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A review of the impact of food design on the mealtimes of people with swallowing disability who require texture-modified food

ABSTRACT

Texture-modified foods are a common component of interventions provided to people with dysphagia (swallowing disorders) to maintain their respiratory health, nutritional health and to reduce the risk of aspiration-related illness or choking on food. However, the unsightly and unappetizing appearance of texture-modified foods may negatively impact on the mealtime experience and acceptance of texture-modified foods of persons with dysphagia. The aim of this review was to determine

KEYWORDS

dysphagia
food design
texture-modified diet
mealtimes
3D food printing
swallowing

what is known about the impact of specific elements of food design – food structure and visual appeal – on the mealtime experiences of people with dysphagia. This review of 35 studies presents evidence on how the physical characteristics of texture-modified foods for people with dysphagia can be considered during food production, formulation or service to improve their mealtime experience. Overall, the visual appeal, texture, taste, aroma, temperature, mealtime environment and mealtime assistance all impact upon mealtime experiences and should be considered carefully in the design of a person's mealtime plan and food-related dysphagia interventions to improve their mealtime-related quality of life. Further research needs to include the views of people with dysphagia, particularly those with lifelong conditions, who might require texture-modified food for an extended period over their lifespan.

INTRODUCTION

Dysphagia, or difficulty swallowing, affects approximately 8 per cent of the world's population (Cichero et al. 2017) and is highly prevalent in people with lifelong and acquired health conditions (e.g. stroke, Parkinson's, cerebral palsy, intellectual disability) (Kumar 2010). Along with its negative impacts on nutritional health, dysphagia and its interventions can negatively impact the person's quality of life, both by the need for restrictions in food choices and by reduced independence, autonomy and self-determination in reliance on others for mealtime assistance (Balandin et al. 2009; Hall and Wendin 2008).

Modifying the texture of food is one of the most commonly used first-line interventions in dysphagia management (Robbins et al. 2002). The International Dysphagia Diet Standardisation Initiative (IDDSI) classifies food and fluid according to texture into eight categories, with five of these relating to food: Level 7 Regular/Easy to Chew; Level 6 Soft and Bite-Sized; Level 5 Minced and Moist; Level 4 Pureed; and Level 3 Liquidized (Cichero et al. 2017). Recommendations for the IDDSI level of food texture required are based on both observational and instrumental assessments of the person's swallowing (Ricci Maccarini et al. 2007). Texture-modified diets, moving through the different levels from Soft & Bite-Sized to Pureed or Liquidized, understandably involve a substantial modification of the food's structure and appearance, affected by how it is processed (e.g. food processor, blender, cut up) and served (e.g. how it is served on a plate or in a bowl).

According to the IDDSI framework, Pureed or Liquidized foods are the most significantly modified food textures (Cichero et al. 2017). However, modifying a food's texture may not remove all the risks associated with swallowing, as pureed food may still pool in the person's neck (in the vallecular spaces) and increase their risk of choking (Gustafsson 1995). Furthermore, adding liquids to food to achieve the correct consistency may dilute the food's flavour and nutritional value, unless this is accounted for in the preparation (Keller et al. 2012; Cichero 2017). Poor acceptance of unappealing meals can reduce the person's food consumption and increase their risk of malnutrition (Keller et al. 2012). Furthermore, dissatisfaction with texture-modified food often leads to non-compliance with diet recommendations to avoid problematic food textures (Colodny 2005). Colodny (2005) reported that 39.7 per cent of participants with dysphagia rejected diet recommendations due to the

food's structure or consistency, or taste. In the interviews, one participant with dysphagia stated, 'take that junk off my tray' (Colodny 2005: 66). Consequently, people with dysphagia may risk eating regular texture foods to maintain their quality of life or mealtime enjoyment, as one participant said: 'I'll take my chances, I don't want that horrible stuff' (Colodny 2005: 66).

Increased acceptance of texture-modified food may be achieved through improved food design (Hemsley et al. 2019). Food design is a broad field that encompasses 'design with food, design for food, food space design or interior design for food, food product design, design about food, and finally, eating design' (Zampollo 2016: 4). Thus, food design – more than the design of the food product – includes the design of tools used in the meal (e.g. cutlery), the mealtime environment (e.g. where the food is consumed) and the design of the social rituals of the meal (Zampollo 2016). The creation of texture-modified food for people with dysphagia relates to a process of design with food where decisions are made about the texture (food structure or consistency), taste, temperature, shape and colour of the food. It is important that the views of the person with dysphagia are considered when designing the food's structure or appearance to improve its acceptability.

