addressing how their findings inform clinical decision-making or patient-centred outcomes such as acceptability. This gap underlines the need for a TF-specific framework that integrates dynamic oral-stage transformation assessment with clinically meaningful outcomes, including sensory acceptability and safety.

Collectively, these methodological issues reinforce the necessity for a structured, evidence-informed framework that guides researchers and clinicians in selecting, implementing, and reporting TF assessment methods with clarity and consistency. The Evidence-Informed Transitional Food

Assessment Framework developed in this study directly responds to these methodological gaps by mandating replicable measurement procedures, transformation validation, saliva interaction assessment, and patient-centred metrics as core framework requirements.

5.4 Objective 3 :

5.4.1 Evidence Synthesis: Interpreting the Thematic Patterns

The thematic synthesis of the evidence base of 28 studies revealed six structural patterns that shape current TMF assessment practices. Taken together, these patterns highlight significant misalignments between what researchers currently measure and what transitional food (TF) evaluation requires. This section interprets each theme, explains its implications, and connects the findings to the need for a TF-specific framework.

Theme 1: Safety-Focused Assessment Highlights Underdeveloped Oral Transformation

The emphasis on pharyngeal outcomes reflects established dysphagia assessment priorities, where airway protection and pharyngeal clearance are routinely evaluated. Within this predominantly pharyngeal-oriented pattern, several studies also captured aspects of oral transformation such as dynamic transformation, sensory indicators of breakdown, and isolated measures of saliva interaction showing that oral-stage processes are observable and measurable within TMF research, even if less frequently assessed. These findings illustrate that while the literature is anchored in safety verification after the swallow, it also contains clear evidence of oral-stage mechanisms that contribute to how foods transition during mastication.

Implication: The presence of measurable oral transformation components within the evidence base suggests that oral-stage changes and oral safety behaviours warrant structured consideration alongside traditional pharyngeal safety outcomes.

Theme 2 : IDDSI Framework Use Demonstrates Both Classification Strength and Measurement Potential

The frequent use of IDDSI for classification demonstrates its strong uptake as a universal texture language across TMF studies. In addition to this descriptive role, a small subset of studies applied IDDSI tests to both initial textures and expectorated bolus samples, showing that the framework can generate quantifiable data relevant to transformation and consistency change. These applications indicate that although measurement use is less common, IDDSI already functions within the evidence base as an accessible, standardised, low-cost method for examining texture behaviour across stages of oral processing.

Implication: The literature shows that IDDSI has practical measurement utility, highlighting its potential role in assessing changes that occur during oral processing, not only in classifying starting textures. This supports the framework's repositioning of IDDSI from a descriptive label to a primary measurement tool for assessing TF.

Theme 3: Rheological Testing Dominance With Static Measurement Bias

Rheological and texture analyses were widely used to characterise the initial properties of TMFs, reflecting strong methodological control over baseline texture. Alongside this static focus, several studies incorporated sensory observations, oral biomechanics, or IDDSI measures that captured changes occurring during oral processing. These scattered but meaningful examples demonstrate that dynamic behaviours such as softening, breakdown, lubrication, and bolus modification are measurable within TMF research, even if less prominently featured.

Implication: The framework must compensate by mandating pre/post comparison, saliva interaction measurement, and bolus-level assessment to capture the full oral processing continuum.

Theme 4: Balanced Method Distribution Masks Functional Imbalance

Although methods appear evenly distributed (rheology, imaging, biomechanics), they are not applied evenly across domains. Most methods target static properties or pharyngeal outcomes rather than oral transformation. This means that even multi-method studies fail to integrate assessments in a way that maps onto the functional sequence of eating.

Implication: A TF framework must reorganise assessments functionally: initial texture → transformation → bolus formation → swallow safety → sensory acceptability, ensuring that methods address the correct stage of the process rather than being used in methodological isolation.

Theme 5: High-Quality Studies Still Show Methodological Gaps

Many studies demonstrated rigorous measurement practices, including validated tools and standardised protocols, showing that high-quality assessment structures already exist within the TMF literature. However, the consistent lack of reported reliability, despite evidence that procedures were performed, indicates incomplete documentation of assessment quality. This limits transparency but also highlights that reliability-enhancing practices are already part of TMF research; they simply require clearer reporting.

Implication: The framework must embed reliability expectations and simple validation pathways to improve reproducibility. The presence of validated tools and reliability procedures within the evidence base suggests that robust measurement practices can be further strengthened through more explicit reporting and integration.

Theme 6: Multi-Method Triangulation Concentrated in Established Domains

Triangulation was well developed in rheology and pharyngeal assessment, where multiple methods converged to describe safety and efficiency outcomes. Transformation-related domains showed more limited integration, yet several studies still triangulated sensory, rheological, or IDDSI measures to describe how foods changed during oral processing. This indicates that cross-method assessment of transformation is feasible and present, though less advanced, within the current evidence base.

Implication: Emerging triangulation patterns in transformation-related measures indicate their growing relevance and suggest that structured integration of these domains is needed for assessing TFs.

Across all six themes, the evidence points to the same core conclusion: existing TMF assessment practices are not structured around the mechanisms that define transitional foods.

TF specific pharyngeal evidence remains sparse and largely concentrated on a single product, though pharyngeal safety is better characterised within the broader TMF literature. Initial texture is also well characterised within the TMF literature. However, transformation, the central property of TFs, is not well assessed, is rarely integrated with saliva mechanisms, and lacks standardised procedures. However, the dataset also shows that several oral-stage components, such as softening behaviour, bolus cohesiveness, dissolution characteristics, and saliva-related changes, have already been measured in TMF studies and can be adapted for TF-specific assessment.

Therefore, the framework developed in this study:

- Fills the most critical evidence gaps
- Shifts assessment upstream to the oral stage
- Integrates IDDSI as a measurement tool
- Introduces reliable, low-cost methods
- Provides a structured pathway linking initial properties through transformation mechanisms to patient acceptability and clinical safety.

Taken together, these thematic findings from TMF assessment give clear indications about the requirements for evaluating transitional foods. To address these gaps and operationalise the evidence generated in this review, the following section presents the Evidence-Informed Transitional Food Assessment Framework, developed directly from the patterns identified across Objectives 1-3.

5.5 Framework Development

5.5.1 Framework Rationale

Evidence synthesis across 28 studies revealed systematic gaps in current transitional food assessment practices. While rheological properties (43%), oral biomechanics (43%), and pharyngeal efficiency (43%) dominate the evidence base, critical transformation-defining domains remain comparatively underassessed: transformation dynamics (29%), saliva interaction (21%), and sensory evaluation

(29%). The identified patterns, pharyngeal-dominant assessment, the IDDSI classification, measurement gap (3:1 ratio), static measurement bias, and uneven methodological triangulation, indicate that current assessment approaches inadequately capture the dynamic oral processing characteristics that distinguish transitional foods from traditional texture-modified foods. Critically, the evidence base also demonstrates that oral processing components essential for transitional food evaluation are measurable, and methods to assess them already exist within current TMF assessment literature. Studies assessing transformation dynamics (29%, n=8) and saliva interaction (21%, n=6) established that these TF-defining mechanisms can be quantified through diverse methodological approaches applicable to TF contexts. The 71% of studies using validated measurement tools and 71% employing standardised protocols demonstrate that rigorous, replicable assessment is achievable. Furthermore, studies applying IDDSI testing as measurement methods (14%) and those conducting pre/post transformation assessment (29%) provide methodological precedents directly adaptable to TF evaluation frameworks. This evidence confirms that comprehensive TF assessment can build upon established TMF assessment approaches, validated tools, standardised protocols, and accessible methods, while redirecting their application toward transformation-specific targets that current literature underemphasises.

This evidence directly informed framework development priorities. The proposed framework addresses three fundamental questions:

1. What components must be assessed to validate TF effectiveness?
2. How should these components be measured using accessible, standardised protocols?
3. Why are these specific assessments necessary to address current evidence gaps?

The framework prioritises transformation assessment, mandates saliva-interaction measurement, utilises IDDSI testing protocols as measurement tools, and incorporates patient-centred sensory evaluation alongside clinical safety validation.

5.5.2 Framework Structure and Components

The Transitional Food Assessment Framework comprises eight essential assessment domains organised across the oral processing continuum from initial properties through patient experience. Each domain addresses specific evidence gaps identified through systematic review and thematic synthesis.

To clearly demonstrate how the thematic synthesis informed the structure and content of the proposed framework, Figure 5 maps each of the six themes to the eight assessment domains. This visual integration shows how evidence from Objectives 1–3 directly shaped the components included in the Transitional Food Assessment Framework.

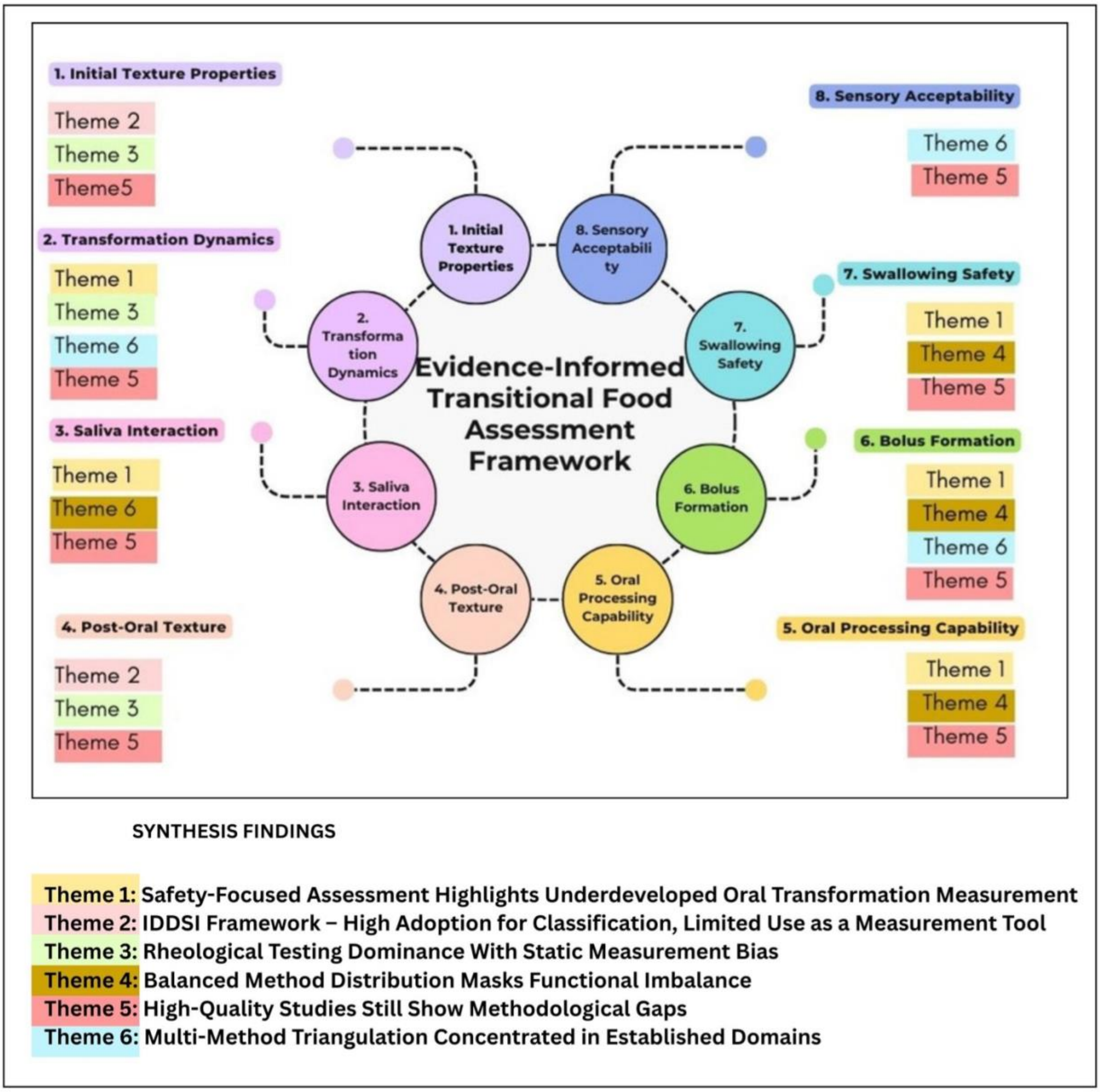

Figure 5: *Mapping of Synthesis Themes to Framework Domains*

- A visual representation of how the six thematic patterns identified in Objective 3 directly inform the eight assessment domains of the Evidence-Informed Transitional Food Assessment Framework.

Evidence-Informed Transitional Food Assessment Framework

Assessment Domain	Rationale	Essential Parameters	Assessment Methods	Equipment Required
1. Initial Texture Properties	Baseline characterization for pre/post comparison	• IDDSI level (0-7) • Initial texture properties	• IDDSI testing (fork drip, spoon tilt) • Texture Analyzer (TPA - if available)	• IDDSI testing kit (including IDDSI fork, IDDSI spoon, 10 ml syringe) • Texture Analyzer
2. Transformation Dynamics	Transformation behaviour determines TF safety through predictable softening and structural breakdown	•Dissolution time (s) • Pre/post texture change • Softening rate	• Timed dissolution protocol + stopwatch • Pre/post IDDSI or TPA comparison • Video observation	•Timer/stopwatch • IDDSI kit (including IDDSI fork, IDDSI spoon, 10 ml syringe) • Video camera
3. Saliva Interaction	Saliva incorporation is the primary mechanism enabling TF to soften and reach swallow-ready state.	• Moisture uptake (%) • Saliva incorporation (g) • Post-oral moisture content	• Pre/post weighing (gravimetric) • Moisture content analysis	• Precision scale (0.1g)
4. Post-Oral Texture	Evaluates whether the food has achieved the appropriate transformed texture at the end of oral phase, prior to swallow initiation.	• Post-oral IDDSI level (0-7) •Transformed texture properties	• IDDSI testing on expectorated bolus • TPA on bolus (if available)	• IDDSI testing kit (including IDDSI fork, IDDSI spoon, 10 ml syringe • Collection container • Texture Analyzer
5. Oral Processing Capability	Functional validation of transformation ability	• Oral preparation time (s) • Chewing cycles (count) •Chewing rate	• Video timing / Stopwatch • Video + manual counting	• Timer • Video camera
6. Bolus Formation	Swallow readiness validation;	• Bolus cohesion (0-2 scale)	• Visual rating scale	• Rating scale • Scale

	Links transformation to safety	• Bolus moisture content (%) • Visual homogeneity	• Gravimetric moisture test • Photography (optional)	•Camera (optional)
7. Swallowing Safety	Clinical necessity; Post-transformation safety validation	• Clinical observation (cough, difficulty) • PAS score (1-8) - if imaging available • Ease of swallow perception	• Clinical observation •VFSS/FEES + PAS rating (gold standard) • Patient self-report (VAS 0-10)	• Observation protocol • VFSS/FEES (ideal) • VAS scale
8. Sensory Acceptability	Patient-centred outcomes; Determines real-world adherence	• Mouthfeel (ordinal) • Ease of swallow (VAS 0-10) • Overall acceptability (5-point) • After-swallow residue perception	• Sensory rating scales (during eating) • VAS scales (post-swallow) • Acceptability questionnaire	• Rating scales • Questionnaire forms

Note: Essential parameters represent minimum assessment requirements. Optional advanced parameters available within each domain for comprehensive research protocols (see Appendix E for complete parameter inventory).

5.5.3 Mandatory Pre/Post Comparison Protocol

A fundamental framework requirement is pre/post comparison to validate transformation occurrence, as identified in this evidence synthesis where most studies assessed static texture but not transformation. This addresses the static measurement bias identified in Theme 3, where 64% of studies employed rheological/texture testing yet only 29% assessed transformation dynamics. The proposed Pre/Post Comparison protocol for this framework requires:

1. Baseline assessment: Measure initial texture (IDDSI level, TPA if available) and weight
2. Oral processing: Timed consumption with observation (record duration, chewing patterns)

3. Bolus collection: Expectorated bolus for post-oral assessment
4. Post-transformation assessment: Measure transformed texture (IDDSI level on bolus, weight)
5. Comparison calculation:
    - Texture change: IDDSI level change (e.g., Level 6 → Level 4 = 2-level reduction)
    - Moisture uptake: (Bolus weight - Initial weight) / Initial weight × 100
    - Transformation validation: Document that change occurred and quantify magnitude

This protocol can be implemented with minimal equipment (IDDSI testing kit, precision scale, timer) yet provides quantifiable transformation validation currently absent in 71% of studies.

5.5.4 Saliva Interaction Assessment: Addressing the Critical Gap

Saliva interaction emerged as the most underassessed domain (21% of studies, 6/28) with zero cross-method integration in synthesis coding, yet saliva incorporation represents the primary mechanism enabling TF transformation. The framework mandates saliva interaction assessment through accessible gravimetric analysis, supported by methods used in the included dataset (Studies 10 and 16).

Measurement protocol:

1. Weigh initial food sample (e.g., 10.0g)
2. After oral processing, collect and weigh expectorated bolus (e.g., 14.2g)
3. Calculate moisture uptake: (14.2g - 10.0g) / 10.0g × 100 = 42% moisture gain

Clinical significance:

- Quantifies saliva-food interaction
- Identifies individual variability (xerostomia vs. hypersalivation)
- Predicts transformation effectiveness across patient populations
- Requires only precision scale, no specialized equipment

This simple addition addresses the most significant evidence gap while maintaining framework accessibility for low-resource settings.

5.5.5 IDDSI Testing as Measurement Protocol

Current research demonstrates a critical implementation gap whereby 46% of studies used IDDSI for classification ("Level 4 food tested") but only 14% employed IDDSI testing protocols as measurement methods—a 3:1 ratio. The framework repositions IDDSI from classification tool to active measurement protocol:

IDDSI measurement applications:

1. Initial texture classification: Standard fork drip, spoon tilt tests on original food
2. Post-oral texture measurement: Apply identical tests to expectorated bolus
3. Transformation quantification: Compare initial vs. post-oral IDDSI levels
4. Safety validation: Confirm post-transformation texture meets safety criteria

Study 18, and study 15, demonstrated this approach's validity and feasibility. Study 18 reported high quality ratings (CASP 10Y/0N/1CT, purpose-developed schedule 21/25) with excellent reliability (documented operator training, ecologically valid protocol), while study 15 reported moderate to high quality ratings (CASP 9Y/1N/1CT; purpose-schedule tool 17/25, Moderate). The framework operationalises this evidence-based practice as standard protocol rather than optional advanced technique.

Advantages:

- Globally accessible (IDDSI testing kit)
- Standardised protocols (established reliability)
- No specialized training beyond IDDSI certification (widely available)
- Applicable to both research and clinical settings
- Directly validates transformation claims

5.5.6 Patient-centred Sensory Evaluation

While 29% of studies (8/28) assessed sensory evaluation, this domain often remained isolated from transformation and safety assessments. These studies consistently highlighted mouthfeel, ease of swallow, and overall acceptability as clinically relevant patient-reported outcomes. The framework integrates patient-centred outcomes as mandatory assessment component, recognising that clinical safety without patient acceptability fails to achieve real-world effectiveness.

Essential sensory parameters:

• Mouthfeel during eating: Texture sensation, perceived ease of oral processing

• Ease of swallow (VAS 0–10): Perceived swallowing difficulty

• After-swallow residue perception: Oral/pharyngeal coating sensation

• Overall acceptability (5-point scale): Willingness to consume regularly

Assessment timing:

1. During oral processing: Mouthfeel evaluation
2. Immediately post-swallow: Ease and residue perception
3. Post-consumption: Overall acceptability rating

Sensory acceptability directly predicts patient adherence and long-term dietary compliance. TFs demonstrating optimal transformation and safety profiles may fail clinically if patients refuse consumption due to unacceptable mouthfeel or perceived residue. Integration of sensory evaluation alongside mechanical and safety assessments ensures patient-centred framework application.

5.5.7 Minimum Essential Assessment Protocol

To ensure global accessibility, the framework defines a minimum essential protocol requiring only basic equipment yet capturing critical transformation validation:

Equipment required:

- IDDSI testing kit (standard set of tools recommended by the International Dysphagia Diet Standardisation Initiative, including the 10 mL syringe for flow testing, IDDSI fork and spoon for fork pressure and spoon tilt tests, a timer, and flat testing surfaces for level verification).
- Precision scale, 0.1g accuracy
- Timer/stopwatch
- Rating scales
- Collection container

Protocol steps (15-20 minutes per sample):

1. Initial assessment:
    - IDDSI testing (fork drip, spoon tilt)
    - Weigh food sample (e.g., 10.0g)
2. Oral processing:
    - Participant processes food orally
    - Time duration (stopwatch)
    - Assess mouthfeel (during eating): "How does this feel in your mouth?"
3. Bolus collection:
    - Collect expectorated bolus
    - Weigh bolus (e.g., 14.2g → 42% moisture uptake)

Following expectorated bolus testing, the participant processes and swallows a second bolus of the same food for safety and acceptability assessment.