Poor acceptability of texture-modified foods by people with dysphagia can be problematic for their mealtime engagement. For example, a person with dysphagia may feel isolated at social gatherings if they cannot eat what others are eating or if they fear choking on food in public (Balandin et al. 2009). In addition, attempts to improve mealtime experiences and inclusion for people with dysphagia should consider several elements of food design beyond the food, including food space design and eating design (Balandin et al. 2009; Reissig 2017). In all of these domains, the needs and preferences of the person with dysphagia must be considered, particularly for those receiving mealtime assistance as it can influence their mealtime pleasure (Reimer and Keller 2009).

The sensory appeal of texture-modified food also influences its acceptance by people with dysphagia (Reissig 2017). Spence et al. (2010) described the importance of a food's colour perceptually matching its intended flavour, as flavours are more likely to be identified correctly if presented in the colour of the original food product (e.g. red, strawberry-flavoured products being more identifiable). The plating of the food also influences the person's perception of the food. For example, if texture-modified food is typically plated in scoops to prevent mixing (Milte et al. 2017), the uniform nature of scoops for each item may disrupt the visual appeal of the meal and reduce interest.

Aguilera and Park (2017) conceptualized *food choice* for people with dysphagia in a model connecting convenience, health and mealtime pleasure (see Figure 1). Through their involvement in making food choices, people with dysphagia can be engaged in the process of designing the menu and selecting foods that are safe and enjoyable to eat. In the model, 'Convenience' refers to accessing food of the correct consistency for safe swallowing; 'Health' refers to food containing adequate nutrients for the consumer's needs, and 'Pleasure' refers to the enjoyment of food's sensory components. The interconnection of these concepts theoretically influences the person's overall mealtime experience.

The model of food choice could help guide an appreciation of literature pertaining to food structure for people with dysphagia on texture-modified diets. Therefore, the aim of this review was to determine what is known about the impact of food structure and composition, including its texture, appearance

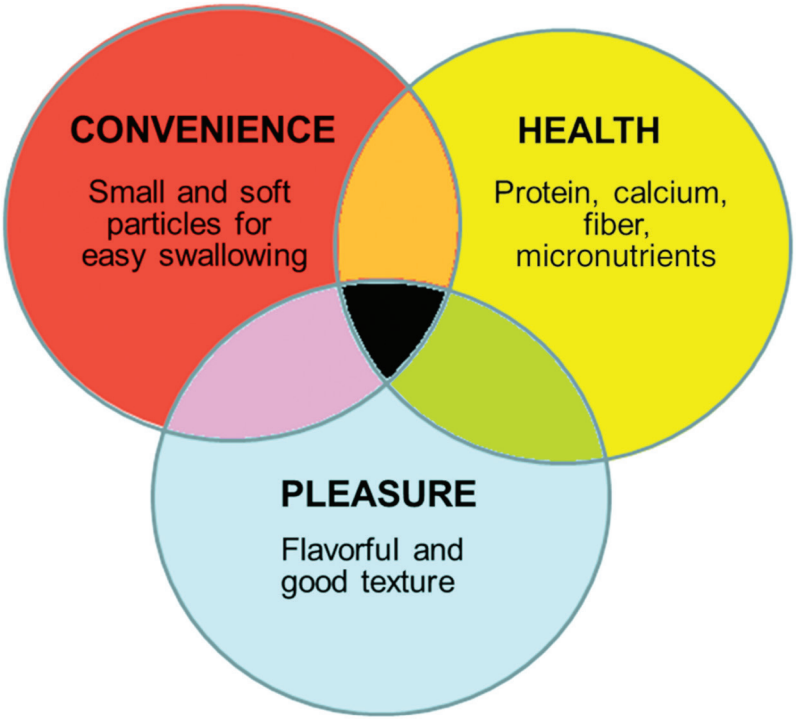

Figure 1: Drivers of Food Choice for People with Dysphagia. *Illustration from bottom-up approaches in the design of soft foods for the elderly (Aguilera and Park 2017: 155). Courtesy of Wiley-VCH Verlag GmbH & Co. KGaA. Reprinted with permission.*

and taste, on the food choices and experiences of people with dysphagia. The theoretical framework for the review recognized the interlinked drivers of food choice conceptualized in the Aguilera and Park (2017) model and how these might impact people with dysphagia. The findings of this review will help identify the gaps in knowledge and strategies for including people with dysphagia in the design of food structure and appearance that support their mealtime-related health and quality of life (Smith et al. 2022).