4. Post-oral assessment:
    - IDDSI testing on bolus
    - Record IDDSI level change
5. Safety observation:
    - Clinical observation (cough, difficulty)
    - Ease of swallow rating (VAS 0-10)
6. Patient acceptability:
    - After-swallow residue perception
    - Overall acceptability (5-point scale)
7. Documentation:
    - Texture change: IDDSI level Δ
    - Moisture uptake: % gain
    - Safety: Clinical observations

- Acceptability: Rating scores

Outcome: Validated transformation profile with safety and acceptability data suitable for clinical decision-making or research publication.

5.5.8 Framework Validation and Implementation

The proposed framework requires prospective validation across diverse TF products, patient populations, and resource settings. This includes evaluation of reliability (e.g., consistency of IDDSI bolus testing, moisture uptake measures, and sensory ratings), construct validity (relationships among transformation, post-oral texture, safety, and acceptability measures), and clinical utility (feasibility, time requirements, and training needs). Further comparative validation may explore alignment between the minimum essential assessment set and more comprehensive testing approaches.

Implementation should prioritize accessible protocols (IDDSI testing, gravimetric analysis) while maintaining scientific rigor through standardised measurement procedures validated across the 28-study evidence base representing 125 distinct parameters.

5.5.9 Reliability and Reproducibility Procedures (Applicable Across All Assessment Domains)

To strengthen methodological rigour while maintaining clinical accessibility, the framework incorporates a set of lightweight reliability procedures across all assessment domains. These reflect practices already embedded in the evidence base: although only 18% of studies reported reliability metrics, 82% conducted reliability procedures (e.g., inter-rater checks, duplicate measurements). This indicates that the essential methodological behaviours required for reliable assessment were present in the dataset and can be legitimately integrated into the framework.

- Inter-rater Agreement:

A second trained assessor repeats key categorical ratings (e.g., IDDSI level, bolus cohesion) or count-based observations (e.g., chewing cycles). Disagreements are resolved through brief consensus checking.

- Duplicate or Repeat Measurements:

Quantitative measures, such as weight, moisture uptake, and dissolution timing, are recorded twice and averaged to reduce random error and enhance reproducibility.

- Standardised Procedures:

All assessors follow consistent step-by-step protocols for IDDSI testing, bolus handling, gravimetric weighing, and video-based timing. This improves comparability across assessors and sessions.

- Documentation of Reliability Steps:

Data sheets include a simple tick-box entry for whether inter-rater checks or duplicate measures were completed. This promotes transparency even when formal statistics (e.g., ICC, kappa) are not calculated.

These procedures ensure that the framework is both practically feasible in low-resource clinical settings and methodologically robust for research applications, addressing the transparency gap identified in the evidence synthesis.

5.5.10 Extended Research Protocol (Optional Research-Level Expansion)

The evidence-Informed transitional food assessment framework was intentionally designed to remain accessible for clinical and low-resource contexts, relying primarily on IDDSI testing, gravimetric analysis, and observational measures. However, the evidence synthesis demonstrated that several studies (e.g., Studies 3, 8, 10, 12, 15, 16, 18, 22) employed advanced analytical techniques, including rheology, tribology, texture profile analysis (TPA), videofluoroscopy (VFSS), FEES, and structured sensory panels, that offer deeper mechanistic insight into transitional food transformation.

To support future research applications, an extended research protocol is proposed. This protocol retains the same eight assessment domains, essential parameters, and rationales, but expands the assessment methods and equipment required columns with research-level options. These extended elements reflect methods already identified in the 28-study dataset and therefore remain evidence grounded.

This extended version is intended for laboratory, academic, or high-resource settings aiming to characterise transformation mechanisms with greater precision. It complements, rather than replaces, the minimum essential protocol, thereby preserving ecological validity while offering a pathway for advanced empirical investigation

Assessment Domain	Rationale	Essential Parameters	Extended Research Methods	Additional Equipment (Research Setting)
1. Initial Texture Properties	Baseline characterisation for pre/post comparison	•IDDSI level (0–7) • Initial texture properties	• Full Texture Profile Analysis (hardness, cohesiveness, springiness, adhesiveness) • Small-amplitude oscillatory rheology (G′, G″, phase angle) • Shear-thinning curve profiling	• Advanced Texture Analyzer (multi-probe setup) • Rheometer (cone–plate preferred)
2. Transformation Dynamics	Transformation behaviour determines TF safety through predictable softening and structural breakdown	• Dissolution time • Pre/post texture change • Softening rate	• Dynamic rheology during dissolution • Hydrocolloid breakdown curves • Real-time thermo-mechanical transformation mapping • High-speed video analysis of structural collapse	• Rheometer with time–temperature control • High-speed camera
3. Saliva Interaction	Saliva incorporation is the primary mechanism enabling TF to soften and reach swallow-ready state	• Moisture uptake (%) • Saliva incorporation (g) • Post-oral moisture content	• Artificial-saliva dissolution protocol • Tribology (friction coefficient under simulated oral conditions) • Moisture sorption isotherms	• Soft-contact tribometer • Environmental balance (for sorption curves)
4. Post-Oral Texture	Evaluates whether the food has reached appropriate transformed texture at end of the oral processing, prior to swallow initiation	• Post-oral IDDSI level • Transformed texture properties	• Post-bolus TPA profile • Phase-angle shift analysis (liquid–solid transition) • Cohesiveness-to-adhesiveness ratio	• Texture Analyzer (bolus-specific probes) • Low-volume rheometer

5. Oral Processing Capability	Functional validation of ability to achieve transformation	• Oral preparation time • Chewing cycles • Chewing rate	• 3D motion capture of mastication • Surface EMG of masseter/temporalis • Automated chew-cycle detection via video tracking	• sEMG system • 3D facial motion-capture (marker-based or markerless)
6. Bolus Formation	Swallow-readiness validation; links transformation to safety	• Bolus cohesion • Bolus moisture content • Visual homogeneity	• Cohesiveness indices (e.g., stickiness-to-cohesiveness ratio) • Microscopy for bolus microstructure • Particle-size distribution analysis	• Optical/light microscope • Particle-size analyser
7. Swallowing Safety	Clinical necessity; validates safety post-transformation	• Clinical signs • PAS score • Ease of swallow	• Full FEES protocol with residue quantification • VFSS temporal–kinematic analysis (OTT, PTT, pharyngeal transit) • Pharyngeal constriction ratio calculation	• FEES system • Fluoroscopy (VFSS) + kinematic analysis software
8. Sensory Acceptability	Patient-centred outcomes influencing real-world adherence	• Mouthfeel • Ease of swallow • Overall acceptability	• Quantitative Descriptive Analysis (trained sensory panel) • Temporal Dominance of Sensations (TDS) • 9-point hedonic ratings • Multi-attribute sensory profiling	• Sensory booths • Electronic sensory-data collection systems

This extended research protocol provides a systematic pathway for advanced empirical evaluation of transitional foods. Although these methods require specialised equipment and controlled testing environments, each extended measure is grounded in evidence from the 28-study dataset, ensuring methodological continuity with the synthesis. This allows the framework to remain globally accessible while supporting high-resolution research capable of driving future innovation in transitional food design, validation, and clinical application.

5.5.11 Framework Limitations and Future Directions

Analysis of the included studies highlights several constraints that shape the current framework and inform areas for future development. Because the synthesis was derived predominantly from healthy adult samples (15/28 studies), further validation in dysphagic populations is required to strengthen its clinical applicability. Evidence supporting IDDSI testing on expectorated bolus remains limited to two studies (Bandini et al., 2022; Barewal et al., 2021), indicating the need for broader empirical confirmation. Sensory evaluation methods also require cultural adaptation to ensure global relevance. Although reliability standards have been specified within the framework, they still require prospective confirmation across assessors, settings, and TF product types.

Future work should therefore focus on developing standardised training for IDDSI bolus testing, establishing normative moisture uptake data across TF categories, and assessing the framework's sensitivity to clinically meaningful differences. Additional priorities include creating implementation guidance for low-resource settings, examining applicability to paediatric and geriatric populations, and developing digital tools to streamline assessment and interpretation.

Overall, the framework represents a systematically derived, evidence-grounded model that will require iterative refinement as further empirical evidence accumulates and TF technologies evolve.

5.5.12 Summary

The Evidence-Informed Transitional Food Assessment Framework addresses systematic gaps identified through comprehensive synthesis of 28 studies representing 125 assessment parameters across 9 domains. By mandating transformation assessment through pre/post comparison, quantifying saliva interaction via accessible gravimetric analysis, operationalizing IDDSI testing as measurement protocol, and integrating patient-centred sensory evaluation, the framework provides a structured, evidence-based approach to TF validation. The minimum essential protocol requires only basic equipment and 15-20 minutes per sample, ensuring global accessibility while capturing the dynamic oral processing characteristics that distinguish transitional foods from traditional texture-modified foods. Framework validation and refinement through prospective research will establish standardised TF assessment practices supporting evidence-based dysphagia management globally.

5.6 Limitations

5.6.1 Methodological and Evidence-Base Limitations

The literature predominantly represented healthy adult samples (15/28 studies, 54%), with dysphagic populations included in 9 studies (32%), mixed populations in 2 studies (7%), and 2 in vitro studies (7%). Thus, generalisability to varied clinical dysphagia populations—including different aetiologies, severities, and age groups—will require future empirical testing. Although this distribution reflects typical recruitment patterns within texture-modified food research, it limits the immediate translation of findings to the broader clinical population.

Despite a staged, iterative search strategy, some relevant studies may not have been retrieved due to inconsistent indexing, varied terminology for texture-modified foods, or evolving definitions of transitional foods. The search did employ multiple search term combinations and synonyms (e.g., texture-modified foods, dysphagic diet, altered texture foods, deglutition disorders) to mitigate this limitation, and citation tracking of key papers provided additional retrieval pathways. Nonetheless, the degree of terminological variation across disciplines (nutrition, food science, speech-language therapy) means some studies may still have been missed.

Quality appraisal employed dual assessment, with a second reviewer independently verifying study selection and rating all 28 included studies using both CASP and the purpose-developed appraisal schedule. However, CASP was designed for human participant studies and was not suitable for the 2 in vitro method-development studies (Studies 7, 28), which received quality appraisal only through the purpose-developed schedule. This meant these studies underwent partial quality evaluation, potentially limiting comparability of quality judgments across the full evidence base. While this dual-review process enhanced reliability, minor subjectivity remains inherent in qualitative appraisal and interpretive coding, with differences resolved through discussion. Data extraction was conducted by the primary researcher using the purpose-developed literature extraction tool, with systematic documentation procedures ensuring consistency. While extraction followed standardised protocols and key decisions were discussed with the supervisory team, the single-extractor approach may introduce individual interpretation bias, particularly when categorizing complex methodological approaches or consolidating overlapping terminology.

A further limitation relates to the heterogeneity of outcome measures and instruments across the included studies. Although this diversity enabled comprehensive mapping of available methods, it also introduced variability that complicates direct comparison and synthesis. Several domains—particularly transformation dynamics and saliva interaction were underrepresented, limiting the strength of conclusions drawn for these areas. In addition, while reliability procedures were frequently described, formal reliability metrics were reported in only a minority of studies, constraining assessment of measurement precision across the evidence base.

5.6.2 Analytical and Reporting Limitations

Although data extraction and synthesis followed a structured approach, the mapping process required interpretive categorisation when consolidating 121 distinct parameters into nine conceptual domains. Every effort was made to ensure transparency and alignment with the original study aims, but some grouping decisions inevitably reflected researcher judgement. This limitation is inherent to evidence-synthesis methodologies that integrate heterogeneous study designs, terminologies, and measurement tools.

Variation in reporting depth across studies also influenced the granularity of the synthesis. Several papers provided limited procedural detail, particularly for oral-stage assessments, sensory measures, and reliability processes, which reduced the clarity and comparability of extracted methods. These inconsistencies restricted the ability to assess methodological robustness within particular domains and highlight the need for more standardised reporting guidelines for TMF and TF research.

5.6.3 Conceptual Limitations Related to Transitional Foods

Transitional foods remain an emerging category, and only three TF-specific studies met inclusion criteria. The framework therefore integrates broader TMF literature to identify principles relevant to TF assessment. While this broader evidence base strengthens the conceptual foundation of the framework, it also means that some domains, particularly transformation and saliva interaction, require validation using TF-specific products.

Furthermore, definitions of TFs continue to evolve. Earlier literature conceptualised transitional textures differently from current IDDSI descriptions, which may influence interpretation of legacy findings. As TF technology develops (e.g., aerated structures, advanced processing techniques), further conceptual refinement will likely be needed to ensure consistent classification and assessment.

5.6.4 Temporal and Measurement Framework Limitations

Temporal considerations also influence framework applicability. The evidence base spans studies published before and after the introduction of the IDDSI framework in 2017, meaning earlier studies could not employ IDDSI terminology or testing protocols. This temporal variation introduces heterogeneity in texture classification and measurement approaches across the evidence base, while also demonstrating the framework's capacity to synthesise both legacy and contemporary assessment methods. Differences in pre-IDDSI and post-IDDSI assessment practices may also explain the underuse of IDDSI as an active measurement tool rather than a classification descriptor.

Additionally, instrumental assessment methods, such as rheometry, tribology, and texture analysis, were used inconsistently across studies and often required specialised equipment. This introduces accessibility limitations for clinical or low-resource settings, reinforcing the need for practical, standardised, and low-cost assessment procedures such as IDDSI-based tests and simple gravimetric methods.

5.7 Directions for Future Research

Future research should prioritise validating the proposed assessment framework using TF-specific products across diverse clinical populations. Establishing normative data for moisture uptake, dissolution behaviours, and bolus formation characteristics across different TF categories will strengthen the clinical interpretability of transformation measures. Prospective studies are needed to examine inter-rater and test-retest reliability of key procedures, particularly IDDSI bolus testing, saliva-interaction measurements, and sensory evaluation tools, to support standardisation.

There is also a need to explore framework implementation across varied practice environments, including low-resource contexts where instrumental equipment is not feasible. Development of standardised training materials, reporting guidelines, and decision-support tools may enhance clinical usability and promote consistent application. Extending validation to paediatric, geriatric, and cognitively impaired populations will be essential for understanding TF suitability across the lifespan. Finally, as TF production technologies advance, ongoing evaluation will be required to ensure that the framework remains responsive to emerging formulations and processing techniques. Continued refinement through empirical testing and clinical application will support its evolution into a robust, evidence-informed tool for both food development and dysphagia management.

In addition to these priorities, further research is required to:

- Empirically examine transformation dynamics as the core defining property of transitional foods, including dissolution rates, softening trajectories, and structural collapse patterns under real oral conditions.
- Investigate saliva, TF interaction mechanisms across individuals with varying salivary profiles (e.g., xerostomia, hypersalivation) to develop clinically relevant transformation thresholds.
- Determine clinically meaningful cut-off values for transformation, post-oral texture, and bolus cohesion that differentiate safe vs. unsafe TF performance.
- Validate the proposed Pre/Post Comparison Protocol across multiple TF brands and formulations, establishing its sensitivity and specificity as a transformation index.
- Evaluate cross-domain interactions (e.g., how moisture uptake influences bolus cohesion and swallow safety), building an integrated mechanistic understanding of TF behaviour.
- Assess patient-centred outcomes specific to transitional foods, including mouthfeel evolution during transformation and acceptability of changing textures, to determine factors influencing long-term adherence.

- Compare TFs with traditional texture-modified foods in experimental and clinical settings to quantify added value, including reduced oral effort, improved bolus control, or enhanced safety margins.
- Develop simulation models or predictive tools (e.g., rheology-based transformation mapping, machine-learning prediction of bolus behaviours) to support TF product design and personalised clinical recommendations.

These TF-specific research priorities reflect the central thrust of the present study: establishing transitional foods as a distinct category requiring dynamic, transformation-based evaluation, and supporting the development of standardised, evidence-informed assessment practices

5.8 Implication

5.8.1 Implications for Clinical Practice

The study highlights a clear need for clinicians to systematically evaluate whether transitional foods (TFs) transform as intended during oral processing, rather than relying on manufacturer claims or trial-and-error selection. The framework supports this by outlining assessment domains that can be implemented with commonly available clinical tools (e.g., IDDSI tests, simple gravimetric measures). Systematic evaluation of transformation, saliva interaction, bolus cohesion, and sensory acceptability enables clinicians to match TF characteristics with individual patient capabilities, improving both safety and adherence. Integrating patient-centred sensory measures also addresses the gap between clinically “safe” foods and foods patients are willing to consume long-term.

5.8.2 Implications for Research

The synthesis demonstrates that transformation dynamics and saliva interaction remain substantially underassessed, despite being central to TF behaviour. This highlights the need for research designs that include pre–post comparison, bolus analysis, and transparent reporting of reliability metrics. The framework’s structured domains provide a foundation for more standardised reporting across studies, improving comparability and supporting future meta-analytic work. Increased inclusion of dysphagic populations is also essential, given that only 39% of studies included clinical participants.

Importantly, the low-equipment requirements of core measures mean TF research can be expanded across diverse settings and food cultures.

5.8.3 Implications for Industry

For manufacturers, the findings emphasise the importance of validating transformation claims using systematic, reproducible methods rather than relying solely on initial texture properties. Incorporating transformation assessment, saliva-interaction testing, and IDDSI-based measures during product development would strengthen quality assurance and clinical relevance. Clear documentation of transformation profiles and bolus properties would support clinicians in making informed choices and could form the basis for standardised TF certification or product specification guidelines.

5.9 Chapter Summary

The discussion highlighted how current TF and TMF assessment practices remain uneven, with strong emphasis on rheology and pharyngeal-stage measures but limited evaluation of oral-stage transformation and saliva interaction. These patterns, together with inconsistent reporting of reliability and limited inclusion of dysphagic populations, underscore the need for more systematic, transparent, and clinically aligned approaches to TF evaluation. The synthesis of findings informed the development of an evidence-informed framework aimed at addressing these gaps by integrating transformation validation, accessible measurement methods, and patient-centred outcomes. Collectively, the discussion demonstrates how the framework responds directly to the methodological and conceptual limitations identified across the evidence base, positioning it as a structured foundation for improving TF research and clinical practice.

6 Chapter Six: Conclusion

This study systematically examined the methods used to assess transitional foods (TFs) and broader texture-modified foods, identifying critical gaps in how transformation behaviour is currently evaluated. Across 28 included studies, assessment methods were heavily concentrated in rheology, texture properties, and pharyngeal-stage outcomes, while oral-stage processes—transformation dynamics, saliva interaction, bolus formation, and sensory acceptability—were substantially underrepresented. Only 29% of studies assessed transformation directly, and only 21% measured saliva interaction, despite these mechanisms defining the fundamental behaviour of TFs. The methodological quality analysis further highlighted underreporting of reliability metrics and limited contextualisation of findings, restricting interpretability and slowing the translation of research into practice. These findings collectively indicated that existing approaches provide an incomplete picture of TF performance and do not adequately support evidence-based decision-making.

In response, this thesis developed the Evidence-Informed Transitional Food Assessment Framework, synthesising nine assessment domains that capture initial properties, oral processing, transformation validation, post-oral texture, safety, and patient-centred acceptability. The framework emphasises systematic pre–post comparison, accessible measurement approaches, and explicit documentation of bolus-level outcomes—components that directly address gaps identified in the evidence base. By aligning core measures with widely available tools such as IDDSI testing and simple gravimetric procedures, the framework offers a practical and scalable model suitable for diverse clinical and research settings, including low-resource environments. It also highlights the importance of integrating sensory evaluation to ensure that foods considered “safe” are also acceptable and adherent to patient preferences.

The study’s findings position the framework as a foundational step towards standardising TF assessment and moving beyond reliance on initial texture classification or manufacturer claims. Future research should prioritise validating the framework’s domains using TF-specific products, expanding evidence across dysphagic populations, and strengthening reliability and reporting standards. As TF technology evolves, continued refinement will ensure the framework remains responsive to new formulations and clinical needs. Overall, this thesis advances the field by providing a structured, evidence-informed foundation to support safer, more transparent, and patient-centred TF development and dysphagia management.

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8 Appendix

8.1 Appendix A: Search Strategy and Search Log

Review Period: September 24, 2025 - October 6, 2025

Databases Searched: PubMed, CINAHL, Cochrane Library, Scopus

Supplementary Methods: Citation tracking

8.1.1 Initial Search

PUBMED

Search Attempt #1

- Date: 24/09/2025
- Search Strategy: "Deglutition Disorders"[Mesh] AND "Diet Therapy"[Mesh]
- Records Retrieved: 179
- Title Filtering: Shortlisted articles containing "dysphagia" → 22 articles
- Abstract Screening: 22 articles
    - Excluded: 22 (not dysphagia related)
    - Included after abstract screening: 0
- Duplicates: 0
- Decision: Refine search strategy to include specific transitional food terminology

Search Attempt #2

- Date: 24/09/2025
- Search Strategy: "Deglutition Disorders"[Mesh] AND "Food Technology"[Mesh]
- Records Retrieved: 59
- Title Filtering: Shortlisted articles containing "texture modified", "3D printing", "Dysphagia Food/Diet" → 24 articles
- Abstract Screening: 24 articles
    - Excluded: 22 (not dysphagia related, wrong population, wrong focus)
    - Included after abstract screening: 2
- Duplicates: 0

- Decision: Further refine search strategy to include specific transitional food terminology

Search Attempt #3

- Date: 24/09/2025
- Search Strategy: "Deglutition Disorders"[Mesh] AND "Mastication"[Mesh]
- Records Retrieved: 252
- Title Filtering: Shortlisted articles containing "texture modified", "oral processing", "Mastication", "Chewing", "Oro-motor function", "Dysphagia Food/Diet", "TOMASS" → 42 articles
- Abstract Screening: 42 articles
    - Excluded: 21 (not dysphagia related, wrong population, wrong focus, liquid only)
    - Included after abstract screening: 20
- Duplicates: 1
- Decision: This search string retained as strong base. Future refinement to combine mastication/oral processing with transitional food terminology.

Search Attempt #4

- Date: 25/09/2025
- Search Strategy:
- ("Deglutition Disorders"[Mesh] OR dysphagia[tiab] OR "swallowing disorder*"[tiab])AND ("Food Technology"[Mesh] OR "Diet Therapy"[Mesh] OR "transitional food*"[tiab] OR "texture modified food*"[tiab] OR IDDSI[tiab])AND ("Mastication"[Mesh] OR "oral processing"[tiab] OR chewing[tiab] OR "bolus formation"[tiab])AND ("Health Status Indicators"[Mesh] OR assessment*[tiab] OR evaluation*[tiab] OR protocol*[tiab])
- Records Retrieved: 14
- Title Filtering: Shortlisted articles containing "texture modified", "oral processing", "Mastication", "Chewing", "Oro-motor function", "Dysphagia Food/Diet", "Transitional Food" → 10 articles

- Abstract Screening: 10 articles
    - Excluded: 4 (wrong population, wrong focus, liquid only)
    - Included after abstract screening: 4
- Duplicates: 2
- Decision: Need to find articles specifically mentioning transitional foods

Search Attempt #5

- Date: 25/09/2025
- Search Strategy: "transitional food*"[tiab] OR "transitional foods"[tiab]
- Records Retrieved: 17
- Title Filtering: Shortlisted articles containing "transitional food" → 15 articles
- Abstract Screening: 15 articles
    - Excluded: 7 (wrong population, wrong focus, liquid only)
    - Included after abstract screening: 6
- Duplicates: 2
- Decision: Complements broader MeSH-based strategies by targeting specific emerging term

PubMed Summary

- Total Records Retrieved: 521
- Duplicates Removed: 5
- Title/Abstract Screened: 113
- Included after Abstract Screening: 32

<u>CINAHL</u>

Search Attempt #1

- Date: 25/09/2025
- Search Strategy: (MM "Deglutition Disorders") AND (MH "Food Technology" OR MH "Diet Therapy")
- Records Retrieved: 31

- Title Filtering: Shortlisted articles containing "dysphagia" → 20 articles
- Abstract Screening: 20 articles
    - Excluded: 18 (not dysphagia related, wrong population, wrong focus, liquid-only)
    - Included after abstract screening: 2
- Duplicates: 0
- Decision: Yield limited; refine using mastication/oral processing terminology

Search Attempt #2

- Date: 25/09/2025
- Search Strategy: (MM "Deglutition Disorders") AND (MH "Mastication")
- Records Retrieved: 67
- Title Filtering: Shortlisted articles containing "dysphagia", "oral processing", "chewing", "mastication" → 32 articles
- Abstract Screening: 32 articles
    - Excluded: 16 (not dysphagia, wrong population, wrong focus)
    - Included after abstract screening: 11
- Duplicates: 5
- Decision: Moderately productive; retain for comprehensiveness

Search Attempt #3

- Date: 25/09/2025
- Search Strategy: (MH "Deglutition Disorders") AND (mastication OR "oral processing" OR chewing OR "bolus formation")
- Records Retrieved: 229
- Title Filtering: Shortlisted articles containing "dysphagia", "oral processing", "chewing", "mastication", "assessments" → 41 articles
- Abstract Screening: 41 articles
    - Excluded: 24 (not dysphagia, wrong population, wrong focus)

    - Included after abstract screening: 17
- Duplicates: 0
- Decision: Successfully captured broader oral processing studies; refine towards transitional foods

Search Attempt #4

- Date: 29/09/2025
- Search Strategy:
- (MH "Deglutition Disorders") AND ("transitional food*" OR "texture modified food*" OR "texture modified diet*" OR "food texture" OR "oral transitional food*" OR "swallowing aid*" OR "texture modification") AND (assessment OR evaluation OR framework OR protocol OR tool OR method)
- Records Retrieved: 92
- Title Filtering: Shortlisted articles containing "dysphagia", "oral processing", "chewing", "mastication", "assessments", "transitional food", "iddsi" → 32 articles
- Abstract Screening: 32 articles
    - Excluded: 27 (not dysphagia, wrong population, wrong focus)
    - Included after abstract screening: 0
- Duplicates: 5
- Decision: Targeted approach; next attempt to directly target "transitional food" keyword

Search Attempt #5

- Date: 29/09/2025
- Search Strategy: "transitional food*"
- Records Retrieved: 4
- Title Filtering: All 4 articles retained
- Abstract Screening: 4 articles
    - Excluded: 1 (not dysphagia, wrong population, wrong focus)

    - Included after abstract screening: 1
- Duplicates: 2
- Decision: Highly targeted search completed

CINAHL Summary

- Total Records Retrieved: 423
- Duplicates Removed: 12
- Title/Abstract Screened: 129
- Included after Abstract Screening: 31

COCHRANE LIBRARY

Search Attempt #1

- Date: 29/09/2025
- Search Strategy: ("Deglutition Disorders" OR dysphagia) AND ("texture modified" OR "transitional food*")
- Records Retrieved: 18
- Title Filtering: Shortlisted 8 articles with "dysphagia", "swallowing", "therapy", "stroke", "oral"
- Abstract Screening: 8 articles
    - Excluded: 8 (wrong population, liquid-only, swallowing therapy without food modification, wrong focus)
    - Included after abstract screening: 0
- Duplicates: 0
- Decision: Produced mainly therapy studies; refine for next attempt

Search Attempt #2

- Date: 29/09/2025
- Search Strategy: (dysphagia OR "swallowing disorder*") AND (mastication OR chewing OR "oral processing") AND ("texture modified" OR "transitional food*")

- Records Retrieved: 0
- Abstract Screening: Not applicable
- Duplicates: 0
- Decision: Too restrictive; broaden in Attempt #3

Search Attempt #3

- Date: 29/09/2025
- Search Strategy:
- dysphagia AND ("texture modified food*" OR "transitional food*" OR IDDSI) AND (mastication OR chewing OR "oral processing" OR "bolus formation") AND (assessment* OR evaluation* OR protocol*)
- Records Retrieved: 1
- Title Filtering: 1 article retained
- Abstract Screening: 1 article
    - Excluded: 0 at abstract
    - Included after abstract screening: 1
- Duplicates: 0
- Decision: Very limited yield; narrow focus to "transitional food*" directly

Search Attempt #4

- Date: 29/09/2025
- Search Strategy: "transitional food*"
- Records Retrieved: 3
- Title Filtering: 2 articles matched context
- Abstract Screening: 2 articles
    - Excluded: 2 (wrong population - pediatric)
    - Included after abstract screening: 0
- Duplicates: 0

- Decision: Only yielded pediatric trials; not suitable

Search Attempt #5

- Date: 29/09/2025
- Search Strategy:
- dysphagia AND ("texture modified food*" OR "transitional food*" OR IDDSI) AND (mastication OR chewing OR "oral processing" OR "bolus formation") AND (assessment* OR evaluation* OR protocol*)
- Records Retrieved: 32
- Title Filtering: 15 articles matched keywords
- Abstract Screening: 10 articles
    - Excluded: 7 (non dysphagia, wrong population, wrong focus)
    - Included after abstract screening: 3
- Duplicates: 5
- Decision: Final Cochrane strategy; identified 3 relevant articles

Cochrane Summary

- Total Records Retrieved: 54
- Duplicates Removed: 5
- Title/Abstract Screened: 26
- Included after Abstract Screening: 4

<u>SCOPUS</u>

Search Attempt #1

- Date: 29/09/2025
- Search Strategy: TITLE-ABS-KEY (dysphag* OR "swallowing disorder*") AND TITLE-ABS-KEY ("texture modified" OR "texture modification" OR "modified diet*")
- Records Retrieved: 430

- Title Filtering: 160 shortlisted (contained "dysphagia," "swallowing," "texture modified," "oral processing," "IDDSI," or "assessment")
- Abstract Screening: 142 articles
    - Excluded: 111
    - Included after abstract screening: 31
- Duplicates: 18
- Decision: Broad but useful; narrow in next attempt

Search Attempt #2

- Date: 01/10/2025
- Search Strategy:
- TITLE-ABS-KEY ((dysphagia OR "swallowing disorder*") AND (mastication OR chewing OR "oral processing" OR "bolus formation") AND ("texture modified food*" OR "transitional food*" OR "texture modified diet*"))
- Records Retrieved: 38
- Title Filtering: 22 articles retained
- Abstract Screening: 5 articles
    - Excluded: 3
    - Included after abstract screening: 2
- Duplicates: 17
- Decision: Targeted; successfully identified 2 directly relevant articles

Search Attempt #3

- Date: 01/10/2025
- Search Strategy:
- TITLE-ABS-KEY ((dysphagia AND ("texture modified food*" OR "transitional food*" OR "texture modified diet*" OR IDDSI) AND (mastication OR chewing OR "oral processing" OR

"bolus formation") AND (assessment* OR evaluation* OR protocol* OR framework OR tool*)))

- Records Retrieved: 34
- Title Filtering: 20 articles shortlisted
- Abstract Screening: 5 articles
    - Excluded: 5
    - Included after abstract screening: 0
- Duplicates: 12
- Decision: No inclusions; refine with rheological properties

Search Attempt #4

- Date: 01/10/2025
- Search Strategy:
- TITLE-ABS-KEY ((dysphagia AND ("texture modified" OR "transitional food*" OR "texture modified diet*") AND (rheology OR tribology OR viscosity OR adhesiveness OR hardness OR cohesiveness)))
- Records Retrieved: 125
- Title Filtering: 56 articles (after excluding food engineering/nutrition-only)
- Abstract Screening: 11 articles
    - Excluded: 10 (wrong focus, liquid only)
    - Included after abstract screening: 1
- Duplicates: 45
- Decision: 1 relevant article identified

Search Attempt #5

- Date: 02/10/2025
- Search Strategy:

- TITLE-ABS-KEY ((dysphagia AND ("texture modified food*" OR "transitional food*" OR IDDSI) AND (guideline* OR consensus OR framework OR classification OR standard*)))
- Records Retrieved: 259
- Title Filtering: 59 articles
- Abstract Screening: 37 articles
    - Excluded: 20 (wrong focus, liquid only)
    - Included after abstract screening: 17
- Duplicates: 22
- Decision: Successfully captured guideline/framework papers

Search Attempt #6

- Date: 02/10/2025
- Search Strategy: TITLE-ABS-KEY ("transitional food*")
- Records Retrieved: 26
- Title Filtering: 14 articles
- Abstract Screening: 2 articles
    - Excluded: 2 (engineering/manufacturing focus only; no clinical relevance)
    - Included after abstract screening: 0
- Duplicates: 12
- Decision: Too narrow; mainly engineering-focused; no inclusions

Scopus Summary

- Total Records Retrieved: 912
- Duplicates Removed: 126
- Title/Abstract Screened: 202
- Included after Abstract Screening: 51

SUPPLEMENTARY SEARCHING

Citation Tracking (Scopus)

- Date: 02/10/2025
- Method: Scopus "related articles" feature
- Source Article: Bruno et al., 2025
- Articles Screened: 20 (from 5000+ available)
- Included: 1 (Takahashi et al., 2025 - Adhesion testing)

COMBINED DATABASE TOTALS

Records Flow

- Total Records Identified: 1,910

  (PubMed 521 + CINAHL 423 + Cochrane 54 + Scopus 912)
- Duplicates Removed: 148

  (PubMed 5 + CINAHL 12 + Cochrane 5 + Scopus 126)
- Unique Records After Deduplication: 1,762
- Title/Abstract Screened: 470

  (PubMed 113 + CINAHL 129 + Cochrane 26 + Scopus 202)
- Records Included After Abstract Screening: 118

  (PubMed 32 + CINAHL 31 + Cochrane 4 + Scopus 51)
- Additional via Citation Tracking: 1
- Total Proceeding to Full-Text Review: 119

8.1.2 Full-Text review phase

Date: 03/10/2025-05/10/2025

Full-Text Assessment

- Total Full Texts Reviewed: 112

  (Note: 7 duplicates identified during full-text stage)
- Final Included: 73

- Final Excluded: 39

Exclusion Reasons (n=39)

1. Product Formulation/Development Studies (n=13)

Reason: Studies focused on creating/optimizing food products rather than developing assessment methodologies

- Lu et al. 2025 - Protein gel formulation for 3D printing
- Liu et al. 2025 - Oyster 3D printing gel development
- Ettinger et al. 2024 - Plant-based frozen dessert formulation
- Yu et al. 2023 - 3D printed fish paste with hydrocolloids
- Hou et al. - 3D printed HIPE gel formulation
- Chang et al. - Sweet potato-based TMF formulation
- Qin et al. (Study 1) - Soy protein custard development
- Qin et al. (Study 2) - Milk protein custard development
- Zhang et al. - Anthocyanin-rice starch dysphagia foods
- Wan et al. - Vegetable-meat-rice puree formulation
- Hassan et al. - 3D printed fish gelatin-vegetable blends
- Charoensri et al. - Xanthan gum optimization in Riceberry porridge
- Rathi et al. - 3D printing technology review

2. Patient Assessment/Screening Tools (n=7)

Reason: Studies focused on evaluating patient capabilities/clinical diagnosis rather than food properties

- Minakuchi et al. 2018 - Oral hypofunction diagnostic criteria
- Clark et al. 2003 - Tongue strength predicting swallowing impairment
- Hiraoka et al. - Tongue pressure assessment in ALS patients
- Schimmel et al. 2017 - Oral sensitivity in stroke patients
- Lee et al. 2023 - Mastication/swallowing and oral health correlations

- Milewska et al. - FOIS-PL validation (patient intake scale)
- Salman et al. - MV-VST adaptation (patient screening tool)

3. Clinical Operations/Quality Improvement (n=2)

Reason: Studies focused on healthcare systems/organisational processes rather than food assessment

- Zaga & Sweeney - Hospital meal delivery system error reduction
- Wu et al. - IDDSI implementation barriers/enablers (CFIR framework)

4. Clinical Guideline/Protocol Development (n=1)

Reason: Development of patient management protocols rather than food assessment methods

- Lü et al. - Hierarchical diet management plan using Delphi method

5. Clinical Syndrome Reviews (n=1)

Reason: Review of patient diagnosis/treatment rather than assessment methodology

- Chen et al. 2021 - Sarcopenic dysphagia narrative review

6. Educational Content (n=1)

Reason: Tutorial/educational material without methodological contribution

- Letawsky 2020 - Saliva tutorial for clinicians

7. Patient Case Studies/Clinical Descriptions (n=5)

Reason: Clinical case presentations without assessment methodology development

- Hyland et al. - Clinical case descriptions
- Park et al. (version) - Patient population descriptive study
- Hase et al. - Clinical observations
- Depeyre et al. - Case series
- Rothenberg et al. - Clinical descriptive study

8. Population/Epidemiology Studies (n=1)

Reason: Disease prevalence study without assessment methodology

- Shi-hong 2024 - Dysphagia prevalence in stroke patients

9. Studies Outside Scope (n=7)

Various exclusion reasons detailed below

- Ajaj 2005 - MRI imaging technology validation study (not food assessment)
- Tagashira 2018 - Dietary intake patterns (epidemiology, not methodology)
- Higashiguchi 2017 - Nutritional status outcomes (not assessment methods)
- Samnieng 2012 - Oral health-food intake associations (not assessment development)
- Kang 2011 - Feeding difficulty risk factors (population study)
- Irles Rocamora 2014 - Nutritional intervention outcomes (not methodology)
- Mestre S., Mendes R., Cruz R., Croca J., Anjo C., & Rios J. - Records available only as conference abstracts or posters without peer-reviewed, full-text methodology or results.
- Krekeler B.N., Hori K., Jones C.A., Rosen S., Abdelhalim S., McCulloch T., et al. (2021) - Records available only as conference abstracts or posters without peer-reviewed, full-text methodology or results.

FINAL STUDY SELECTION FOR THE NEXT PHASE

Included Studies: 73

Distribution by Database:

- PubMed: 32
- CINAHL: 31
- Cochrane: 4
- Scopus: 49
- Citation tracking: 1
- *Note: Totals exceed 75 due to database overlap*

Exclusion Summary by Category

Category	Count	% of Excluded
Product formulation	13	33%

Patient assessment tools	7	18%
Clinical operations	2	5%
Clinical guidelines	1	3%
Syndrome reviews	1	3%
Educational content	1	3%
Case studies	5	13%
Population studies	1	3%
Outside scope	8	21%
Total Excluded	**39**	**100%**

Search strategy notes

Rationale for Staged Approach

A staged, iterative search strategy was employed across all databases:

1. Broad MeSH/controlled vocabulary (Attempts 1-3) - Ensured comprehensive coverage
2. Combined MeSH + free-text with assessment terms (Attempt 4) - Increased precision
3. Focused "transitional food" search (Attempt 5) - Captured emerging, under-indexed terminology

Key Methodological Decisions

Title Filtering

Applied consistently across databases to manage large initial retrievals while maintaining sensitivity for relevant studies.

Abstract Screening

All abstract screening conducted by using pre-defined inclusion/exclusion criteria focused on:

- Oral processing assessment methods
- Food property evaluation
- Transitional food characterization

- Methodological development

Full-Text Review

Conducted on 112 unique articles after abstract screening and duplicate removal. Focus on extracting:

- Assessment methodologies
- Measurement protocols
- Validation approaches
- Clinical application frameworks

8.1.3 Post-screening re-evaluation phase

Date: 05/10/2025- 06/10/2025

Method: Comprehensive re-evaluation of initially included 75 studies against refined inclusion criteria

Refined Inclusion Criteria:

Studies were re-evaluated and must meet ONE of the following:

1. Develop novel assessment methodologies for texture-modified or transitional foods (rheological, textural, sensory, biomechanical, or integrated approaches)
2. Validate existing assessment approaches with new protocols, instrumentation, or populations
3. Use instrumental assessment (VFSS, FEES, rheology, texture analysis, sensory evaluation, EMG) to systematically evaluate food behaviour during oral processing and/or swallowing

Criterion Expansion Rationale:

Given the limited evidence base specifically for transitional foods in adults, we expanded criteria to include clinical validation studies using instrumental assessment to evaluate transitional food or texture-modified food behaviour during swallowing. This expansion was necessary to capture foundational evidence while maintaining focus on empirical food assessment methodologies rather than patient screening tools, product formulation studies, or secondary sources.