METHOD

In an emergent area of interdisciplinary research, involving fields of both food design and dysphagia management, a narrative review methodology was used. In July 2020, five databases (EMBASE, Medline, CINAHL, Web of Science and PsycINFO) were searched using combinations and permutations of terms related to dysphagia (e.g. dysphagia, swallowing disorder, deglutition disorder), food texture (e.g. puree, soft, minced and moist) and food structure and appearance (e.g. food shape/shaping, food mould, piping bag, 3D food printer, aesthetics). A copy of the full search strategy is available from the first author. Inclusion criteria were: (1) relates to dysphagia and the design of texture-modified foods, (2) is written in English and (3) is a full paper of original research, a critical review, commentary or editorial. While it is recognized that mealtime experiences are influenced by the emotional,

social and cultural contexts of meals more broadly (Ochs and Shohet 2006), these wider concepts were only included in the review as they appeared in studies relating to people with dysphagia and their experiences of texture-modified foods.

Following the initial search, two raters (RS and BH) were involved in selecting studies at the title, abstract and full text stages with a third rater (CR) assisting to resolve disputes on inclusion. On study selection between the two raters, an inter-rater reliability rate of 0.97 was achieved, indicating almost perfect reliability (McHugh 2012). Cited sources and forward citations of included papers were searched for relevant studies, and Google Scholar was searched for relevant authors to locate additional studies. With a wide range of study designs included, narrative synthesis was used (Ryan and Cochrane Consumers and Communication Review Group 2013) to examine the relationships of concepts in the Aguilera and Park (2017) Drivers of Food Choice model.

RESULTS

The initial database search located 276 articles. Another 23 relevant papers were found through cited sources, forward citations and Google Scholar searches. In total, 35 studies were included, and the characteristics of included studies are in Table 1. Figure 2 is a flowchart outlining the steps for study inclusion.

Food preparation

Techniques for creating texture-modified foods

Various technologies can be used to create the desired food texture for people with dysphagia and improve the convenience and pleasure of meals (Aguilera and Park 2017). High-pressure food processing is widely used to create texture-modified foods (Cichero 2017); however, other techniques used include ultrasound, thermal processing and pulsed electric fields (Sungsinchai et al. 2019). The success of texture modification is influenced by the type of food, its size and how it is prepared when raw (Sungsinchai et al. 2019). The most appropriate food and texture modification methods must be used to optimize the safety of texture-modified food.

Gels are also used to create the correct food consistency and to hold the shape of pureed food for people with dysphagia (Hori et al. 2015). Hori et al. (2015) examined the level of tongue pressure required to swallow different gels and reported that as gel consistency increased, so did the amplitude and duration of tongue pressure required and the amount of stress exerted by the tongue. However, the duration of swallow was not impacted (Hori et al. 2015). Hence, gel consistencies must match the tongue strength of an individual to optimize mealtime engagement.

Techniques used to create texture-modified food also impact mealtime experience and mealtime safety. Ilhamto et al. (2014) reported that people did not consistently use standardized recipes or governance documents and instead used experimentation to achieve the correct food consistency or to meet individual preferences. Consequently, food no longer met the standard texture requirements (Ilhamto et al. 2014). This highlighted the difficulties associated with creating food that is aesthetically pleasing, meets the individual's preferences and adheres to texture modification guidelines.

Table 1: Included studies.

First author, year	Aim to determine	Methods and participants	Relevant findings	Further research
Aguilera, 2017	Food choice for the elderly	Edited book section	Food choice driven by convenience, health and pleasure. Changing the food properties can meet needs	Examination of functional/ nutritional ingredients
Balandin, 2009	How adults with cerebral palsy experience mealtimes	Qualitative interviews. Adults with cerebral palsy (N = 32)	A good relationship with support staff providing mealtime assistance essential for enjoyable mealtimes	Larger participant group
Burger, 2019	Texture-modified diet best practice accessibility within German aged care homes	Quantitative cross-sectional survey. N = 590 aged care homes	84.2% separated texture-modified food on plates. Only 27.9% reshaped food	Develop a best practice approach for texture-modified food and improve implementation
Cassens, 1996	Amount of pureed food eaten with 3D food presentation	Mixed methods. Aged care residents (N = 18)	15% increase in food intake, 41% increase in caloric intake, 36% increase in protein intake	Long-term impacts of 3D food presentation
Cichero, 2015	Needs of hospitalized patients with dysphagia	Edited book section	Food should be of correct texture, nutrient-dense, flavoursome and appealing	N/A
Cichero, 2017	Impacts of taste and texture on swallowing	Review	Modify textures to meet chewing/swallowing ability. Label food using IDDSI	Novel strategies of food appearance and structure promoting variety and nutrition
Dick, 2019	3D food-printing application with meat	Review	3D-printed meat could help people with dysphagia	Better understanding of meat properties for printing
Ettinger, 2014	How older adults like modified food	Quantitative taste testing. People with dysphagia (n = 12), people without dysphagia (n = 45)	Ratings significantly different between groups. People without dysphagia cannot be used instead of people with dysphagia	Cognitive function assessment to control for cognitive impairments