Re-Evaluation Results:

- Studies Re-Evaluated: 73
- Final Included After Re-Evaluation: 28
- Additional Excluded After Re-Evaluation: 45

Primary Reasons for Additional Exclusions:

- Review articles/book chapters/secondary sources (n=20)
- Patient assessment tools rather than food assessment (n=7 additional to initial exclusions)
- Food characterization without methodology development (n=9)
- Liquids-only studies (n=4)
- Theoretical/conceptual papers without empirical methods (n=3)
- Other methodological mismatches (n=2)

FINAL EXCLUSION SUMMARY

Total Full Texts Reviewed: 73

Final Included: 28

Final Excluded: 45

Exclusion Reasons (n=45)

1. Product Formulation/Development Studies (n=13)

Reason: Studies focused on creating/optimizing food products rather than developing assessment methodologies

- Lu et al. 2025 - Protein gel formulation for 3D printing
- Liu et al. 2025 - Oyster 3D printing gel development
- Ettinger et al. 2024 - Plant-based frozen dessert formulation
- Yu et al. 2023 - 3D printed fish paste with hydrocolloids
- Hou et al. - 3D printed HIPE gel formulation
- Chang et al. - Sweet potato-based TMF formulation
- Qin et al. (Study 1) - Soy protein custard development

- Qin et al. (Study 2) - Milk protein custard development
- Zhang et al. - Anthocyanin-rice starch dysphagia foods
- Wan et al. - Vegetable-meat-rice puree formulation
- Hassan et al. - 3D printed fish gelatin-vegetable blends
- Charoensri et al. - Xanthan gum optimization in Riceberry porridge
- Rathi et al. - 3D printing technology review

2. Reviews, Commentaries, and Secondary Sources (n=20)

Reason: Review articles, book chapters, commentaries, editorials, tutorials without original methodology development

- Funami & Nakauma 2022 - Book chapter on consumer perception assessment
- Hadde & Chen 2023 - Book chapter on textural aspects
- Bolívar-Prados et al. 2024 - Book chapter on TMF
- Fiszman & Laguna 2023 - Narrative review on food design
- Ibañez et al. 2022 - Systematic review of texture characterization techniques
- Gray-Stuart 2020 - Conceptual framework
- Woda 2006 - Theoretical adaptation model
- Tymchuck 2024 - Food texture tutorial
- Chen 2021 - Sarcopenic dysphagia narrative review
- Letawsky 2020 - Saliva tutorial for clinicians
- Additional review articles and book chapters (n=10)

3. Patient Assessment/Screening Tools (n=14)

Reason: Studies focused on evaluating patient capabilities/clinical diagnosis rather than food properties

- Huckabee et al. 2018 - TOMASS original validation
- Lamvik-Gozdzikowska et al. 2019 - TOMASS with anaesthesia
- Hägglund et al. 2021 - TOMASS Scandinavian norms

- Todaro et al. 2021 - TOMASS validation in dysphagia patients
- Sella-Weiss 2023 - TOMASS and TWST reliability/normative data
- Nagashima et al. 2022 - Sakiika Transport Test development
- Minakuchi et al. 2018 - Oral hypofunction diagnostic criteria
- Clark et al. 2003 - Tongue strength predicting swallowing impairment
- Hiraoka et al. - Tongue pressure assessment in ALS patients
- Schimmel et al. 2017 - Oral sensitivity in stroke patients
- Lee et al. 2023 - Mastication/swallowing and oral health correlations
- Milewska et al. - FOIS-PL validation
- Salman et al. - MV-VST adaptation
- Han dysphagia scale and similar patient tools

4. Food/Product Characterization Studies (n=9)

Reason: Laboratory characterization of food products without human assessment or methodology development

- Chen 2025 - Food characterization without methodology
- Larsen - Gelatin testing with IDDSI
- Stading 2021 - Physical properties of model TMF set (companion to methodology paper)
- Wong et al. 2023 (database) - Quantitative IDDSI values for Chinese foods
- Gamonpilas 2023 - Thickener characterization (liquids)
- Marconati 2020 - Extensional rheology of thickened liquids
- de Villiers et al., 2019 – Impact of modification techniques on rheological properties of dysphagia foods and liquids
- Additional characterization studies (n=2)

5. Liquids-Only Studies (n=4)

Reason: Studies focused exclusively on thickened liquids rather than solid/semi-solid foods requiring oral processing

- Gamonpilas 2023 - Thickener characterization
- Marconati 2020 - Extensional rheology of thickened liquids
- Hadde et al. 2022 Part 1 - IDDSI levels for thickened fluids
- Ribes et al. 2022- PUREED/LIQUID FOOD - specifically texture-modified SAUCES

6. Clinical Operations/Quality Improvement (n=2)

Reason: Studies focused on healthcare systems/organisational processes rather than food assessment

- Zaga & Sweeney - Hospital meal delivery system error reduction
- Wu et al. - IDDSI implementation barriers/enablers (CFIR framework)

7. Theoretical/Conceptual Papers (n=3)

Reason: Theoretical frameworks without empirical methodology development

- Woda 2006 - Theoretical adaptation model
- Gray-Stuart 2020 - Conceptual framework
- Tymchuck 2024 - Food texture tutorial

8. Qualitative/Patient Perspective Studies (n=1)

Reason: Qualitative research without instrumental assessment

- Shune & Barewal 2022 - Resident perceptions of snacking (qualitative interviews)

9. Clinical Comparison Studies Without Methodology (n=2)

Reason: Clinical outcomes research using existing tools without developing assessment methods

- Kagaya et al. 2015 - Brief communication on pharyngeal timing
- Bayne et al. 2022 - Nutritional intervention comparing snacks

10. Pediatric Population Studies (n=1)

Reason: Pediatric-focused research outside adult scope

- Drzewicki - Pediatric transitional foods study

11. Clinical Guideline/Protocol Development (n=1)

Reason: Development of patient management protocols rather than food assessment methods

- Lü et al. - Hierarchical diet management plan using Delphi method

12. Patient Case Studies/Clinical Descriptions (n=5)

Reason: Clinical case presentations without assessment methodology development

- Hyland et al. - Clinical case descriptions
- Park et al. (version) - Patient population descriptive study
- Hase et al. - Clinical observations
- Depeyre et al. - Case series
- Rothenberg et al. - Clinical descriptive study

13. Population/Epidemiology Studies (n=1)

Reason: Disease prevalence study without assessment methodology

- Shi-hong 2024 - Dysphagia prevalence in stroke patients

14. Studies Outside Scope (n=6)

Various exclusion reasons:

- Ajaj 2005 - MRI imaging technology validation study (not food assessment)
- Tagashira 2018 - Dietary intake patterns (epidemiology, not methodology)
- Higashiguchi 2017 - Nutritional status outcomes (not assessment methods)
- Samnieng 2012 - Oral health-food intake associations (not assessment development)
- Kang 2011 - Feeding difficulty risk factors (population study)
- Irles Rocamora 2014 - Nutritional intervention outcomes (not methodology)

EXCLUSION SUMMARY BY CATEGORY

Category	Count	% of Excluded
Product formulation / development	13	29.5 %
Reviews / commentaries / secondary sources	20	45.5 %
Patient assessment tools	14	31.8 %
Food / product characterization only	9	20 %

Liquids-only studies	4	9.1 %
Clinical operations / quality improvement	2	4.5 %
Theoretical / conceptual papers	3	6.8 %
Qualitative / patient perspective	1	2.3 %
Clinical comparison without methodology	2	4.5 %
Pediatric population	1	2.3 %
Clinical guidelines	1	2.3 %
Case studies	5	11.4 %
Population / epidemiology studies	1	2.3 %
Outside scope (misc)	6	13.6 %
TOTAL EXCLUDED	45	100%

Note: Some studies may fit multiple categories; percentages calculated based on primary exclusion reason

FINAL STUDY SELECTION

Included Studies: 28

Distribution by Study Type:

- Methodology development studies: ~20
    - Rheological/textural assessment methods
    - Sensory evaluation protocols
    - Bolus characterization approaches
    - Biomechanical assessment techniques
    - Integrated multi-modal methods
- Clinical validation studies with instrumental assessment: ~8
    - VFSS/FEES comparative studies
    - Transitional food clinical validation
    - Particle-containing TMF evaluation

- Multi-texture clinical comparisons

Key Study Categories:

1. Rheological and Textural Methods
    - Viscosity, tribology, extensional properties
    - Texture profile analysis protocols
    - Pre/post oral processing comparison
2. Sensory Evaluation Approaches
    - Descriptive analysis methodologies
    - Age-stratified assessment
    - Instrumental-sensory correlation
3. Oral Processing Assessment
    - EMG, videofluoroscopy, FEES
    - Mastication biomechanics
    - Bolus formation characterization
4. Integrated Assessment Frameworks
    - Multi-modal evaluation combining instrumental, sensory, and clinical measures
    - Transitional food-specific protocols
5. Clinical Validation Studies
    - VFSS/FEES comparison of texture types
    - Particle effects on swallowing
    - Temporal swallowing parameter assessment

SEARCH STRATEGY NOTES

Rationale for Staged Approach

A staged, iterative search strategy was employed across all databases:

1. Broad MeSH/controlled vocabulary (Attempts 1-3) - Ensured comprehensive coverage
2. Combined MeSH + free-text with assessment terms (Attempt 4) - Increased precision

3. Focused "transitional food" search (Attempt 5) - Captured emerging, under-indexed terminology

8.1.4 Key Methodological Decisions

Title Filtering

Applied consistently across databases to manage large initial retrievals while maintaining sensitivity for relevant studies.

Abstract Screening

All abstract screening conducted using pre-defined inclusion/exclusion criteria focused on:

- Oral processing assessment methods
- Food property evaluation
- Transitional food characterization
- Methodological development

Full-Text Review

Conducted on 73 unique articles after abstract screening and duplicate removal. Initial focus on extracting:

- Assessment methodologies
- Measurement protocols
- Validation approaches
- Clinical application frameworks

Post-Screening Re-Evaluation

Comprehensive re-evaluation against refined criteria to ensure only studies developing or validating assessment methodologies were included, resulting in final selection of 30 studies with clear methodological contributions to transitional food and texture-modified food assessment.

8.2 Appendix B: Literature Extraction

8.2.1 Appendix B1:Purpose-developed literature extraction tool - Blank

LITERATURE EXTRACTION TOOL

Systematic Extraction of Measurement Methods from Transitional Food/Dysphagia Studies

STUDY IDENTIFICATION	
Study ID:	
Authors:	
Year:	
Journal:	
Country:	
Study Design:	

KEY MEASUREMENT FOCUS

☐ Timing (e.g., oral transit, mastication)

☐ Bolus formation (e.g., cohesion, readiness)

☐ Residue

☐ Instrumental (VFSS/FEES/EMA)

☐ Pressure/Force

☐ Perceptual/Subjective

Other: ________________________

POPULATION & CONTEXT

Population Type: ☐ Healthy ☐ Dysphagic ☐ Mixed ☐ Other: _________________

Sample Size: __________________________________

Age Range: __________________________________

Setting: ☐ Laboratory ☐ Clinical ☐ Community ☐ Other: _________________

FOOD TEXTURE DETAILS

Food Type(s) Used: ___________________________________

Initial Texture: ___________________________________

Expected Transformation: ☐ Transitional ☐ Static ☐ Not specified

Texture Classification System: ☐ IDDSI ☐ Not specified ☐ Other: _________________

Study Focus: ☐ Transitional foods ☐ General mastication ☐ Swallowing mechanics ☐ Food texture

☐ Other: _________________

MEASUREMENT METHODS EXTRACTION

ORAL PROCESSING PHASE MEASUREMENTS

TIMING MEASUREMENTS

Measurement	Method/Tool Used	Operational Definition	Units	Reliability Data
Oral Transit Time				
Oral Preparation Time				
Total Oral Phase Duration				
Chew Time				
Mastication Duration				
Pre-swallow Duration				

Stage II Transport Time				
Pharyngeal Transit Time				
Other:				

BOLUS FORMATION ASSESSMENT

Aspect Measured	**Rating Method**	**Scale/Criteria Used**	**Scoring System**	**Inter-rater Reliability**
Bolus Cohesion				
Bolus Size				
Bolus Consistency				
Bolus Readiness				
Other:				

ORAL RESIDUE ASSESSMENT

Location	**Assessment Method**	**Scale Used**	**Operational Definition**	**Reliability Measures**
Oral Cavity (general)				
Tongue Surface				
Hard Palate				
Sulci				
Other locations:				

INSTRUMENTAL MEASUREMENTS

IMAGING/VISUALIZATION

Technology	Parameters Measured	Analysis Method	Software Used	Validation Data
VFSS (Videofluoroscopy)				
FEES (Endoscopy)				
Ultrasound				
High-speed Video				
Other:				

PRESSURE/FORCE MEASUREMENTS

Measurement	Equipment	Location	Analysis Protocol	Normative Data
Tongue Pressure				
Lip Force				
Jaw Force				
Other:				

SUBJECTIVE/PERCEPTUAL MEASURES

PARTICIPANT-REPORTED

Measure	Scale/Questionnaire	Response Options	Validation Info	Administration
Swallowing Effort				

Texture Perception				
Acceptability				
Safety Perception				
Other:				

CLINICIAN-RATED

Measure	Rating System	Criteria	Training Required	Inter-rater Agreement
Swallowing Safety				
Swallowing Efficiency				
Overall Performance				
Other:				

METHODOLOGICAL DETAILS

DATA COLLECTION PROTOCOL

Number of Trials: ___________________________________

Trial Randomization: ☐ Yes ☐ No - Method: _________________

Rest Periods: ___________________________________

Standardisation Procedures:

RELIABILITY MEASURES

Type	Method	Results
Intra-rater Reliability		
Inter-rater Reliability		
Test-retest Reliability		

VALIDITY EVIDENCE

Content Validity:

Construct Validity:

Criterion Validity:

ADAPTATION POTENTIAL FOR HEALTHY ADULTS

Feasibility: ☐ High ☐ Medium ☐ Low

Equipment Requirements:

Expertise Needed:

Safety Considerations:

Modifications Needed:

STUDY QUALITY INDICATORS

Criterion	Rating	Notes
Clear Operational Definitions	☐ Yes ☐ Partial ☐ No	
Standardised Protocol	☐ Yes ☐ Partial ☐ No	
Reliability Testing	☐ Yes ☐ Partial ☐ No	
Sample Size Justification	☐ Yes ☐ Partial ☐ No	
Appropriate Analysis	☐ Yes ☐ Partial ☐ No	

KEY STRENGTHS OF MEASUREMENT APPROACH:

LIMITATIONS/GAPS IDENTIFIED:

POTENTIAL FOR ADAPTATION:

Extraction Completed by: ___________________________________

Date: ___________________________________

Review Status: ☐ First extraction ☐ Verified ☐ Discrepancies resolved

8.2.2 Appendix B2:Purpose-developed literature extraction tool – Completed example

LITERATURE EXTRACTION TOOL

Systematic Extraction of Measurement Methods from Transitional Food/Dysphagia Studies

STUDY IDENTIFICATION	
Study ID:	001
Authors:	Mineka Yoshikawa, Jun Kayashita, Masahiro Nakamori, Toshikazu Nagasaki, Shin Masuda, Mitsuyoshi Yoshida
Year:	2025
Journal:	Scientific Reports
Country:	Japan
Study Design:	Prospective cross-sectional comparative study (Videofluoroscopic analysis)

KEY MEASUREMENT FOCUS

☑ Timing ((PTT, PDT, LEDT, oPTT, hPTT))

☐ Bolus formation (e.g., cohesion, readiness)

☐ Residue

☑ Instrumental (VFSS/FEES/EMA)

☐ Pressure/Force

☐ Perceptual/Subjective

Other: ________________________

Primary focus: Videofluoroscopic temporal analysis of swallowing dynamics comparing jelly, thickened liquid, and thin liquid

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POPULATION & CONTEXT

Population Type: ☐ Healthy ☑ Dysphagic (mild stroke / near-normal swallowers) ☐ Mixed ☐ Other:

Sample Size: 175 stroke patients (104 men, 71 women; mean 68.6 ± 12 y)

Age Range: ≥ 20 years

Setting: ☐ Laboratory ☑ Clinical (hospital VF lab) ☐ Community ☐ Other: ________________

FOOD TEXTURE DETAILS

Food Type(s) Used: Thin liquid; Thickened liquid (3 % Neo High Toromeal); Jelly (Aqua Jelly Powder)

Initial Texture: Jelly: Homogeneous, cohesive, soft, low-shrinkage (can be scooped and swallowed without chewing); Thickened liquid: Moderately thick (flows slowly); Thin liquid: Standard water consistency

Expected Transformation: ☐ Transitional ☑ Static ☐ Not specified

Texture Classification System: ☐ IDDSI ☐ Not specified ☑ Other: Japan Dysphagia Diet 2021 (0j, 0t) ≈ IDDSI 3–4

Study Focus: ☐ Transitional foods ☐ General mastication ☑Swallowing mechanics ☑ Food texture ☑ Other: Aspiration risk assessment; swallowing timing parameters

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MEASUREMENT METHODS EXTRACTION

ORAL PROCESSING PHASE MEASUREMENTS

TIMING MEASUREMENTS

Measurement	Method/Tool Used	Operational Definition	Units	Reliability Data
Oral Transit Time	-	-	-	-
Oral Preparation Time	-	-	-	-

Total Oral Phase Duration	-	-	-	-
Chew Time	-	-	-	-
Mastication Duration	-			
Pre-swallow Duration	-			
Stage II Transport Time	-			
Pharyngeal Transit Time (PTT)	Videofluoroscopy (VF) at 30 fps	Interval from bolus head reaching mandibular ramus-tongue base junction until bolus tail passed cricopharyngeal region/pharyngoesophageal segment	Seconds (s)	Inter-rater reliability: 2 blinded experienced dentists
Pharyngeal Delay Time (PDT)	Videofluoroscopy	Interval from bolus head reaching mandibular ramus-tongue base junction to onset of laryngeal elevation	Seconds (s)	Inter-rater reliability: 2 blinded examiners
Pharyngeal Delay Time (PDT)	Videofluoroscopy	Interval from bolus head reaching mandibular ramus-tongue base junction to onset of laryngeal elevation	Seconds (s)	Inter-rater reliability: 2 blinded examiners

Laryngeal Elevation Delay Time (LEDT)	Videofluoroscopy	Interval from bolus arrival at pyriform sinus to onset of maximum laryngeal elevation	Seconds (s)	Inter-rater reliability: 2 blinded examiners; Cutoff value >0.35s for aspiration risk
Oropharyngeal Transit Time (oPTT)	Videofluoroscopy	Time from mandibular ramus-tongue base junction to bolus epiglottic passage	Seconds (s)	Inter-rater reliability: 2 blinded examiners
Hypopharyngeal Transit Time (hPTT)	Videofluoroscopy	Interval from bolus epiglottic passage to cricopharyngeal transit	Seconds (s)	Inter-rater reliability: 2 blinded examiners

Note: PTT was divided into two phases (oPTT and hPTT) to distinguish between bolus passage in middle pharynx vs. hypopharynx.

BOLUS FORMATION ASSESSMENT

Not directly assessed. Bolus characteristics predetermined by food form (jelly, thickened liquid, thin liquid with 50% iodine contrast medium)

Aspect Measured	**Rating Method**	**Scale/Criteria Used**	**Scoring System**	**Inter-rater Reliability**
Bolus Cohesion				
Bolus Size				

Bolus Consistency				
Bolus Readiness				
Other: Bolus Passage	Visual observation via VF	Bolus passage Complete passage vs. residue	Binary (passed/residue)	2 blinded examiners

Protocol:

- 3 mL thin liquid
- 3 mL thickened liquid (3% Neo High Toromeal thickening agent)
- 3g jelly (Aqua Jelly Powder)
- All contained 50% iodine contrast medium (Oypalomin 370)
- Placed on tongue, swallowed in one motion
- Fixed sequence: thin → thickened → jelly
- 1-2 trials per food form; best trial analyzed

ORAL RESIDUE ASSESSMENT

Not systematically assessed. Study notes "no residue remained after swallowing" for all food forms in analyzed patients.

Location	Assessment Method	Scale Used	Operational Definition	Reliability Measures
Oral Cavity (general)				
Tongue Surface				
Hard Palate				
Sulci				

Other locations:				

<u>INSTRUMENTAL MEASUREMENTS</u>

IMAGING/VISUALIZATION

Technology	**Parameters Measured**	**Analysis Method**	**Software Used**	**Validation Data**
VFSS (Videofluoroscopy)	PTT, PDT, LEDT, oPTT, hPTT; Aspiration presence	Lateral view imaging at 30 fps; Philips BV Pulsera X-ray system	DVD recording analyzed frame-by-frame	2 experienced dentists (TN, MY) specialized in VF evaluation; blinded to
	Anatomical landmarks: lips (anterior) to pharynx wall (posterior); nasal cavity (superior) to upper esophageal sphincter (inferior)	Temporal measurements from bolus position to anatomical events	Not specified	Natural light-visible aspiration
FEES (Endoscopy)				
Ultrasound				
High-speed Video				
Other:				

Imaging Protocol:

- Patient seated position
- Lateral view
- 30 frames per second
- DVD recording for analysis
- Each food form tested 1-2 times in fixed sequence
- Best replicate selected by inter-examiner discussion

PRESSURE/FORCE MEASUREMENTS

Not measured.

Measurement	**Equipment**	**Location**	**Analysis Protocol**	**Normative Data**
Tongue Pressure				
Lip Force				
Jaw Force				
Other:				

SUBJECTIVE/PERCEPTUAL MEASURES

PARTICIPANT-REPORTED

Not assessed. No sensory evaluation or patient-reported outcomes.

Measure	**Scale/Questionnaire**	**Response Options**	**Validation Info**	**Administration**
Swallowing Effort				
Texture Perception				
Acceptability				

Safety Perception				
Other:				

CLINICIAN-RATED

Measure	**Rating System**	**Criteria**	**Training Required**	**Inter-rater Agreement**
Swallowing Safety				
Swallowing Efficiency				
Overall Performance				
Other:**Aspiration presence**	Binary (present/absent)	Natural light-visible aspiration on VF	Specialized VF evaluation experience	2 experienced dentists, blinded; inter-examiner discussion for consensus

METHODOLOGICAL DETAILS

<u>DATA COLLECTION PROTOCOL</u>

Number of Trials: 1-2 per food form per patient; best trial analyzed

Trial Randomization: ☐ Yes ☑ No - Method: Fixed sequence (thin liquid → thickened liquid → jelly)

Rest Periods: Not specified between trials

Standardisation Procedures:

- VF conducted within 14 days of stroke event
- Fixed bolus volumes (3 mL liquids, 3g jelly)
- 50% iodine contrast medium in all samples

- Seated patient position
- Standardised anatomical landmarks for imaging
- Food placed on tongue by tester
- Instruction to swallow in one motion
- 2 blinded examiners for analysis

Screening Tests Used:

- Modified Water Swallow Test (MWST) - score >4 required
- Repetitive Saliva Swallowing Test (RSST) - ≥3 swallows in 30s required
- Modified Mann Assessment of Swallowing Ability (MMASA) - score ≥95 required

RELIABILITY MEASURES

Type	Method	Results
Intra-rater Reliability	Not reported	-
Inter-rater Reliability	2 blinded experienced dentists analyzed all VF recordings	No formal statistics reported (ICC, kappa); inter-examiner discussion for best trial selection
Test-retest Reliability	Not applicable (single VF session per patient)	-

Note: Study used 2 independent blinded raters but did not report formal reliability coefficients.

VALIDITY EVIDENCE

Content Validity:

Timing parameters (PTT, PDT, LEDT) are established VF measures commonly used to assess aspiration risk, validated in prior literature (references 13-16 cited). LEDT cutoff value >0.35s established for aspiration risk.

Construct Validity:

LEDT significantly prolonged in patients who aspirated ($p<0.05$), supporting construct validity of LEDT as aspiration risk indicator. Screening tests (MWST, RSST, MMASA) validated in Japanese population.

Criterion Validity:

Food forms validated against JDD2021 classification system. Thickening agent viscosity (150-300 mPa) aligns with JDD2021 code 0t standards. Aspiration confirmed via visual VF assessment (gold standard).

ADAPTATION POTENTIAL FOR HEALTHY ADULTS

Feasibility: ☐ High ☑ Medium ☐ Low

Equipment Requirements:

- High-end radiographic setup (Philips BV Pulsera 30 fps, contrast media).
- Could be substituted with ultrasound or high-speed camera for healthy trials.
- specialized thickening agents and jelly products
- DVD recording system

Expertise Needed:

- Advanced VF interpretation by trained radiologists or dysphagia specialists.
- Requires familiarity with timing parameters (PTT, PDT, LEDT).

Safety Considerations:

- Radiation exposure restricts direct testing in healthy populations.
- Ethical clearance essential; alternative imaging recommended for non-clinical participants.

Modifications Needed:

- Replace VF with non-radiative method (ultrasound, surface EMG, or HSC).
- Adjust food quantities to match transitional texture testing (≤ 3 mL).
- Add perceptual or sensory assessment for comprehensive data.

STUDY QUALITY INDICATORS

Criterion	Rating	Notes
Clear Operational Definitions	☑ Yes ☐ Partial ☐ No	All timing parameters clearly defined with anatomical landmarks
Standardised Protocol	☑ Yes ☐ Partial ☐ No	Fixed sequence, volumes, contrast medium concentration, patient positioning
Reliability Testing	☐ Yes ☑ Partial ☐ No	2 blinded raters used but no formal reliability statistics reported
Sample Size Justification	☐ Yes ☐ Partial ☑ No	n=175 not justified; consecutive enrollment stated
Appropriate Analysis	☑ Yes ☐ Partial ☐ No	Friedman test, Scheffe post hoc, Mann-Whitney U, χ^2 test appropriate

KEY STRENGTHS OF MEASUREMENT APPROACH:

- Clear operationalization of pharyngeal timing measures (PTT, PDT, LEDT, oPTT, hPTT)
- Excellent control and standardisation (fixed sequence, volumes, and contrast medium concentration)
- Construct validity supported by LEDT-aspiration link (LEDT >0.35s associated with aspiration)
- Two-phase PTT analysis (oPTT + hPTT) distinguishes oropharyngeal vs. hypopharyngeal passage
- Within-subject design (same patients tested with all 3 food forms) reduces variability
- Blinded assessment by 2 experienced examiners increases objectivity

LIMITATIONS/GAPS IDENTIFIED:

- Lack of formal reliability coefficients (ICC/Kappa) despite using 2 raters
- Stroke-only population limits generalizability to healthy adults
- No kinematic measures (hyoid/laryngeal range of motion, displacement)

- No sensory/perceptual measures (patient-reported outcomes)
- Fixed sequence testing (not randomized) - potential order effects
- Static textures only - not true transitional foods
- Radiation exposure prevents direct use in healthy adults
- Single-centre study in Japan - cultural/practice specificity (JDD2021)

POTENTIAL FOR ADAPTATION:

- Timing framework (PTT, PDT, LEDT, oPTT, hPTT) transferable to non-invasive imaging (ultrasound or high-speed camera)
- Useful benchmark data for transitional food validation in healthy adults
- Two-phase PTT analysis approach could assess texture transformation timing
- Temporal parameter definitions applicable to other imaging modalities
- Standardised protocol provides model for food texture comparison studies
- Multimodal screening approach (MWST, RSST, MMASA) could establish baseline for healthy adults

Extraction Completed by: Samurdi M

Date: 06/10/2025

Review Status: ☐ First extraction ☑ Verified ☐ Discrepancies resolved

NOTES

- **RELEVANCE TO SYSTEMATIC REVIEW:** This study uses static food textures (jelly, thickened liquid, thin liquid) with **no inherent texture transformation** during swallowing. However, the **temporal measurement framework** is highly relevant and could be adapted for transitional food assessment.
- **Major barrier:** Radiation exposure from VF makes direct application to healthy adults impossible without ethical concerns

- **Innovative approach:** Two-phase PTT analysis (oPTT + hPTT) distinguishes oropharyngeal vs. hypopharyngeal passage timing
- **Clinical context:** Study validates JDD2021 dysphagia diet classification system used in Japan
- **Aspiration findings:** LEDT >0.35s associated with thin liquid aspiration; thickened liquid delays bolus arrival at pyriform sinus
- **Key insight:** Jelly triggers swallowing reflex at epiglottis/vallecula, allowing hypopharyngeal passage after laryngeal closure
- Study population is stroke patients with near-normal swallowing (screened to minimize dysphagia), not true dysphagic population

8.2.3 Appendix B3:Ppurpose-developed literature extraction tool summary - Blank

Literature Extraction Summary

Study ID	Authors (Year)	Population (Healthy / Dysphagic / Mixed)	Food Type	Key Measurement Focus	Tools / Methods Used	Scales / Criteria	Reliability Reported (Y/N)	Relevance (H/M/L)	Adaptable to Healthy Adults (Y/N)	Notes

8.2.4 *Appendix B4 : Purpose-developed literature extraction tool summary – All 28 included studies*

Study ID	Authors (Year)	Population (Healthy/Dysphagic/Mixed)	Food Type	Key Measurement Focus	Tools/Methods Used	Scales/Criteria	Reliability Reported (Y/N)	Relevance (H/M/L)	Adaptable to Healthy Adults	Notes
1	Yoshikawa M., Kayashita J., Nakamori M., Nagasaki T., Masuda S., Yoshida M. (2025)	Dysphagic (mild stroke patients with near-normal swallow screening; n = 175)	Jelly (0j), Thickened liquid (0t), Thin liquid – Japan Dysphagia Diet 2021 (≈ IDDSI 3–4)	VF timing analysis – PTT, PDT, LEDT, oPTT, hPTT comparison	Videofluoroscopy (Philips BV Pulsera 30 fps), frame-by-frame temporal analysis (SPSS v23), Friedman + Scheffé tests	JDD 2021 classification codes 0j/0t; quantitative VF timing metrics	Partial (two blinded raters; no ICC reported)	H – clinically relevant VF timing benchmarks for texture transition	Y – methods adaptable to healthy adults via non-radiative imaging (e.g., US/HSC)	Jelly delayed trigger (↑ oPTT) → safer post-closure swallow; thin liquid LEDT ↑ → aspiration risk 13.7 %; supports thickened/jelly use in rehab; excellent protocol control; provides baseline timing data for TF framework.
2	Van den Steen et al. (2025)	Dysphagic (neurological/age-related; n = 10)	Carrot purée base (B1) + 2 mm & 4 mm vegetable particles (30 %)	Tongue strength (Pswal), swallowing safety (PAS), efficiency (Pooling score)	IOPI: Tongue pressure during swallowing ; FEES: Safety/efficiency assessment	IOPI: kPa; PAS: 8-point scale (1-8); Pooling score: 3 subscales (site, amount, management); IDDSI Level 4	Partial (3 blinded FEES raters, no ICC/kappa; IOPI duplicates)	H	Y	Particulate purée safe; no ↑ tongue pressure; conceptually transitional (L4→L5) but functionally static
3	Mocchetti V., Barewal R., Curtis J.A., Erardi E., Scholl R., Rameau A. (2025)	Dysphagic adults (outpatients, heterogeneous etiologies)	Transitional (Crispy Melts IDDSI Transitional), Pureed (applesauce L4), Regular (graham	Residue, Swallow Count, Safety (PAS)	FEES (PENTAX VNL8-J10, DEFINA EPK-300); VASES framework ; multilevel β and ordinal models in R 4.1.1	PAS 1–8; Residue % (oro-/hypo-/epiglottic) per region models	Y : ICC 0.84–0.91 (residue), κw 0.78–0.94 (PAS, swallow count)	H	Y (transferable to healthy adults with protocol adjustments)	Transitional foods showed better efficiency (less residue, fewer swallows) than puree/regular; safety differences indeterminate due to PAS ceiling; recommend randomized order + mass matching in future research

			cracker L7)							
4	Ismael-Mohammed K et al., 2025	Dysphagic (older in-patients, n = 20)	Six thick purees (BDA Texture C = IDDSI L4)	Rheology, texture (TPA), mastication (EMG), swallow safety & efficacy (V-VST), palatability	Anton Paar RheolabQC rheometer; Stable Micro Systems Texture Analyzer; EMG; adapted TOMASS & V-VST	Quantitative viscosity (mPa·s), TPA parameters (hardness/cohesiveness/ adhesiveness), mastication cycles/time, binary residue report, 5-point hedonic scale	Partial (10 replicates per puree; no ICC reported)	H	Y (methods non-invasive and transferable to healthy samples)	Within-subject comparative design (pre/post-oral processing); power analysis reported (α = 0.05, power = 0.8); rheology and texture protocols standardised; safe and feasible for adaptation to healthy participants.
5	Bruno E., Barewal R., & Shune S. (2025)	Dysphagic (inpatients, severe n=31)	Transitional foods vs purees	Oropharyngeal swallow safety and efficiency	VFSS (C-arm); MBSImP; PAS; IDDSI-FDS scales	Validated ordinal scales (0–4 MBSImP, 1–8 PAS, 0–8 IDDSI-FDS)	N :(single rater, MBSImP-trained clinician	H - for TF	Partial : (radiation limits; needs non-radiologic methods)	No significant differences between TF and puree trials; PAS = 1 (no airway invasion); supports TF as safe bridge texture; limited by retrospective design and lack of reliability data.
6	Ismael-Mohammed K., Bolívar-Prados M., Laguna L., Nuñez Lara A., & Clavé P. (2024).	Healthy: 5 healthy adults (30 ± 3.9 years, 3 female, 2 male)	10 fork-mashable dishes (BDA Texture E / IDDSI Level 6)	Mastication biomechanics + texture properties (pre/post-mastication)	Texture Analyzer (TPA) + Surface EMG (adapted TOMASS protocol)	TPA parameters (max force, cohesiveness, adhesiveness, N/N·s); EMG cycles/time/frequency; ANOVA comparisons	Partial – replicates only (no formal ICC or rater testing)	H- for TMD	Y (directly applicable, minor procedural adjustments only)	Quantified SI-unit texture and oral processing of IDDSI 6 dishes in healthy adults; high protocol control but small sample; supports need for standardised SI measurements in dysphagia research.

7	Ihrke et al. (2024)	Other – In vitro recipes	Thickened liquids & soft solids (IDDSI 0–7)	Radiologic visibility & IDDSI classification	IDDSI tests (flow, spoon, fork) + fluoroscopy	IDDSI framework (0–7) + pixel contrast metrics	Partial (4 replications)	H	Y: recipes tested for clinical transfer	Standardised VFSS contrast recipes; transitional foods (5–7) showed reduced homogeneity but remained clinically usable; no human subjects
8	Aii, Fujishima, Shigematsu, Ohno, Kunieda, Yamawaki (2024)	Dysphagic (n=50, age 77.2±11.5y; 64% male)	Sliced gelatin jelly (SGJ) vs moderately thick liquid (MTL, JDD2021)	Pharyngeal timing (PTT); bolus formation and cohesion; residue (NRRSv/p); aspiration risk (PAS)	VFSS (Philips Veradius Unity C-arm, 30 fps); quantitative frame-by-frame analysis via FilmoraX software	PAS (8-point); NRRS (vallecula/pyriform); PTT (seconds)	Y: intra/inter-rater κ > 0.6 (NRRS, PAS); test-retest not assessed	H – strong clinical relevance to transitional swallowing mechanics and texture safety	Partial: feasible with adaptation (e.g., replace VFSS with FEES or ultrasound for healthy populations)	SJWS showed significantly less pharyngeal residue than moderately thick liquid and similar PAS safety scores (≤ 2). Demonstrated cohesive “whole-bolus” transit and applicability to transitional-food frameworks. Feasibility moderate due to radiation risk.
9	Wong, M.K.L., Ku, P.K.M., Tong, M.C.F., Lee, K.Y.S., & Fong, R. (2023)	Healthy adults (n = 32, age 24–46 yrs)	Traditional puree vs. molded puree (IDDSI Level 4–5 hybrid)	Oral and pharyngeal timing, swallow initiation, residue, perceptual ratings	FEES, mastication observation, video analysis	PAS, Yale Pharyngeal Residue Scale, Likert (5-point)	Y – Intra-/inter-rater ICC = 0.55–1.0; κ = 0.57–1.0	H	Y: non-radiation FEES protocol suitable	Combined objective (FEES) and perceptual data; molded puree required more mastication and had delayed swallow initiation; valuable for exploring transitional textures.
10	Stading, M., Miljkovic, A., Andersson, J., & Matsuo, K. (2023)	Healthy adults (Older adults, 70–76 yrs)	Regular, Timbale, and Gel forms	Bolus rheology, salivary incorporation, and oral processing (chews-until-swallow)	Rheometry (ARES-G2, HR30 parallel-plate system, 37 °C); Moisture content	Rheological indices (G’, Phase Angle, Viscosity); Moisture content %; Chew count; Physical strength and oral motor scales	N: Instrument calibration described but no formal reliability statistics reported	H :Directly examines texture-modified foods and bolus properties related	Y :Directly applicable (healthy cohort, standardised oral task)	Investigates bolus formation and rheological adaptation with age; compares outcomes to younger cohort (Stading 2021a). Provides normative reference for bolus mechanical

					analysis; Tongue and hand dynamometers; Oral diadochokinesis test; Stimulated salivary flow measurement			to swallowing mechanics		behaviour in aging; strong ecological validity but limited by small sample and no randomization
11	Ismael-Mohammed, Bolivar-Prados, Laguna, Clavé (2023)	Healthy (n=5, 30±3.9y, 3F/2M)	10 Mediterranean thick purees (BDA Level C)	Rheological properties (viscosity), Textural properties (TPA), Oral processing effects, Bolus formation	Anton Paar RheolabQC rheometer (CC27/QC-LTD geometry), TA.XTPlus Texture Analyzer, Gravimetric moisture analyzer, Oral processing simulation (expectoration method)	Viscosity at 50 s^{-1} & 300 s^{-1} (mPa·s), Maximum force (N), Cohesiveness (dimensionless ratio), Adhesiveness (N·s), Flow index (n), Consistency index (K) $Pa \cdot s^n$, BDA Level C descriptors, Ostwald-de Waele power law model	Partial - Multiple measurements (n=15 per puree), T-score outlier removal, NO formal ICC/Kappa	H - Gold standard methodology for instrumental measurement; SI units throughout; physiologically relevant shear rates	Yes – directly applicable to healthy adults	First comprehensive study combining rheology (50 & 300 s^{-1}) + TPA + oral processing effects for thick purees. Key finding: 81.78% viscosity variability among purees all meeting BDA Level C descriptors - PROVES need for SI units. Identifies "oral processing-resistant" (20%) vs "oral processing-sensitive" (80%) patterns. Methods build on validated Bolivar-Prados et al. 2022 protocol. HIGH PRIORITY for methodology/standardisation. LIMITATION: Small n=5, no patient validation required for clinical use.

12	Sharma M, Pondicherry KS, Duizer L(2021)	Healthy adults (n=16 trained panelists + 1 saliva donor)	puree (IDDSI Level4)	Bolus simulation,Rheology,Tribology, Sensory (TDS)	Physica MCR 301 Rheometer + Tribology Accessory (T-PTD200); Temporal Dominance of Sensations (TDS) software	IDDSI fork/spoon test (Level 4); TDS nine-attribute protocol (Pineau 2009)	Partial – duplicates done, no formal ICC	H	Y	Focuses on rheology–tribology–sensory link in purees with saliva. Static textures only (not transitional). Good simulation model for future adaptation
13	Peh, Lim, Goh & Dharmawan (2021)	Healthy (8 trained panelists; 23–50 y)	Carrot purée + thickeners (XG, GG, Suberakaze, UNI-PURE® Dys-sperse, ULTRA-SPERSE® M)	Instrumental–sensory correlation for texture attributes relevant to swallowing effort	TA.XT.plus back-extrusion (3.5 cm disc; 5 kg load; 40 °C; 1 mm/s; 3.5 cm depth; n=10/cond); QDA with 7 attributes (triplicates; randomized, 3-digit codes); ANOVA/Tukey; Pearson r	15-cm line scales (sensory); instrumental outputs: Firmness (N), Consistency (N·s), Cohesiveness (N), Adhesiveness (N·s)	Partial: panel trained, triplicate ratings; no ICC/test-retest reported	H (directly informs dysphagia TMF targets)	Y- (already healthy; feasible lab setup)	Strong r (0.88–0.96) between instrumental and sensory; GG highest firmness/consistency/adhesiveness; US/XG smoother, faster breakdown; details on formulations and temps helpful for replication
14	Mihnea et al. (2022)	Healthy (Young n = 16; Elderly n = 19)	Broccoli purées (water vs xanthan; processed H+B / B+H)	Bolus formation ("effort required to prepare to swallow", cohesiveness, adhesiveness); Residue ("residues in-mouth");	Structured sensory evaluation (5-point categorical scales); randomized sample	1 = very easy / none → 5 = very difficult / a lot; attribute definitions from Tobin et al. (2020) and Sharma et al. (2017)	Partial – Training and standardised references used; no formal	High – Strong standardisation and robust statistics; clinically	Yes – Protocol readily adaptable for healthy adults and potentiall	Compared young vs elderly panels for ease of swallow and texture attributes. Elderly panel more sensitive to "ease of swallow". Results showed xanthan improves

				Perceptual ease of swallow and texture discrimination	presentation using EyeQuestion software; multivariate analysis (PCA, MFA, ANOVA, Tukey)		ICC/CV reported	relevant attributes	y clinical populations with texture adjustment	swallowing ease and reduces residue. High construct validity via multivariate consistency. Excellent framework for sensory evaluation of texture-modified foods.
15	Bandini et al. (2022)	Healthy (n=17, 7F,10,M)	Cracker, carrot, gummy (solid & semi-solid textures; IDDSI PU4–EC7)	Bolus formation, residue, perceptual ease, EMG chewing dynamics	KayPENTAX Digital Swallow Workstation (sEMG, 250 Hz), chew-and-spit/swallow trials, IOPI, Saxon test, clinician choking risk rating	EMG amplitude/duration, chew cycles, IDDSI audit sheets, descriptive safety rating	Partial (qualitative rater agreement ; no ICC/CV)	H : clinically applicable and objectively measured oral processing	yes: already validated in non-dysphagic population	Integrated EMG and bolus texture testing; moderate standardisation; no randomization; suitable for framework adaptation in sensory–biomechanical crossover methods.
16	Mats Stading (2021)	Healthy adults (n = 5; 3F / 2M; 32–58 yrs)	12 food types – gel bread, timbales, carrot, tomato, gummy, etc.	Bolus formation, rheology, mastication timing, tongue pressure	Chew-and-swallow / chew-and-spit trials (6 per food); Rheometry (SAOS, steady shear); Extensional viscometry (HCF); IOPI for tongue pressure; saliva flow	G′, G″, phase angle (δ), viscosity (η), Trouton ratio; % moisture; MAIP (kPa)	Partial (method consistency only; no ICC/CV)	High	Yes	Laboratory-based experimental study from Sweden. High procedural control and standardised methods; strong quantitative texture analysis. No randomization or formal reliability testing; residue not measured. Highly relevant for protocol development in transitional-food evaluation.