First author, year	Aim to determine	Methods and participants	Relevant findings	Further research
Farrer, 2016	Food intake changes through food moulds	Quantitative intervention study. Aged care residents (N = 65)	Non-statistical difference in food wastage or satisfaction with moulds	Larger cohort studies
Germain, 2006	Nutritional care programme's impact on food intake	Quantitative intervention study. Aged care residents with dysphagia (N = 15)	Participants gained weight, increased intake of energy, protein, fats, phosphorus, potassium, calcium, magnesium, vitamin D, zinc, vitamin B12	Larger participant groups. Evaluate overall health status
Hemsley, 2019	Review 3D food-printing studies and its use in dysphagia management	Review	Sixteen papers included. None examined the feasibility of 3D-printed food for dysphagia	Reactions of people with dysphagia to 3D-printed foods. Barriers/facilitators to use
Higashiguchi, 2013	'iEat®' impact on consumption rate, nutritional intake and satisfaction	Quantitative intervention study. Aged care residents (N = 57)	'iEat®': Significant higher scores on appearance, joy of eating, satisfaction of shaped food	N/A
Hori, 2015	Gel consistency's impact on tongue pressure during swallow	Quantitative tongue pressure test. Adults without dysphagia (N = 15)	Tongue pressure required increased as gel consistency increased. Duration of swallow not impacted	Bolus textures prepared for a natural swallow
Hung, 2011	Understand personhood during mealtimes	Qualitative interviews. Aged care residents with dementia (n = 20), carers (n = 4)	Dining experience related to pacing, providing assistance, environmental stimulation/utilization, respectfulness, validation of feelings and connecting with others	Include more people with dementia in research. Translate theoretical basis into practical applications
Hung, 2015	Care facility dining room renovation influences residents' experiences	Mixed: focus groups, environmental assessment Care facility staff (N = 14)	Renovations improved atmosphere, social interaction, autonomy, independence, lighting. Residents stayed in the dining room longer, 72% gained weight	Environmental changes influence cultural mealtime components

Continued

Table 1: Continued

First author, year	Aim to determine	Methods and participants	Relevant findings	Further research
Ilhamto, 2014	Challenges and practices of pureed food production in care facilities	Qualitative interviews. Nutrition managers (n = 27), cooks (n = 26)	Standardized recipes/ governance documents not consistently followed. Inconsistent terminology between sites	Consistent terminology. Strategies to improve visual appeal of food
Keller, 2014	Perceptions of pureed food: experiences, impacts on quality of life. Strategies to improve texture-modified food	Qualitative interviews. People with dysphagia (N = 15)	Food had poor sensory appeal, lacked variety and inconsistent quality. None enjoyed the food but appreciated oral meals and knew food was necessary	N/A
Lepore, 2014	Plating impacts the identification and acceptability of puree	Quantitative food rating. Young adults (n = 97), older adults (n = 70)	Younger adults identified more pureed food. Scooped purees were more accepted. Older people preferred the taste of scooped food	Pureed food acceptability. Impact of shaping food on food intake
Liu, 2017	Creation of accurate 3D food prints	Review	Printing challenges: accuracy, productivity, creating colourful/ flavourful food	Precision, speed and productivity, nutritional benefits of 3D food printing
Liu, 2018	Develop a 3D food printer for fibrous meat	Quantitative experimental testing	Printer developed: addressed storage and food variety concerns	N/A
Milte, 2017	Mealtime experiences of people with cognitive impairment and carers	Qualitative interviews. People with cognitive impairment and carers (N = 19)	Barriers faced in receiving appealing and nutritional meals. Participants lost control/choice with dysphagia	Improving mealtime quality of life within budgetary boundaries
Okkels, 2018	Most liked modified snacks based on flavour and sensory properties	Quantitative ratings. Adults with dysphagia (N = 30)	Cold and sweet foods were most liked. Flavour and appearance were equally important	Larger participant group, longer trial period
Ott, 2019	Impact of Biozoon® texture-modified, nutritionally enriched and reshaped food	Quantitative intervention study. Aged care residents (N = 16)	Significant increase in energy/protein intake and in body weight. Some participants did not like the food	Larger participant groups to confirm effects

First author, year	Aim to determine	Methods and participants	Relevant findings	Further research
Piwnica-Worms, 2010	Flavour processing in semantic dementia using a novel flavour assessment	Quantitative flavour test. People with semantic dementia (n = 3), logopenic primary progressive aphasia (n = 1)	Participants had significant difficulty determining the congruence of flavour combinations and identifying flavour correlating with odour identification	Chemosensory dysfunction correlates with neurodegenerative conditions
Pouyet, 2014	Finger food attractiveness to people with Alzheimer's disease	Quantitative paired comparison testing. People with Alzheimer's disease (N = 114)	Finger foods with sauce chosen more. Food shape did not significantly impact food chosen first or amount eaten. Food with two layers chosen more frequently	Food attractiveness, impact of cognitive and sensory abilities
Reilly, 2013	Molecular gastronomy to improve the texture of dysphagia-safe food	Quantitative sensory testing. University students (N = 60)	Spherification, gelification, emulsification, food moulds and piping bags improved food appeal	Benefits of techniques versus oral supplements
Roberts, 2011	Large versus small dinner settings: impact of care homes on mealtime interactions	Qualitative case study. Observations and interviews. Care staff (N = 2)	Six-person lunch allowed for shared dining experiences, minimal noise/ distraction, choice and resident-led conversation	Therapeutic dining environments for people with dementia
Ruigrok, 2006	Improving mealtimes and dignity in assisted feeding	Quantitative case study. Aged care residents (N = 23)	Residents valued socializing with staff. Background music relaxed them. Mealtime assistance more dignified when staff sat at their level and asked for permission	Examine unappealing minced meals, positioning, dental care plans, social grouping influence
Stahlman, 2000	Views of moulded pureed fruits and their influence of visual appeal	Quantitative taste test. Adults with dysphagia (n = 2), adults without dysphagia (n =12)	Food moulds did not positively influence taste, liking, texture, appearance, ease of chewing or swallowing	Better understanding of food mould impacts

Continued

Table 1: Continued

First author, year	Aim to determine	Methods and participants	Relevant findings	Further research
Stahlman, 2001	Perceptions of pureed food and ease of chewing/swallowing for people with/without dysphagia using thickeners and moulds	Quantitative taste test. Adults with dysphagia (n = 15), adults without dysphagia (n = 15)	Participants with dysphagia found moulded food significantly more difficult to chew and swallow. Moulded food was not seen favourably	Food moulds with a larger participant group
Sungsinchai, 2019	Use texture modification technologies for different foods	Review	Technologies used: high pressure processing, high hydrodynamic pressure, ultrasound, gamma irradiation and pulsed electric field	Non-traditional texture modification methods and their combined use
Tan, 2018a	Review 3D printing studies, food modification and use of hydrocolloids for printability	Review	Hydrocolloids improved puree printability and fidelity. No single solution for all foods. Each food is different	How hydrocolloids are chosen, optimal hydrocolloid amounts, minimum hydrocolloid content
Tan, 2018b	Food ink formation using texture modifiers	Review	Hydrocolloids improve food printability. Future 3D food printers should be efficient, able to cook, continuously print, easy to maintain	Types of hydrocolloids, optimal hydrocolloid ratios, minimum hydrocolloid amount needed
Ullrich, 2014	Mealtime experiences of older people with dysphagia	Qualitative interviews, observations. Aged care residents and staff (N = 35)	Participants with dysphagia separated from others. Non-moulded food viewed negatively. Interactions increased with moulded food	Provide nutritious, socially appropriate, tasty food
de Villiers, 2019	Impacts of production methods on bolus properties	Quantitative experimental testing	Heating food increased viscosity, no longer smooth. Aeration created safe room temperature boluses	Impacts of body temperature and saliva on food consistency