					(Saxon test)					
17	Kwak et al. (2021)	Dysphagic (brain disorders: stroke, TBI, Parkinson's, Alzheimer's, brain tumor, HIE)	Rice gruel, rice porridge, bulgogi mousse, ground bulgogi	VFSS-based assessment of swallowing safety and efficiency; texture–swallow relationship	VFSS (30 fps, Toshiba Zexira); Texture Analyzer (compression test for hardness & adhesiveness)	Penetration–Aspiration Scale (PAS), Vallecular & Pyriform Sinus Residue Scale (0–3), UDF Stages 3–4	Partial (two raters with consensus, no numerical reliability)	High	Moderate (adaptation limited by VFSS radiation; feasible via FEES/ultrasound for healthy adults)	Large clinical study comparing specially designed texture-modified foods; clear timing and residue definitions; UDF classification instead of IDDSI; strong quantitative outcomes; lacks randomization and sample size justification.
18	Barewal R., Shune S., Ball J., & Kosty D. (2021)	Mixed (Healthy + Dysphagic + Xerostomia)	Dry solid foams – Savorease crackers (± dip), shrimp chips, Baby Mum Mum, EAT bar (IDDSI Level 7 before wetting)	Dissolution behaviour under oral conditions (time, pressure, saliva)	IDDSI Fork Pressure Test (in vivo & benchtop); IOPI for 17 kPa tongue pressure training	Binary positive/negative fork test for dissolution; controlled exposure (5 s / 12 s)	Partial – operator training and consensus used, no coefficients reported	H	Yes – directly applicable to healthy adults	First systematic in-vivo assessment of transitional foods; bench-top vs oral comparison; xerostomia self-reported not validated
19	Park J-W, Lee S, Yoo B, Nam K (2020)	Healthy (older adults, n=18, 65–83 yrs)	Semi-solid foods (whipped cream, mayonnaise, tofu,	Texture–swallowing relationship; adhesiveness and perceived effort/residue	CT3 Texture Analyzer (TPA) – Hardness (P1), Adhesiven	TPA parameters; 9-point sensory hedonic scale (1–very little → 9–very much)	Low (Triplicate TPA trials; no ICC/test–retest data)	Medium	Yes (safe, feasible, already tested on healthy adults)	Adhesiveness strongly correlated with swallow effort (r = 0.882) and residue (r = 0.879); clear texture definitions but lacks

			puddings, mashed vegetables, red bean paste, peanut butter)		ess (B1), Cohesiveness (A2/A1); Sensory Test – 9-point hedonic scale for swallow effort and residue					objective validation or reliability testing.
20	Merino et al. (2020)	Dysphagic – Individuals with cerebral palsy (mixed ages, institutional setting) + trained sensory panel (n = 5)	Puréed and thickened soups (XG + gelatin blends)	Texture–sensory alignment for dysphagia menu development	Texture Profile Analysis (CT3), Line Spread Test, Sensory evaluation (9-point scale), ANOVA / t-test / discriminant analysis	Instrumental parameters (hardness, cohesiveness, adhesiveness); Sensory 9-point hedonic scale (appearance, texture, aroma, overall acceptability)	Y – Partial (replicates done; no ICC/CV)	Medium	Yes – directly applicable for texture validation of transitional foods	Mixed-age CP population; robust instrumental + sensory link; no reliability stats but clinically relevant for texture acceptability research.
21	Matsuno K., Nohara K., Fukatsu H., Tanaka N., Fujii N., Sasao Y., Sakai T. (2015)	Healthy (older vs younger adults, dentate)	Cooked white & green rice (soft cohesive grains)	Bolus formation (cohesion, mixing, aggregation) + chewing cycles	FEES (videoendoscopy) to observe bolus at pre-swallow; concurrent video recording for mandibular movement (chewing count)	0–2 point scale for Grinding, Mixing, Aggregation (Fukatsu et al., 2008)	Y (κ = 0.88 inter-rater; κ = 0.95 intra-rater)	High	Yes	Evaluated pre-swallow bolus formation in younger vs older adults using standardised cooked-rice protocol; older adults showed lower aggregation scores and significantly more chewing cycles. Provides robust endoscopic rating method for oral bolus formation.

22	Momosaki R., Abo M., Kobayashi K. (2011)	Dysphagic (post-stroke)	Semisolid foods – pudding, jelly, yogurt	Pharyngeal residue, penetration & aspiration in relation to texture	FEES + TPU-2S Rheometer (Yamaden Co.)	Hardness (N/m^2), Cohesiveness, Adhesiveness (J/m^3), Gumminess (N/m^2); PAS scale (2–8)	N	H – clinically strong rheology–FEES link	yes with minor modifications	Cohesiveness ↑ → pharyngeal residue ↑ ($p = 0.005$); Gumminess ↑ → aspiration ↑ ($p = 0.03$); Hardness/Adhesiveness ns; no timing data or inter-rater reliability reported. Supports protocol texture parameter selection.
23	Sugimoto K., Iegami C.M., Iida S., Naito M., Tamaki R., Minagi S. (2012)	Healthy (female only)	Raw carrot, peanut, cooked beef	Bolus formation / comminution analysis (oral phase)	Double dark-field illumination + digital image analysis + EMG-regulated mastication system	Regression coefficients for particle size distribution (slope 1.62, intercept 0.10 thresholds); force conditions (20 % EMG)	partial–cross-method validation with sieve method ($r = 0.833$)	H – strong oral-phase measurement relevance	Yes – requires minor adaptations (e.g., include males, expand textures)	Innovative quantitative oral bolus analysis using real foods; validated imaging system; no timing or residue data but high value for oral-phase modelling in transitional food protocols.
24	Iida, Katsumata & Fujishita (2011)	Healthy (young adults,mean = 22.4 years)	Cooked white rice and udon noodles	Timing, bolus formation, stage 2 transport	Videofluoroscopy (VF); Texture analyzer (RE-3305S, Yamaden, Japan)	Stage 2 transport scale (a–d); Hardness, stickiness, cohesiveness (texture parameters)	Partial (texture data replicated; no rater reliability)	H- (links oral and pharyngeal dynamics, informs transitional food design)	Yes with non radiological option	Quantified oral-to-pharyngeal coordination using VF; stage 2 transport classification validated; texture analyzer data provided instrumental context. No inter-rater reliability. Requires high equipment/expertise; adaptable via non-radiation substitutes (e.g., ultrasound/FEES).

25	Wendin et al. (2010)	Healthy (trained sensory panel)	Texture-modified foods (pâtés, timbales, jellied foods, thickened & unthickened soups)	Sensory and rheological characterization of texture-modified foods	QDA by ISO-trained panel + Rheometry (Instron 5542, Stresstech HR) + Penetration Tests + PCA/PLS Analysis	100-mm VAS for texture attributes; Rheological parameters (G′, G″, Δ, K, n, Kext, next)	Y (Panel repeatability confirmed via low p & MSE; instrument repeatability ≤ 5%)	H	Yes	Combined sensory-rheology method provides quantitative texture benchmarking; medium feasibility due to advanced equipment and expertise required.
26	Saitoh et al. (2007)	Healthy	Liquids, semi-solids (corned beef hash, cookie), and mixed two-phase foods (solid + liquid barium)	Timing of bolus transport and swallow initiation across consistencies and postures	Videofluoroscopy (VFSS, 30 fps, lateral view); Process Model segmentation (Processing, PFAT, VAT, HTT + swallow onset interval)	Anatomical region classification (oral, upper oropharynx, valleculae, hypopharynx); temporal intervals in seconds (ANOVA, Friedman, Wilcoxon)	N – no inter/intra-rater testing reported	H – high methodological and conceptual relevance for phase-timing studies	Yes – protocol feasible for healthy population with non-radiological tools (FEES/EMA adaptation)	Provided quantitative timing benchmarks for oral-to-pharyngeal transition; defined Process Model phases used in later frameworks; high precision timing but limited reliability data; excellent conceptual fit for timing and phase coordination analysis.
27	Kim I.S. & Han T.R. (2005)	Mixed (stroke vs healthy)	Diluted barium, pudding, thick rice gruel, curd-type yogurt	Timing (oral phase duration, chew count), salivation rate, rheology change pre/post oral phase	Direct observation of chewing + laryngeal trigger timing; rotational viscometer (10 rpm) for viscosity; spitting	Mean ± SD reported; statistical comparisons via t-tests and Wilcoxon tests	N	H	Yes	Quantitative analysis of mastication, salivation and food viscosity; method directly transferable to healthy adult protocols; no radiology during testing – VFSS used only for screening.

					method for saliva flow (30 min collection)					
28	Takahashi K., Yoshida R., Ohie K., Kumagai S., Tasaka Y. (2025)	Laboratory / Non-human (model simulation)	Scallop mousse and rice porridge (semi-solid dysphagia diets)	Adhesion / Detachment behaviour; Swallowability simulation	Dynamic Mechanical Analysis (DMA); Shear and Probe-Tack Adhesion Tests using silicone "pharyngeal mucosa" model + artificial saliva (PEO-27)	Quantitative stress values (Pa); shear and detachment forces vs simulated saliva and thickener conditions	Y (repeated trials ×2 for reproducibility stated)	High	Yes – Directly applicable for developing objective texture metrics in healthy adult protocols	Focuses on adhesion as a new dimension of swallow ease; used semi-solid IDDSI-relevant foods under controlled lab conditions; provides valuable method for tribological and cohesiveness assessment in transitional food framework.

8.3 Appendix C: Quality Appraisal

8.3.1 Appendix C1: CASP- filled example

Critical Appraisal Skills Programme

CASP Checklist:

For Descriptive/Cross-Sectional Studies

Reviewer Name:	Samurdi M
Paper Title:	A Comparison of Behaviour of Transitional-State Foods Under Varying Oral Conditions
Author:	R. Barewal, S. Shune, J. Ball and D. Kosty
Web Link:	https://doi.org/10.1007/s00455-020-10135-w
Appraisal Date:	16/10/2025

During critical appraisal, never make assumptions about what the researchers have done. If it is not possible to tell, use the "Can't tell" response box. If you can't tell, at best it means the researchers have not been explicit or transparent, but at worst it could mean the researchers have not undertaken a particular task or process. Once you've finished the critical appraisal, if there are a large number of "Can't tell" responses, consider whether the findings of the study are trustworthy and interpret the results with caution.

Section A: Are the results valid?	
1. Did the study address a clearly focused issue?	☑Yes ☐ No ☐ Can't Tell Examined dissolution behaviour of transitional foods in adults (with and without xerostomia/dysphagia) under controlled oral and benchtop conditions.
CONSIDER: *A question can be 'focused' in terms of* • *the population studied* • *the risk factors studied* • *is it clear whether the study tried to detect a beneficial or harmful effect* • *the outcomes considered*	
2. Did the authors use an appropriate method to answer their question?	☑Yes ☐ No ☐ Can't Tell Cross-sectional experimental design with repeated in-vivo and benchtop testing was suitable for the aims.
CONSIDER: • *Is a descriptive/cross-sectional study an appropriate way of answering the question* • *did it address the study question*	
3. Were the subjects recruited in an acceptable way?	☑Yes ☐ No ☐ Can't Tell Community-dwelling adults recruited via flyers; inclusion/exclusion criteria clearly defined; IRB approval and consent obtained.
CONSIDER: *We are looking for selection bias which might compromise the generalisability of the findings:* • *Was the sample representative of a defined population* • *Was everybody included who should have been included*	
4. Were the measures accurately measured to reduce bias?	☑Yes ☐ No ☐ Can't Tell Standardised IDDSI fork-pressure protocol and IOPI calibration (17 kPa); triply trained examiners with consensus checking minimized bias.
CONSIDER: *Look for measurement or classification bias:* • *did they use subjective or objective measurements* • *do the measurements truly reflect what you want them to (have they been validated)*	
5. Were the data collected in a way that addressed the research issue?	☑Yes ☐ No ☐ Can't Tell Systematic exposure durations (5 s and 12 s) and tongue-pressure conditions directly targeted oral dissolution behaviour.
CONSIDER:	

• *if the setting for data collection was justified* • *if it is clear how data were collected (e.g., interview, questionnaire, chart review)* • *if the researcher has justified the methods chosen* • *if the researcher has made the methods explicit (e.g. for interview method, is there an indication of how interviews were conducted?)*	
6. Did the study have enough participants to minimise the play of chance?	☐Yes ☐ No ☑Can't Tell Thirty participants (10 xerostomia, 8 dysphagia) adequate for pilot data but no power calculation or justification provided
CONSIDER: • *if the result is precise enough to make a decision* • *if there is a power calculation. This will estimate how many subjects are needed to produce a reliable estimate of the measure(s) of interest.*	
7. How are the results presented and what is the main result?	☑Yes ☐ No ☐ Can't Tell Results clearly presented in tables & GLMM outputs; significant product-wise differences identified; Savorease showed greatest dissolution.
CONSIDER: • *if, for example, the results are presented as a proportion of people experiencing an outcome, such as risks, or as a measurement, such as mean or median differences, or as survival curves and hazards* • *how large this size of result is and how meaningful it is* • *how you would sum up the bottom-line result of the trial in one sentence*	
8. Was the data analysis sufficiently rigorous?	☑Yes ☐ No ☐ Can't Tell Used multilevel generalized linear mixed models accounting for repeated measures; appropriate contrasts and confidence intervals reported.
CONSIDER: • *if there is an in-depth description of the analysis process* • *if sufficient data are presented to support the findings*	
9. Is there a clear statement of findings?	☑Yes ☐ No ☐ Can't Tell Findings explicitly summarized with clinical relevance; limitations acknowledged
CONSIDER: • *if the findings are explicit* • *if there is adequate discussion of the evidence both for and against the researchers' arguments* • *if the researchers have discussed the credibility of their findings* • *if the findings are discussed in relation to the original research questions*	
10. Can the results be applied to the local population?	☑Yes ☐ No ☐ Can't Tell Adult population (50–88 yrs) with varying oral conditions; results relevant to both healthy and dysphagic adults.
CONSIDER:	

• *the subjects covered in the study could be sufficiently different from your population to cause concern.* • *your local setting is likely to differ much from that of the study*	
11. How valuable is the research?	☑Yes ☐ No ☐ Can't Tell Provides first systematic evidence on in-vivo behaviour of transitional foods and their potential therapeutic and safety implications.
CONSIDER: • *one descriptive/cross-sectional study rarely provides sufficiently robust evidence to recommend changes to clinical practice or within health policy decision making* • *if the researcher discusses the contribution the study makes to existing knowledge (e.g., do they consider the findings in relation to current practice or policy, or relevant research-based literature?)* • *if the researchers have discussed whether or how the findings can be transferred to other populations*	

APPRAISAL SUMMARY: *List key points from your critical appraisal that need to be considered when assessing the validity of the results and their usefulness in decision-making.*		
Positive/Methodologically sound	**Negative/Relatively poor methodology**	**Unknowns**
• Clear aims, standardised procedures, examiner training, and appropriate statistics. • Relevance to dysphagia management and IDDSI validation.	• Self-reported xerostomia and dysphagia status (no instrumental confirmation). • Small sample, no power analysis	• Long-term clinical translation and swallowing outcomes not assessed.

Referencing recommendation:

CASP recommends using the Harvard style referencing, which is an author/date method. Sources are cited within the body of your assignment by giving the name of the author(s) followed by the date of publication. All other details about the publication are given in the list of references or bibliography at the end.

Example:

Critical Appraisal Skills Programme (2024). CASP (insert name of checklist i.e. cross sectional Checklist.) [online] Available at: insert URL. Accessed: insert date accessed.

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8.3.2 Appendix C2: Purpose-developed methodological quality appraisal Schedule – Blank

Purpose - Developed Methodological Quality Appraisal Schedule

Study ID: ____________ **Reviewer:** ____________ **Date:** ____________

---

1. Measurement Quality (Score: ___ / 15)

Operational Definitions (___ / 5)

☐ Clear timing measurement endpoints defined

☐ Bolus formation criteria clearly specified

☐ Residue measurement criteria clearly defined

☐ Texture parameters specified

☐ All measurement phases explicitly defined

Standardisation (___ / 5)

☐ Consistent bolus volume/size

☐ Standardised presentation method

☐ Controlled environmental conditions

☐ Consistent participant positioning

☐ Standardised participant instructions

Reliability Evidence (___ / 5)

☐ Intra-rater reliability reported (Value: ______) — Meets threshold >0.7: ☐ Yes ☐ No

☐ Inter-rater reliability reported (Value: ______) — Meets threshold >0.7: ☐ Yes ☐ No

☐ Test–retest reliability reported (Value: ______) — Meets threshold >0.7: ☐ Yes ☐ No

☐ Reliability testing method described

☐ Sample size adequate for reliability testing

---

2. Study Design Quality (Score: ___ / 10)

Sampling & Design Rigor (___ / 5)

☐ Sample size justified

☐ Inclusion/exclusion criteria clearly stated

☐ Participant demographics reported

☐ Baseline characteristics assessed

☐ Study design appropriate to aims

Protocol Implementation (___ / 5)

☐ Number of trials specified

☐ Randomization/counterbalancing described

☐ Blinding procedures (where applicable)

☐ Equipment calibration mentioned

☐ Handling of missing/incomplete data reported

---

3. Adaptation Potential

Feasibility Assessment

- Equipment: ☐ Basic ☐ Moderate ☐ High-tech
- Expertise: ☐ Low ☐ Medium ☐ High
- Time: ☐ <30 min ☐ 30–60 min ☐ >60 min
- Cost: ☐ Low ☐ Medium ☐ High

Modification Requirements for Healthy Adults

☐ Directly applicable — no changes needed

☐ Minor adaptations required — simple adjustments

☐ Major modifications required — significant redesign

Specific modifications needed:

---

4. Overall Assessment

Quality Rating (Total Score: ___ / 25)

- ☐ **High Quality (20–25):** Strong methodology, highly reliable
- ☐ **Moderate Quality (15–19):** Acceptable methodology, some limitations
- ☐ **Low Quality (<15):** Weak methodology, major concerns

Priority for Framework Development

- ☐ High priority — Excellent methods, directly applicable
- ☐ Medium priority — Good methods, minor adaptations needed
- ☐ Low priority — Poor methods or major modifications required

---

5. Key Extraction Notes

Main Strengths:

1. ____
2. ____

Critical Limitations:

1. ____
2. ____

Adaptation Notes:

Specific Measurements to Adopt:

☐ Timing protocols ☐ Rating scales ☐ Equipment setup ☐ Analysis methods

Review Status: ☐ Complete ☐ Needs follow-up ☐ Unclear — requires discussion

Notes:

8.3.3 *Appendix C3: Purpose-developed methodological quality appraisal Schedule – Filled Example*

Purpose – Developed Methodological Quality Appraisal Schedule

Study ID: 018 **Reviewer:** Samurdi M **Date:** 16/10/202

---

1. Measurement Quality (Score: 13/ 15)

Operational Definitions (5 / 5)

☑ Clear timing measurement endpoints defined (5 s and 12 s exposure durations under different oral conditions)

☑ Bolus formation criteria clearly specified (transition and disintegration behaviour evaluated under varying saliva and tongue-pressure conditions)

☑ Residue measurement criteria clearly defined — Residue operationalized through the IDDSI fork pressure test outcome; a positive test (sample squashed or disintegrated) indicated minimal residue potential, whereas a negative test (sample retained shape) reflected incomplete dissolution and probable oral residue**.**

☑ Texture parameters specified (dry solid-foam transitional foods, IDDSI Level 7 before wetting)

☑ All measurement phases explicitly defined (in-vivo and benchtop testing procedures described in detail)

Standardisation (5 / 5)

☑ Consistent bolus size (1.5 cm × 1.5 cm samples per IDDSI standard)

☑ Standardised presentation method (randomized order of snack presentation; controlled 5 s and 12 s exposure times with defined tongue-pressure conditions)

☑ Controlled environmental conditions (room-temperature samples tested in semi-private booth setting)

☑ Consistent participant positioning (seated upright throughout testing)

☑ Standardised participant instructions (participants trained with IOPI to apply ~17 kPa tongue pressure per IDDSI guideline)

Reliability Evidence (3/ 5)

☐ Intra-rater reliability reported *(not reported)*

☐ Inter-rater reliability reported *(not numerically stated; only consensus-based)*

☐ Test–retest reliability reported *(not applicable)*

☑ Reliability testing method described *(raters trained on IDDSI method; consensus process used for ambiguous samples)*

☑ Sample size adequate for reliability testing *(30 participants, 5 food types × 4 conditions → 600+ total observations)*

---

2. Study Design Quality (Score: 8 / 10)

Sampling & Design Rigor (4 / 5)

☑ Inclusion/exclusion criteria clearly stated (age > 50, cognitive intactness, no severe dysphagia etc.)

☑ Participant demographics reported (age, sex, dry-mouth and dysphagia status)

☑ Baseline characteristics assessed (xerostomia and dysphagia subgroups identified)

☑ Study design appropriate to aims (behavioural comparison of transitional foods under oral conditions)

☐ Sample size justified (no power analysis reported)

Protocol Implementation (4 / 5)

☑ Number of trials specified (four exposure conditions × five food types)

☑ Randomization/counterbalancing described (randomized plate order)

☐ Blinding procedures (where applicable) — none reported

☑ Equipment calibration mentioned (IOPI calibration for 17 kPa pressure standard)

☑ Handling of missing/incomplete data reported (unclear samples re-checked by consensus)

---

3. Adaptation Potential

Feasibility Assessment

- Equipment: ☐ Basic ☑ Moderate ☐ High-tech (IOPI device + IDDSI test set)
- Expertise: ☐ Low ☑ Medium ☐ High (researcher/clinician familiar with IDDSI and oral testing)
- Time: ☐ <30 min ☑ 30–60 min ☐ >60 min
- Cost: ☑ Low ☐ Medium ☐ High

Modification Requirements for Healthy Adults

☑ Directly applicable — no changes needed

☐ Minor adaptations required — simple adjustments

☐ Major modifications required — significant redesign

Specific modifications needed:

None (no validated screening methods used; protocol directly applicable to healthy adult population)

---

4. Overall Assessment

Quality Rating (Total Score: 21 / 25)

- ☑ **High Quality (20–25):** Strong methodology, highly reliable
- ☐ **Moderate Quality (15–19):** Acceptable methodology, some limitations
- ☐ **Low Quality (<15):** Weak methodology, major concerns

Priority for Framework Development

- ☑ High priority — Excellent methods, directly applicable
- ☐ Medium priority — Good methods, minor adaptations needed
- ☐ Low priority — Poor methods or major modifications required

---

5. Key Extraction Notes

Main Strengths:

1. Comprehensive evaluation of multiple transitional-state foods under controlled in vivo and benchtop conditions.
2. Use of standardised IDDSI fork pressure testing with clear operational definitions.
3. Well-structured comparison across oral conditions (time, tongue pressure, saliva quantity).

Critical Limitations:

1. Reliability not statistically quantified (no intra- or inter-rater coefficients).
2. Small sample size and self-reported xerostomia/dysphagia classification.

Adaptation Notes:

Directly applicable to healthy adults; no modification required.