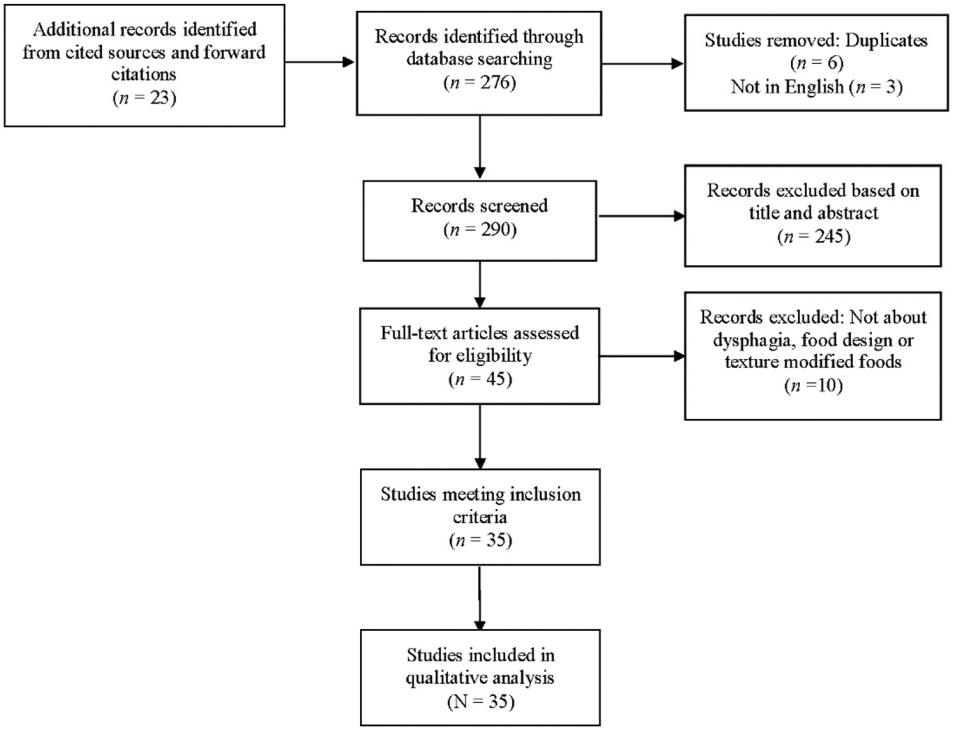

Figure 2: Study inclusion process.

Designing sensory appeal: Taste and aroma

When eating, flavour is determined not only through taste but also through food aromas and the chewing process where aerosols are produced and registered in the frontal cortex of the brain (Cichero 2015). This process may drive mealtime pleasure (Aguilera and Park 2017). Texture-modified foods require less chewing, meaning that fewer aerosols are produced, thereby reducing the sensory experience. Keller and Duizer (2014) reported that reduced aroma and taste led to reduced interest in food, which could be problematic if the food was already diluted with liquid to meet the texture requirements. In a study of aged care residents, one resident with dysphagia descried the food as 'horrible […] tastes just like chalk', and participants added their own condiments to food to increase their interest (Ullrich et al. 2014: 233). Cichero (2017) also reported that using natural flavours, including garlic, black pepper, thyme and ginger, may increase food intake in elderly people by up to 25 per cent. Thus, manipulating food flavours may increase mealtime enjoyment for people with dysphagia, and these strategies should also be promoted within the community (Cichero 2017).

The impact of dementia on flavour perception was discussed by Piwnica-Worms et al. (2010). In their study, three adults with dementia and six age-matched people without dementia tasted individual jellybeans of one flavour and jellybeans of mixed flavours. Participants with dementia showed a significantly reduced ability to identify flavour combination compatibility and a reduced ability to name single flavours when compared to participants

without dementia (Piwnica-Worms et al. 2010). Many people with dementia have dysphagia, impaired flavour-processing skills and limited contextual food knowledge; hence texture-modified foods require other markers for food identification (e.g. matching the food's appearance and smell) (Piwnica-Worms et al. 2010).

Flavour preferences may assist in meeting a person's nutritional needs in dysphagia management (Okkels et al. 2018). In a pilot study, Okkels et al. (2018) reported that 55 older adults tasted different texture-modified snack foods and then completed a survey on their preferences. Cold, sweet foods were the most 'well liked' (e.g. vanilla ice cream), while the 'least liked' were pumpkin, carrot and clear soups. There was also a strong correlation between fat content, energy intake and how much the flavour was liked (Okkels et al. 2018). The authors concluded that snack food flavours are important for people with dysphagia and that high-energy sweet snack foods may increase nutritional consumption and mealtime engagement (Okkels et al. 2018).