Specific Measurements to Adopt:

☑ Timing protocols ☑ Rating scales ☑ Equipment setup ☑ Analysis methods

Review Status: ☑ Complete ☐ Needs follow-up ☐ Unclear — requires discussion

Notes:

Study provides high-quality methodological foundation for testing transitional foods, directly transferable to healthy adult research contexts.

8.3.4 *Appendix C4: Methodological Quality Appraisal Summary – All 28 included studies*

Study ID	Authors (Year)	Measurement Quality Score (/15)	Study Design Quality Score (/10)	Total P.D.Q.A Schedule Score (/25)	MORE Rating (auto)	CASP Checklist	CASP Rating Y/N/CT	CASP Overall Rating	CASP Notes
1	Yoshikawa M., Kayashita J., Nakamori M., Nagasaki T., Masuda S., Yoshida M. (2025)	10	8	18	Moderate	Cross-Sectional (2024)	9Y / 0N / 2CT	High	No power calculation; no formal inter-rater reliability stats; applicability to healthy adults limited by radiation
2	Van den Steen et al. (2025	11	8	19	Moderate	Cross-Sectional (2024)	9Y / 0N / 2CT	High	Key Concerns: Sample size adequacy unclear (high variability); fixed FEES order; no reliability stats; applicability partially uncertain
3	Mocchetti V., Barewal R., Curtis J.A., Erardi E., Scholl R., Rameau A. (2025)	13	8	21	High	Cross-Sectional (2024)	9Y / 0N / 2CT	High	High relevance to transitional-food measurement
4	Ismael-Mohammed K et al., 2025	14	10	24	High	Cross-Sectional (2024)	11Y / 0N / 0CT	High	High methodological rigor; power justified; subjective swallow-readiness and small sample noted; no inter-rater stats but strong applicability to transitional-food protocol development.
5	Bruno E., Barewal R., & Shune S. (2025)	10	7	17	Moderate	Cross-Sectional (2024)	11Y / 0N / 0CT	High	Power analysis adequate; validated VFSS tools (MBSImP, PAS, IDDSI-FDS); all TF trials safe; single rater and retrospective design limit reliability; high relevance to transitional-food framework but applicability to healthy adults constrained by radiation.
6	Ismael-Mohammed K., Bolívar-Prados M., Laguna L., Nuñez Lara A., & Clavé P. (2024).	11	7.5	18.5	Moderate	Cross-Sectional (2024)	9Y / 0N / 2CT	High	strong internal validity and high relevence for framework. Not enough sample size and justification

7	Ihrke et al. (2024)	12	6.5	18.5	Moderate	NA	NA		study is in-vitro method development; assessed with adapted methodological rubric
8	Aii, Fujishima, Shigematsu, Ohno, Kunieda, Yamawaki (2024)	11	10	21	High	Cross-Sectional (2024)	9Y / 0N / 2CT	High	well-defined protocol, objective instrumentation, strong reliability evidence.no power calculation though
9	Wong, M.K.L., Ku, P.K.M., Tong, M.C.F., Lee, K.Y.S., & Fong, R. (2023)	13.5	8	21.5	High	Cross-Sectional (2024)	9Y / 0N / 2CT	High	**high methodological quality** with excellent reliability and clearly operationalized measures using non-radiation FEES methods. Although the small, healthy cohort limits external validity, the design provides **robust baseline data** for transitional food evaluation and clinical adaptation studies.
10	Stading, M., Miljkovic, A., Andersson, J., & Matsuo, K. (2023)	13	7	20	High	Cross-Sectional (2024)	9Y / 0N / 2CT	High	**well-conducted, descriptive, laboratory-based cross-sectional analysis** with **robust measurement validity** but limited generalizability due to its small, homogeneous sample.
11	Ismael-Mohammed, Bolivar-Prados, Laguna, Clavé (2023)	13	7	20	High	Cross-Sectional (2024)	9Y / 1N / 1CT	High	Methodologically strong in measurement precision and laboratory control; minor statistical and sampling weaknesses limit generalisability but not data validity. Overall rated **High-quality / Low bias risk** for instrumental analysis studies.
12	Sharma M, Pondicherry KS, Duizer L	14	8	22	High	Cross-Sectional (2024)	10Y / 0N / 1CT	High	methodologically strong. And good reliability
13	Peh, Lim, Goh & Dharmawan (2021)	12	7	19	Moderate	Cross-Sectional (2024)	9Y / 1N / 1CT	High	this study demonstrates high internal validity and strong methodological control, though external validity is limited by small sample and absence of clinical subjects. Results provide valuable objective–sensory correlation evidence for future dysphagia framework development.
14	Mihnea et al. (2022)	12	8	20	High	Cross-Sectional (2024)	10Y / 0N / 1CT	High	Strong methodological clarity and robust sensory design, but limited participant details and lack of reliability data reduce external validity

15	Bandini et al. (2022)	10	7	17	Moderate	Cross-Sectional (2024)	9Y / 1N / 1CT	High	Pilot proof-of-concept with strong operational rigor and clinical potential; small sample and lack of formal reliability reporting noted.
16	Stading (2021)	13	7	20	High	Cross-Sectional (2024)	8Y / 1N / 2CT	Medium	Clear aim; robust rheological protocol (SAOS, HCF); strong operational control (21–37 °C, 4 g samples). Validity supported though no reliability stats. Small n = 5 without justification; individual variation not controlled. Findings relevant to texture modification and transitional-food adaptation.
17	Kwak et al. (2021)	13	7	20	High	Cross-Sectional (2024)	9Y/0N/2CT	High	Clearly defined aims and appropriate comparative VFSS design. Reliable outcome measures (PAS, residue, transit time) with dual rater evaluation. Large sample (n=101) enhances clinical relevance though no power analysis. Limited blinding and absence of randomization lower rigor. Applicable for dysphagic populations; limited transferability to healthy adults. Overall strong clinical evidence for texture-modified food efficacy and safety assessment.
18	Barewal R., Shune S., Ball J., & Kosty D. (2021)	13	8	21	High	Cross-Sectional (2024)	10Y/0N/1ct	High	Clear aims and appropriate cross-sectional design. Systematic in-vivo and benchtop comparison using IDDSI fork pressure test and IOPI calibration. Examiner training and consensus improved rigor. Moderate sample (n=30) without power analysis. Xerostomia and dysphagia self-reported, not validated. Results relevant to adult dysphagic and healthy populations.
19	Park, J-W., Lee, S., Yoo, B., & Nam, K. (2020)	8	7	15	Moderate	Cross-Sectional (2024)	8Y / 1N / 2CT	Medium	Clear aim; appropriate cross-sectional design; TPA + sensory correlation; community-recruited older adults (n = 18). Reliability not reported, small sample size, and subjective sensory data limit generalizability.
20	Merino et al. (2020)	8	6	14	Low	Cross-Sectional (2024)	8y / 0N / 3CT	Medium	Participants were appropriately recruited from an institutional dysphagia population (CP, mixed ages). Aims and methods were clearly stated, and measurement tools were valid for texture and sensory analysis. However, reliability data were limited and the small sensory panel reduced generalizability. Ethical approval not explicitly reported. Overall, moderate methodological quality with relevant clinical application for texture–sensory adaptation in dysphagia diets.
21	Matsuno K., Nohara K., Fukatsu H., Tanaka N., Fujii N., Sasao Y., Sakai T. (2015)	13	9	22	High	Cross-Sectional (2024)	9Y / 0N / 2CT	High	Clear focused comparison between older vs younger adults using standardised cooked-rice protocol and FEES at pre-swallow. Strong inter/intra-rater reliability (κ = 0.88–0.95). Appropriate analysis and ethical approval stated. Recruitment source and sampling strategy not

									clearly detailed; no explicit sample-size justification. Method clinically relevant but population generalizability uncertain (Japanese context).
22	Momosaki R., Abo M., Kobayashi K. (2011)	12	8	20	High	Cross-Sectional (2024)	9Y / 0N / 2CT	High	Clear link between texture parameters and FEES findings; rigorous methods but no inter-rater reliability or sample justification; strong internal validity, limited external generalizability (clinical only
23	Sugimoto K., Iegami C.M., Iida S., Naito M., Tamaki R., Minagi S. (2012)	10	7	17	Modera te	Cross-Sectional (2024)	9Y / 0N / 2CT	High	Clear methodological aim; strict dental inclusion and ethics approval; validated imaging vs sieve (r = 0.833); randomised mastication protocol; small homogeneous sample (20 females, no size justification); limited generalisability beyond healthy adults.
24	Iida, Katsumata & Fujishita (2011)	11	7	18	Modera te	Cross-Sectional (2024)	9Y / 0N / 2CT	High	Clear aim; robust VF + texture methods; standardised positioning & instructions; appropriate analysis. Partial limitations: no sample size justification; limited external validity (young Japanese cohort). Reliability reporting limited but method sound; findings valuable for oral & pharyngeal phase benchmarking in transitional food protocol design.
25	Wendin et al. (2010)	12	8	20	High	Cross-Sectional (2024)	9Y / 0N / 2CT	High	Clear, focused aim and appropriate quantitative methods (sensory + rheological testing). Reliable data collection with trained panel and instrument calibration. Robust analysis (ANOVA, PCA, PLS) and explicit reporting of findings. However, small sample (n = 8 panelists) and lack of clinical participants limit external generalizability. High methodological rigor and strong relevance for objective texture definition frameworks.
26	Saitoh et al. (2007)	9	5	14	Low	Cross-Sectional (2024)	9Y / 1N / 1CT	High	Clear aims; precise VFSS timing (Processing–PFAT–VAT–HTT); appropriate analyses. Limitations: no reliability testing, no sample-size justification, limited generalisability. Adapt using non-radiological timing where possible.
27	Kim I.S. & Han T.R. (2005)	10	6.5	16.5	Modera te	Cross-Sectional (2024)	9Y / 0N / 2CT	High	Clear comparative design with validated measurement methods and standardised procedures; no reliability testing or sample-size justification; findings robust for oral phase evaluation and adaptable for transitional food frameworks

28	Takahashi K., Yoshida R., Ohie K., Kumagai S., Tasaka Y. (2025)	12	7	19	Moderate	NA	NA		study is in-vitro method development; assessed with adapted methodological rubric

8.4 Appendix D: NVivo Coding Framework, Query Procedures, and Analytical Integration

Software used : NVivo 15

8.4.1 Appendix D1: Coding Framework and Rationale

Coding was conducted using a structured, three-level framework to organise the dataset and support systematic theme development.

Level 1: Parent Categories: Four overarching analytical domains guided data organisation:

1. Components Assessed
2. Methods Used
3. Populations
4. Study Quality

Level 2: Axial (Child) Codes: Each parent category contained grouped sub-codes organised by conceptual similarity.

- Components Assessed:
  - Transformation Dynamics
  - Saliva Interaction
  - Texture Properties (TPA)
  - Oral Biomechanics
  - Pharyngeal Efficiency
  - Swallowing Safety
  - Bolus Formation
  - Rheological Properties
- Methods Used:
  - Rheological / Texture Testing
  - IDDSI Framework Use
  - Sensory & Acceptability
  - Clinical Assessments

    - Biomechanical / Physiological
    - Imaging Methods
- Population
    - Healthy Adults
    - Dysphagic Populations
    - Mixed Populations
- Study Quality:
    - Standardised Protocols
    - Reliability Reported
    - Methodological Limitations
    - High Design Quality

Level 3: Substantive Codes (Granular Descriptors)

These captured detailed measurement parameters, components assessed, quantitative values, bolus/texture characteristics, and specific methodological actions.

They ensured adequate depth for both descriptive quantification and interpretive synthesis.

Rationale: This hierarchical coding structure enabled clear organisation of the dataset and supported later analytical synthesis. Parent categories captured the major analytic dimensions relevant to the review (components assessed, methods used, populations, and study quality). Axial codes grouped conceptually related features within each dimension, while substantive codes captured specific measurement details (e.g., exact parameters, values, or procedural descriptions).

This structure ensured:

- consistent coding across all studies,
- easy aggregation of related concepts,
- compatibility with matrix queries, and
- transparent alignment between coded data and the final analytical themes.

8.4.2 *Appendix D2: Query Procedures*

Two matrix coding queries were run to explore relationships between assessment components, methods, and study quality.

Matrix Query 1: Components × Methods

Purpose:

To identify which assessment methods were used to evaluate specific components of transitional or texture-modified foods.

Columns = Methods codes. Rows = Component categories

M1_components_methods

	A : Biomechanical_Physiological Measures	B : Clinical Assessments methods	C : IDDSI Framework Use	D : Imaging Methods	E : Rheological_Texture Testing	F : Sensory & Acceptability Evaluation
1 : Bolus F...	0	2	1	0	0	3
2 : Oral Bi...	1	1	3	0	0	10
3 : Pharyn...	1	4	2	0	0	3
4 : Rheolo...	2	2	10	1	1	17
5 : Saliva I...	0	0	0	0	0	0
6 : Swallo...	1	4	9	0	0	13
7 : Texture...	1	2	1	0	0	4
8 : Transf...	1	0	7	0	0	11

Figure 6: *NVivo Matrix Query1 :Components × Methods*

Matrix Query 2: Study Quality × Methods

Purpose:

To determine how methodological quality features aligned with the assessment methods used.

Columns = Method codes. Rows = Study Quality codes

M4_StudyQuality_methods

	A : Biomechanical_Physiological Measures	B : Clinical Assessments methods	C : IDDSI Framework Use	D : Imaging Methods	E : Rheological_Texture Testing	F : Sensory & Acceptability Evaluation
1 : High D...	0	0	2	0	0	0
2 : Metho...	0	0	6	0	0	3
3 : Reliabil...	0	0	0	0	0	0
4 : Standa...	0	4	10	0	0	11

Figure 7: *NVivo Query 2 : Study Quality × Methods*

8.4.3 Appendix D3: Key Findings from the Matrix Queries

Matrix 1: Components × Methods

- **Rheological Properties** formed the dominant focus (33 method links), showing strong integration with IDDSI (10), sensory methods (17), and some clinical and biomechanical tools.
- **Swallowing Safety** was well assessed (27 links), primarily through sensory evaluation (13) and IDDSI testing (9), with surprisingly limited use of clinical tools (4) and **no imaging methods** (0).
- **Saliva Interaction** showed **no method associations**, despite 6 coded references—indicating a clear evidence gap.
- **Transformation Dynamics** had moderate assessment (19 links) but **lacked clinical measures linking transformation to safety outcomes**.
- **Bolus Formation** was under-assessed (6 links) despite its clinical relevance.

Matrix 2: Study Quality × Methods

- **Standardised Protocols** were most associated with sensory evaluation (11), IDDSI use (10), and clinical assessments (4).
- **Reliability Reported** had **no method associations**, even though reliability was coded 23 times—reflecting the absence of reported reliability metrics in publications.
- **Methodological Limitations** were most commonly attached to studies using IDDSI (6) and sensory methods (3).

8.4.4 *Appendix D4: How Matrix Results Informed Theme Development*

The matrix patterns were used alongside the broader narrative synthesis to support and confirm the development of the six analytical theme.

Table D.1

Mapping Matrix Findings to Final Themes

Matrix Finding	Contribution to Theme
Saliva Interaction = 0 across all methods	Theme 1: Underdeveloped oral transformation; Theme 3: Static bias; Theme 4: Hidden functional imbalance; Theme 6: Missing triangulation
Rheology dominates (33 codings)	Theme 3: Rheological/static dominance
Safety assessed without imaging	Theme 1: Pharyngeal bias; Theme 4: Functional imbalance
Transformation Dynamics moderate but weakly linked to safety	Theme 1: Gap between oral and pharyngeal domains; Theme 6: Partial triangulation
Bolus Formation under-assessed	Theme 1 & 4: Discontinuous assessment chain
Standardised Protocols high	Theme 5: Strong foundational design
Zero reliability reporting linkage	Theme 5: Transparency gap
IDDSI used more for classification than measurement	Theme 2: Classification strength vs measurement underuse

8.4.5 *Appendix D5: Code References*

Name	**Description**	**Sources**	**References**
COMPONENTS ASSESSED	All measurable biomechanical, rheological, textural, oral-processing, or swallowing-related components assessed in the study	0	0
Bolus Formation	Characteristics of bolus produced before swallowing. (Cohesion, particle size, uniformity, mixing ability…)	1	6
Oral Biomechanics	EMG, tongue pressure, jaw kinematics, muscle activity measurements	1	64

Pharyngeal Efficiency	Measures of post-swallow clearance and swallow efficiency. (Residue levels, transit times, number of swallows…)	1	12
Rheological_Properties	Viscosity, cohesiveness, adhesiveness, TPA, tribology - food texture properties	1	95
Saliva Interaction	Influence of saliva on food texture or breakdown. (Saliva incorporation, moisture ratio, dissolution…)	1	6
Swallowing Safety	VFSS, FEES, transit times, PAS, penetration-aspiration scale, pharyngeal residue	1	80
Texture Properties (TPA)	Mechanical texture attributes measured through instrumental texture analysis. (Hardness, cohesiveness, adhesiveness, springiness…)	1	11
Transformation Dynamics	Dynamic texture changes during oral processing - solid to puree transition, melting, hydration, particle breakdown, disintegration behaviours	1	90
METHODS USED	All measurement tools, analytical techniques, and assessment methods used in the study.	0	0
Biomechanical_Physiological Measures	Tools measuring oral forces or physiological swallowing activity. (EMG, IOPI, bite force sensors, kinematic tracking…)	1	15
Clinical Assessments methods	Validated tools for evaluating swallow safety. (PAS, MBSImP, FOIS, residue scales…)	1	7
IDDSI Framework Use	Use of IDDSI levels or testing methods to classify texture. (IDDSI levels 0–7, syringe flow, fork-drip tests…)	1	26
Imaging Methods	Visualisation tools capturing swallowing physiology. (VFSS, FEES, ultrasound, high-speed video…)	1	14
Rheological_Texture Testing	Laboratory instruments that measure flow or texture properties. (Rheometer, viscometer, TPA analyser…)	1	16
Sensory & Acceptability Evaluation	Human perception, sensory, or acceptability assessments. (QDA, TDS, hedonic scales, patient-reported outcomes…)	1	38
POPULATIONS	Classification of the study sample based on swallowing function.	0	0
Dysphagic Populations	Participants with diagnosed or suspected dysphagia.	1	9
Healthy Adults	Participants without any swallowing impairment.	1	15
Mixed Populations	Studies including both healthy and dysphagic groups.	1	2
STUDY QUALITY	Indicators of methodological rigour and limitations based on CASP and MORE appraisal.	0	0
High Design Quality	Strong methodological features that improve validity. (Randomisation, blinding, adequate sample size…)	1	36
Methodological Limitations	Weaknesses or constraints affecting study quality. (Small sample, no blinding, inadequate reporting…)	1	48
Reliability Reported	Presence of formal reliability or agreement statistics.	1	23
Standardised Protocols	Use of validated, standardised, or calibrated measurement procedures.	1	65

8.5 Appendix E: Complete Inventory of Measured Components Across All Studies (n=28)

Alphabetical listing of all oral processing components, physiological measures, and assessment parameters reported across the evidence base, prior to thematic categorization

Component/Parameter	Measurement Description	Studies Reporting	n	%
Acceptability/Palatability	Hedonic ratings, overall acceptance, satisfaction scales	4, 9, 20	3	11%
Adhesiveness	Negative force area under TPA curve (N·s) or tribological adhesion	4, 6, 11, 13, 17, 19, 20, 22, 28	9	32%
Anatomical region classification	Oral, oropharynx, valleculae, hypopharynx location during swallow	26	1	4%
Aspiration events	Presence/absence of airway penetration below vocal folds	2, 3, 5, 8, 9, 17, 22	7	25%
Bolus cohesion/aggregation	Degree of bolus unity, mixing, particle aggregation (0-2 scales)	8, 9, 10, 15, 16, 21	6	21%
Bolus formation time	Duration from mastication start to swallow initiation	9, 24, 27	3	11%
Chewing cycles/strokes	Number of masticatory cycles until swallow	4, 6, 9, 10, 15, 16, 21, 23, 24, 27	10	36%
Chewing duration/time	Total time spent chewing before swallow (seconds)	4, 6, 9, 24, 27	5	18%
Chewing resistance (perceived)	Subjective rating of effort required to chew	25	1	4%
Cohesiveness	TPA ratio A2/A1 or perceived cohesion during eating	4, 6, 7, 11, 13, 17, 19, 20, 22, 24, 25	11	39%
Consistency index (K)	Rheological parameter from power law model (Pa·s^n)	11, 25	2	7%
Creamy (perceived)	Sensory descriptor for smoothness/richness	25	1	4%
Detachment forces	Force required to separate bolus from surface (Pa)	28	1	4%