Designing nutritious food

According to the model of food choice used in this review (see Figure 1), the nutritional value of food can also be modified to maintain health in dysphagia management. Many people with dysphagia fatigue during mealtimes and may require nutritionally dense meals to reduce the risk of malnutrition or dehydration. This can be achieved by adding food enrichers, including protein powder or butter (Cichero 2015). Similarly, microgels or soft gels can be added to carry proteins, fats and fibre in texture-modified food (Aguilera and Park 2017). This shows how the nutrients of texture-modified foods can be increased for the person to receive adequate energy (Aguilera and Park 2017).

Gels were used by Ott et al. (2019) to modify the protein content and shape of texture-modified food. Participants with dysphagia received food that was shaped using food moulds and Biozoon® Smoothfood texturizers (Biozoon 2020) and enriched with protein powder or rapeseed oil for six weeks to determine if it improved their nutritional status (Ott et al. 2019). Participants' energy and protein intake significantly increased during the six-week trial compared to a six-week period of receiving regular texture-modified food (Ott et al. 2019). In regard to enjoyment, five participants enjoyed the trial diet, while one did not like the taste (Ott et al. 2019). As the study examined shape and nutrition modification concurrently, the authors could not determine which factor had a greater impact on mealtime engagement (Ott et al. 2019). They reported that an increased protein intake may have only occurred due to the enriched protein content of the food, not as a result of increased mealtime enjoyment.

Food formulation

Designing the visual appearance of texture-modified food

The visual appeal of texture-modified food and the ability to discern a food based on its appearance are important for the acceptance of food and mealtime enjoyment (Cichero 2015). Keller and Duizer (2014) examined how people on texture-modified diets experienced food presentation in aged care settings. Residents on a pureed diet considered their food plain, and adding sauce and/or coloured spices improved the food's appearance. In interviews with residents who had a cognitive impairment, Milte et al. reported that one

participant described the presentation of pureed food as 'pulverized slop […] it was so disgusting' (2017: 55). Furthermore, in a cross-sectional survey of German aged care homes, 84.2 per cent of aged care facilities served pureed food items separately on the plate, but only 27.9 per cent reshaped the food (Burger et al. 2019). Most facilities in the study did not modify the food's structural shape to increase its visual appeal; they simply modified its texture to the correct texture and ensured foods were served separately on the plate. This may have been due to a lack of resources or knowledge, but it likely impacted the mealtime engagement of residents (Burger et al. 2019).

Poor plating of food, or lack of attention to its structure and shape, can also make it difficult for aged care staff providing mealtime assistance to accurately identify texture-modified food, which reduces opportunities for interaction between the person with dysphagia and the staff (Ullrich et al. 2014). Pouyet et al. (2014) examined how the appearance of texture-modified finger food impacted the enjoyment of meals of 114 people with Alzheimer's disease. In the study, foods that were layered and had sauce were more visually appealing than foods presented in one layer or without sauce (Pouyet et al. 2014). Milte et al. (2017) discussed the loss of mealtime choices linked to poor food presentation, noting that adults with cognitive impairment reported little variety in options presented (i.e. all items looked the same) as few people required texture-modified foods at their home. This reduced their mealtime pleasure and their overall opinions of texture-modified foods (Milte et al. 2017).

Cassens et al. (1996) explored the 3D presentation of texture-modified foods with thickeners (i.e. to retain the shape created). In a mixed-methods study with eighteen residents in aged care with swallowing difficulties, 3D food presentation strategies resulted in a 15 per cent increase in food intake, a 41 per cent increase in calorie intake and a 36 per cent increase in protein intake (Cassens et al. 1996). However, results may not have been due to the presentation alone; during the trial, participants also received more attention from the staff who potentially encouraged them to eat more food.

In a study comparing the opinions of twelve people with dysphagia and 45 people without dysphagia, Ettinger et al. (2014) explored the acceptability of pureed turkey and pureed carrot samples, which were rated on visual appearance and flavour. There was no significant difference between the ratings of appearance or flavour for the carrot and turkey samples for the twelve participants with dysphagia. In contrast, there was a significant difference in the ratings from participants without dysphagia for the appearance and flavour of pureed carrot and for the flavour of pureed turkey samples (Ettinger et al. 2014). Participants with dysphagia gave samples a higher rating, indicating they liked the food more than people without dysphagia did. The positive correlation of food appearance and flavour ratings in this larger participant group demonstrates the potential benefits of presenting pureed food in appealing ways to improve flavour perceptions (Ettinger et al. 2014). However, the differences in results between participant groups show that the opinion of people without dysphagia cannot be used in place of the opinion of people with dysphagia, who should be consulted about their preferences (Ettinger et al. 2014).

Several technologies and food preparation techniques that consider the structure and visual appeal of food are featured in literature and are described below.