Difficulty to swallow	Patient-reported ease/difficulty rating	13, 14	2	7%
Dissolution time	Time for food to dissolve with saliva (seconds)	18	1	4%
Ease of swallow	Patient/consumer perception of swallowing ease	4, 9, 13, 14, 15, 19, 20, 25	8	29%
Effort required to prepare to swallow	Perceived exertion during oral preparatory phase	14	1	4%
EMG amplitude/duration	Muscle electrical activity magnitude and temporal parameters	4, 6, 15, 23	4	14%
Firmness (instrumental)	Maximum force during compression (N)	13, 25	2	7%
Firmness (perceived)	Sensory rating of texture resistance	13, 25	2	7%
Flow index (n)	Power law exponent indicating shear-thinning/thickening behaviour	11, 25	2	7%
Flow rate	Volume flowing per time (mL/10s)	7	1	4%
Frequency of stage 2 transport	Occurrence of premature spillage to pharynx	24	1	4%
G′ (Storage modulus)	Elastic component of viscoelasticity (Pa)	10, 11, 16, 25	4	14%
G″ (Loss modulus)	Viscous component of viscoelasticity (Pa)	10, 16, 25	3	11%
Grainy (perceived)	Sensory descriptor for particle texture	25	1	4%
Grinding ability	Bolus formation subscale for particle size reduction (0-2)	21	1	4%
Gumminess	TPA-derived parameter: Hardness × Cohesiveness (N or N/m^2)	20, 22	2	7%
Hardness	Maximum force during first compression in TPA (N or N/m^2)	4, 6, 7, 11, 13, 17, 19, 20, 22, 24	10	36%

Homogeneous (perceived)	Sensory rating of texture uniformity	25	1	4%
IDDSI classification level	International framework level assignment (0-7 or 0-8)	2, 3, 4, 5, 6, 7, 9, 12, 13, 15, 18, 19, 28	13	46%
IDDSI fork/spoon test result	Pass/fail on standardised IDDSI testing protocols	7, 12, 15, 18	4	14%
Image contrast/visibility	Quantitative fluoroscopic pixel analysis for bolus visualization	7	1	4%
Ingestion time (total)	Time from first bite to complete oral clearance	9	1	4%
Laryngeal elevation duration (LEDT)	Time larynx remains elevated during swallow (seconds)	1	1	4%
Laryngeal penetration	Bolus entry into laryngeal vestibule above vocal folds	8	1	4%
Lip motor function	Lip strength, movement, coordination assessment	16	1	4%
Mastication frequency	Chewing rate (cycles per second)	6	1	4%
Maximum force	Peak force during TPA or bite (N)	6, 11, 13	3	11%
MBSImP component scores	Modified Barium Swallow Impairment Profile 17-component ordinal ratings (0-4)	5	1	4%
Melting sensation	Perceived dissolution/melting in mouth	25	1	4%
Mixing ability	Bolus formation subscale for saliva incorporation (0-2)	21	1	4%
Moistness (perceived)	Sensory rating of moisture/wetness	14	1	4%
Moisture content/ratio	Percentage water or moisture in bolus	10, 16, 18, 27	4	14%
Mouthcoating (perceived)	Degree of oral residue sensation	14	1	4%
Mouthfeel acceptability	Overall texture acceptability rating	20	1	4%

Number of partitioned swallows	Multiple swallows required to clear single bolus	24	1	4%
Number of swallows per bolus	Swallow count to achieve complete clearance	2, 9	2	7%
Oral phase duration	Time from bolus entry to swallow initiation (seconds)	1, 27	2	7%
Oral transit time (oPTT)	Time for bolus to traverse oral cavity (seconds)	1	1	4%
Oropharyngeal transit time	Combined oral + pharyngeal transit duration	17	1	4%
Particle size distribution	Bolus particle dimensions after mastication	23, 25	2	7%
Particles (perceived)	Sensory rating of detectable particles	14, 25	2	7%
Particles after swallowing (perceived)	Residual particle sensation post-swallow	25	1	4%
PAS (Penetration-Aspiration Scale)	8-point ordinal scale for airway safety (1-8)	2, 3, 5, 8, 9, 17, 22	7	25%
Phase angle (δ)	Viscoelastic parameter: arctan(G″/G′)	10, 11, 16, 25	4	14%
Pharyngeal delay time (PDT)	Time from bolus head reaching set point to UES opening	1	1	4%
Pharyngeal residue	Food remaining in pharynx post-swallow (valleculae/pyriform)	3, 8, 9, 17, 19, 22	6	21%
Pharyngeal transit time (PTT, hPTT)	Time for bolus to traverse pharynx (seconds)	1, 8, 17, 26	4	14%
Pixel contrast metrics	Quantitative image analysis for bolus visibility	3, 8, 9, 17	4	14%
Pooling score	Residue site, amount, management subscales	2	1	4%
Porous (perceived)	Sensory descriptor for air-filled texture	25	1	4%
Rate of breakdown (perceived)	Speed of texture disintegration in mouth	13, 25	2	7%

Residue (binary detection)	Present/absent residue via visual assessment	4	1	4%
Residue percentage	Quantitative residue in oro-/hypo-/epiglottic regions	3	1	4%
Residues in-mouth (perceived)	Subjective rating of oral residue	14	1	4%
Rough (perceived)	Sensory descriptor for texture irregularity	25	1	4%
Saliva content in bolus	Amount/percentage of saliva mixed with bolus	10, 16, 18, 23	4	14%
Salivation rate (resting)	Baseline saliva production (mL/min)	27	1	4%
Satisfaction	Overall satisfaction with eating experience	9	1	4%
Shear forces	Forces applied during simulated swallowing	28	1	4%
Site of swallow initiation	Anatomical location where pharyngeal swallow triggered	9	1	4%
Smoothness (perceived)	Sensory rating of texture evenness	13, 14, 25	3	11%
Stage 2 transport degree	Extent of premature spillage to pharynx	24	1	4%
Stickiness (instrumental)	Adhesive properties via tribology or TPA	13, 19, 20, 24, 25	5	18%
Stickiness (perceived)	Sensory rating of adhesion to oral surfaces	14, 24	2	7%
Swallow count	Total number of swallows per eating task	3, 9	2	7%
Swallow effort (perceived)	Perceived exertion during swallowing	19	1	4%
Swallow reaction time	Latency from cue to swallow initiation	9	1	4%
Swallowability (simulation)	Computational modelling of swallow success	28	1	4%

Tongue motor function	Tongue strength, movement, coordination	16	1	4%
Tongue pressure/strength	Maximum tongue force during swallowing or at rest (kPa)	2, 10, 15, 16, 18	5	18%
Trouton ratio	Extensional viscosity/shear viscosity ratio	16	1	4%
Vallecular residue	Residue in valleculae specifically (ordinal scale 0-3)	8, 9, 17	3	11%
Viscosity (at specified shear rates)	Flow resistance at 10, 50, 300 rpm or s^{-1} (mPa·s)	4, 7, 10, 11, 12, 13, 16, 20, 25, 27, 28	11	39%
Viscous (perceived)	Sensory rating of thickness/flow resistance	13, 14	2	7%
White-out duration	Time of complete bolus obscuration during pharyngeal swallow	9	1	4%
Wobbling (perceived)	Sensory descriptor for gelatin-like movement	25	1	4%
Yale Pharyngeal Residue Scale	Validated residue rating system	9	1	4%

8.6 Appendix F: Glossary of Components and Methods

This glossary provides brief definitions of all assessment components and measurement parameters identified in this review. Definitions describe how each parameter was operationalised or understood within the included studies, rather than offering technical or discipline-wide definitions.

Adhesion to Mucosa

Force required for food or bolus material to detach from oral or simulated mucosal surfaces during contact tests.

Adhesiveness (instrumental)

Work or force needed to pull a probe away from a food sample during compression, representing how sticky the product is.

After-Swallow Residue Perception

Subjective rating of how much material feels as if it remains in the mouth or throat after swallowing.

Apparent Viscosity

Viscosity of a material measured at a specific shear rate, reflecting flow behaviour under defined conditions.

Aspiration

Entry of material below the level of the vocal folds into the airway during swallowing

Bite Force

Maximum force generated between the teeth during biting or chewing, usually measured with a bite force sensor.

Bolus Aggregation

Degree to which chewed food particles gather into a single mass during bolus formation.

Bolus Boundary

Clarity of the bolus outline against surrounding structures on imaging (e.g., VFSS frame).

Bolus Cohesion

Extent to which the bolus holds together as a unified mass suitable for safe swallowing.

Bolus Firmness (instrumental)

Peak force required to compress an expectorated bolus to a set deformation.

Bolus Flow Speed

Velocity at which the bolus travels through the oral or pharyngeal structures, typically measured on VFSS.

Bolus Homogeneity

Uniformity of particle size and texture within the bolus, indicating how evenly mixed it is.

Bolus Lubrication

Effectiveness of saliva and food components in reducing friction between the bolus and oral/pharyngeal surfaces.

Bolus Moisture Content

Percentage of water in the formed bolus, including both original food moisture and incorporated saliva.

Bolus Moisture Ratio

Comparison of pre- and post-oral processing moisture levels, often expressed as a percentage or ratio.

Bolus Shape Compactness

Geometric compactness of the bolus (e.g., circularity or sphericity) derived from image analysis.

Bolus Stickiness

Tendency of the bolus to adhere to surfaces such as tongue, palate, or pharyngeal walls.

Chewiness

Texture parameter representing energy needed to chew food until it is ready to swallow (often gumminess × springiness).

Chew Resistance (perceived)

Subjective perception of how hard or effortful a food is to chew.

Chewing Cycles / Strokes

Number of mandibular opening–closing movements performed before the swallow.

Chewing Duration / Chewing Time

Total time spent chewing from first bite until swallow initiation.

Chewing Rate

Frequency of chewing cycles per second, typically expressed in Hz.

Chewing Sequence Structure

Pattern and regularity of chewing movements, including side preference and alternation.

Clearance Score

Rating of how effectively a bolus is cleared from the pharynx after swallowing, often based on residue amount and location.

Cohesive Energy Density

Energy required to separate internal structures of a material per unit volume, derived from rheological data.

Cohesiveness (instrumental)

Proportion of structural integrity maintained between two texture-analysis compressions; reflects internal bonding.

Consistency Index (K)

Constant in the power-law rheology model indicating overall thickness of a fluid at a given shear rate.

Cough Reflex Response

Presence or absence of a reflexive cough in response to material entering the larynx or trachea.

Creaminess (perceived)

Sensory perception of smooth, rich, and often fatty mouthfeel.

Deformation at Break

Amount of sample deformation at the point of fracture during compression or extension testing.

Delayed Swallow Initiation

Longer-than-typical time between bolus reaching a trigger point and onset of the pharyngeal swallow.

Detachment Stress

Stress required to separate food material from a contact surface during probe-tack or adhesion testing.

Dissolution Rate

Speed at which a food dissolves or breaks down in liquid, usually expressed as mass or percentage loss over time.

Dissolution Time

Time taken for a food to fully dissolve or reach a specified endpoint under defined conditions.

Ease of Swallow

Subjective rating of how easy or difficult it feels to swallow a given food or bolus.

Electromyography (EMG) Amplitude

Magnitude of electrical activity recorded from chewing or swallowing muscles.

EMG Frequency

Frequency content of the EMG signal, reflecting patterns of muscle activation.

EMG Timing

Onset, offset, and duration of muscle activation bursts relative to chewing or swallowing events.

Firmness (instrumental)

Peak force measured during a single compression of the sample; often used for simple hardness tests.

Firmness (perceived)

Subjective sense of how hard or resistant a food feels when bitten or compressed in the mouth.

Flavour Intensity

Perceived strength of taste and aroma for a given sample.

Flow Curve Behaviour

Overall pattern of how shear stress changes with shear rate across a flow curve for a material.

Flow Index (n)

Exponent in the power-law model indicating whether a fluid is shear-thinning, Newtonian, or shear-thickening.

Fraction / Frequency of Stage 2 Transport

Number of instances where part of the bolus spills into the pharynx before swallow initiation.

Friction Coefficient (μ)

Ratio of frictional force to normal force between two surfaces, used to quantify lubrication performance.

Fracturability

Force at which a brittle or crisp product first breaks during compression.

Frequency Sweep Response

Change in viscoelastic moduli of a sample across a range of oscillation frequencies in rheology testing.

Graininess (perceived)

Sensation of small grains or particles in a food during oral processing.

Grinding Ability

Effectiveness of chewing in reducing particle size, often expressed as a reduction ratio.

Gumminess

Texture parameter for semi-solid foods representing energy needed to disintegrate a food to a swallowable state.

G′ (Storage Modulus)

Elastic component of viscoelastic behaviour, representing energy stored during deformation.

G" (Loss Modulus)

Viscous component of viscoelastic behaviour, representing energy lost as heat during deformation.

Hardness (instrumental)

Maximum force recorded during the first compression cycle in Texture Profile Analysis.

Homogeneity Perception

Subjective impression of how uniform or lumpy a food feels in the mouth.

Hydration

Absolute moisture content of the food or bolus, commonly expressed as percentage water by weight.

Hypopharyngeal Transit Time

Time taken for the bolus tail to travel through the hypopharynx.

IDDSI Level – Initial

Classification of a food's starting texture using IDDSI tests (e.g., fork, spoon, syringe) before oral processing.

Incomplete Airway Closure

Insufficient closure of laryngeal structures during swallowing, increasing the risk of penetration or aspiration.

Internal Structural Integrity

Extent to which the internal microstructure of a food is maintained, as seen on microscopy.

Jaw Kinematics

Three-dimensional movement patterns of the mandible (displacement, angles, velocity) during chewing.

Laryngeal Invasion

Entry of material into the laryngeal vestibule, encompassing both penetration and aspiration events.

Lingual Movement

Range and pattern of tongue motion during oral processing or swallowing.

Loss Tangent (tan δ)

Ratio of loss to storage modulus (G"/G'), indicating the balance of viscous and elastic behaviour.

Lubrication Coefficient

Measure summarising how effectively a sample reduces friction between moving surfaces.

Matrix Disintegration Pattern

Qualitative description of how a food's internal matrix breaks down during oral processing (e.g., crumbling, dissolving).

Melting Perception

Subjective sensation of a product softening or dissolving in the mouth with time or warmth.

Mixing Ability

Degree to which saliva and food become evenly blended within the bolus.

Moisture Uptake

Change in moisture content of food or bolus over time, typically as a percentage increase.

Mouthfeel

Overall textural impression of a food in the mouth, combining multiple sensory attributes.

Mouthfeel Acceptability

Overall judgement of whether the texture is acceptable or pleasant to the eater.

Mouthcoating (perceived)

Subjective feeling of a film or coating left on oral surfaces after swallowing.

Moistness (perceived)

Subjective rating of perceived wetness or juiciness of the food.

Number of Partitioned Swallows

Number of separate swallows required to clear a single bolus.

Number of Swallows per Bolus / Swallow Count

Total number of swallows observed for a given test portion.

Oral Dryness Perception

Subjective sense of dryness in the mouth, often linked to reduced saliva.

Oral Phase Duration

Time from bolus entry into the mouth to onset of the pharyngeal swallow.

Oral Preparation Time / Chewing Duration

Time spent preparing the bolus (chewing and manipulating) before swallow initiation.

Oral Processing Time to Swallow

Total duration from first bite until the swallow that clears the bolus.

Oral Transit Time (OTT)

Time taken for the bolus to move from the oral cavity to the point of pharyngeal swallow trigger.

Oral-Pharyngeal Coordination

Timing and synchronisation between movements in the oral phase and events in the pharyngeal phase.

Oropharyngeal Transit Time

Combined duration of oral and pharyngeal transit, from oral propulsion to completion of pharyngeal clearance.

PAS Score (Penetration–Aspiration Scale)

Eight-point ordinal scale describing depth of airway invasion and patient response during swallowing.

Particle Size Distribution

Spread of particle sizes present in a sample or bolus, usually presented as a distribution curve.

Particle Swelling

Increase in particle size after contact with liquid or saliva, expressed as percentage change.

Perceived Adhesiveness

Subjective impression of how much food sticks to oral tissues.

Perceived Cohesiveness

Subjective sense of how well the food holds together during chewing.

Perceived Firmness

Subjective rating of how hard or resistant the food feels.

Perception of Particles

Subjective awareness and intensity of discrete particles in the mouth.

Pharyngeal Delay Time (PDT)

Time from bolus head reaching a reference location to onset of upper oesophageal sphincter opening.

Pharyngeal Residue

Material remaining in any pharyngeal space (valleculae, pyriform sinuses, etc.) after a swallow.

Pharyngeal Transit Time (PTT)

Time taken for the bolus to move through the pharynx from swallow initiation to upper oesophageal sphincter closure.

Pooling Score

Composite rating of premature pooling of material in the pharynx prior to swallow and its management.

Porous (perceived)

Subjective sense of airiness or sponge-like texture in food.

Posterior Spillage Timing

Time at which bolus material spills from the oral cavity into the pharynx before swallow initiation.

Posterior Tongue–Palate Seal

Effectiveness of contact between the tongue and palate in containing the bolus before the swallow.

Pre/Post Hardness Change

Difference in hardness values measured before and after oral processing or modelled chewing.

Pre/Post Oral Viscosity Change / Pre/Post Viscosity Change

Difference in measured viscosity before and after oral processing or saliva incorporation.

Pooling, Residue Percentage, and Residues In-Mouth (perceived)

Various metrics describing objective or perceived amounts of material left after swallowing.

Rate of Breakdown (perceived)

Subjective impression of how quickly a food disintegrates in the mouth.

Residual Management / Residue Management

Effectiveness of strategies (e.g., additional swallows) in clearing residual material after an initial swallow.

Resilience

Proportion of energy recovered during decompression in Texture Profile Analysis, reflecting bounce-back.

Rheological Stability

Consistency of rheological properties across repeated measures or over time, often summarised with coefficient of variation.

Roughness (perceived)

Sensation of irregular, abrasive, or coarse texture in the mouth.

Saliva Incorporation Volume

Amount of saliva that becomes mixed into the bolus, usually calculated from mass change.

Saliva Mixing Efficiency

How evenly saliva is distributed throughout the bolus, expressed via mixing indices.

Saliva-Induced Viscosity Drop

Decrease in viscosity of a product after saliva is mixed in.

Salivation Rate

Volume or mass of saliva produced per unit time during resting or stimulated conditions.

Satisfaction

Overall subjective satisfaction with the eating or swallowing experience.

Sensory Smoothness

Perception of absence of lumps or irregularities in a food’s texture.

Shear Forces

Forces generated under shear conditions in simulated or modelled swallowing systems.

Shear Rate

Rate at which adjacent layers in a fluid move relative to each other during flow.

Shear Thinning Index

Quantitative descriptor of how much a material's viscosity decreases with increasing shear rate.

Site of Swallow Initiation

Anatomical location where the pharyngeal swallow is first triggered (e.g., faucial pillars, valleculae).

Softening Rate

Speed at which a product loses firmness over time or during repeated loading.

Stage 2 Transport Degree

Severity or extent of premature bolus spillage into the pharynx before swallow initiation.

Stickiness (instrumental)

Adhesive properties of a sample measured using tribology or texture-analysis methods.

Stickiness (perceived)

Subjective rating of how much a product clings to teeth, tongue, or palate.

Storage Modulus (G′)

See G′ (Storage Modulus) – elastic component of viscoelastic response.

Structural Breakdown Force

Force at which a material undergoes major structural collapse during repeated compression.

Structural Change with Saliva

Alterations in food structure after exposure to saliva, observed via rheology or imaging.

Swallow Effort (perceived)

Subjective sense of effort required to complete a swallow.

Swallow Efficiency Rating

Composite assessment of how effectively a bolus is cleared from the pharynx without residue or multiple swallows.

Swallow Reaction Time

Latency between an external cue to swallow and the actual onset of the swallow.

Swallowability (Simulation)

Modelled prediction of how well a sample would transport and clear during a swallow using in-vitro or in-silico models.

Texture Analyzer

Instrument that applies controlled forces to food samples to measure textural properties such as hardness or adhesiveness.

Texture Profile Analysis (TPA)

Standard two-cycle compression protocol used to derive multiple texture parameters (e.g., hardness, cohesiveness, chewiness).

Thixotropy

Time-dependent decrease in viscosity under constant shear, with recovery when shear is removed.

Time-Dependent Viscosity Change

Change in viscosity over time under a constant shear or oscillation condition.

Tongue Motor Function

Combined assessment of tongue strength, movement range, and coordination.

Tongue Pressure / Tongue Strength

Maximum pressure the tongue can exert against a surface, typically measured in kPa.

Tongue–Palate Contact Duration

Length of time the tongue maintains contact with the palate during bolus propulsion or manipulation.

Trouton Ratio

Ratio of extensional viscosity to shear viscosity for a given material.

Vallecular Residue

Material remaining in the valleculae after a swallow, scored on imaging.

Viscoelastic Spectrum

Pattern of storage and loss moduli across frequencies, describing viscoelastic behaviour over time scales.

Viscosity / Viscosity at Specified Shear Rates

Resistance of a fluid to flow, often measured at defined shear rates relevant to oral processing.

Viscous (perceived)

Subjective sense of thickness or resistance to flow in the mouth.

Videofluoroscopic Timing Measures (e.g., LEDT, oPTT, hPTT)

Various temporal measures derived from VFSS, such as laryngeal elevation duration and specific oral or pharyngeal transit times.

White-Out Duration

Period during FEES when the endoscopic view is obscured by pharyngeal wall movement at the height of the swallow.

Wobbliness (perceived)

Perception of jiggly or unstable gel-like movement in a product.

Work of Compression

Total energy required to compress a sample to a predefined distance or deformation.

Work of Shear

Energy needed to shear a sample using a blade or similar probe.

Zero-Shear Viscosity

Limiting viscosity value measured at very low shear rates where structural disruption is minimal.