Food moulds. Food moulds are generally silicon moulds into which puree food is placed to create a desired shape. Despite their commercial availability

(see Flavour Creations 2020 for an example), there is limited research evaluating the effectiveness of food moulds for mealtime enjoyment. Stahlman et al. (2000) examined the perceptions of people (N = 14) towards moulded puree compared to puree scooped into a bowl. On a rating scale from 'extreme dislike' to 'extreme like', moulded peach puree was liked significantly less than scooped puree by participants without dysphagia. Participants with dysphagia also found moulded puree more difficult to swallow (Stahlman et al. 2000). A second study by Stahlman et al. (2001) compared the acceptability of moulded food for participants with and without dysphagia (N = 30). Both groups rated the moulded puree significantly lower on satisfaction than the scooped puree (Stahlman et al. 2001), suggesting that food moulds did not positively influence the perceptions of pureed food.

Other studies have reported mixed results on the effectiveness of food moulds. In a sample of 65 participants, Farrer et al. (2016) found no significant differences in food waste or satisfaction between participants who received moulded food and those who did not. In a larger study of 167 young and old adults without dysphagia, Lepore et al. (2014) found that food moulds helped younger people identify food; however, participants preferred scooped food. In contrast, Higashiguchi (2013) found that moulded meals led to a greater satisfaction with food appearance and the joy of eating. Similarly, Germain et al. (2006) found that participants who received moulded food gained weight and experienced an increased energy and nutrient intake. Ullrich et al. (2014) also reported that moulded food assisted the staff in describing the food to residents. These mixed results demonstrate the need for further studies verifying the benefits of food moulds.

3D-printed foods. 3D food printing is an additive manufacturing process where food is printed in layers to create shapes (Hemsley et al. 2019). The PERFORMANCE Project aimed to develop visually appealing meals using 3D printing for elderly people with dysphagia (Liu et al. 2017; RTDS Group 2015). A literature review by Liu et al. (2017) described the results of a survey conducted with aged care residents who tried 3D-printed food (Lunardo cited it Liu et al. 2017). Results indicated that 79 per cent found the food comparable to scooped food; 43 per cent preferred 3D-printed food over scooped food; and 54 per cent believed the texture was good (Lunardo cited in Liu et al. 2017). However, no results from this project have been published as original data in a peer-reviewed journal (Hemsley et al. 2019); so research is needed to determine the acceptability of 3D-printed foods in people with dysphagia.

There are five literature reviews examining 3D food printing and its impact on mealtime experience for people with dysphagia. The reviews concluded that 3D food printing could benefit people with dysphagia as food could be printed separately on the plate without mixing, and hydrocolloids (e.g. gelatine) could be added to pureed food to assist with the food's printability and visual appeal (Liu et al. 2018; Tan et al. 2018b). However, each food product would require individualized preparation methods, and further research should examine the correct types and amounts of hydrocolloids for successful 3D food printing (Tan et al. 2018a).

The use of meat in 3D food printing and its potential impact on the mealtime engagement of people with dysphagia was reviewed by Dick et al. (2019). Little evidence was found on the printing of pureed fibrous meats and no evidence relating to beef meat, although it could provide an alternative to scooped meat in aged care homes (Dick et al. 2019). Dick et al. (2019)

highlighted that difficulties may arise with printing meat at a safe temperature and recommended further research. Hemsley et al. (2019) further reviewed sixteen papers on the use of 3D food printing and concluded that 3D food printing could provide visually appealing meals for people with dysphagia, but there was little original research to support this claim or the claim that there might be nutritional benefits of 3D-printed food (Hemsley et al. 2019). At the time there were no studies on the usability or feasibility of 3D-printed food for people with swallowing disability; however, the authors recommended that 3D-printed food should be at least the same quality as traditionally prepared food (Hemsley et al. 2019).

Mixed presentation methods. Molecular gastronomy is the study of physical transformations that occur to food while being prepared (Reilly et al. 2013). Some techniques, including piping bag use, spherification, gelification and emulsification, have been tested to improve the visual appeal of texture-modified food. In Reilly et al. (2013), 60 people without swallowing difficulties reported that molecular gastronomy techniques could improve the sensory appeal of pureed food. Participants rated the taste, visual appeal and texture of pureed foods on a five-point Likert scale, where 1 was 'did not like at all', 3 was 'neutral' and 5 was 'much liked'. All five food products ranked between 3 and 5 on the scale (Reilly et al. 2013). Authors suggested that although food created using these techniques may be costly, extra food would be eaten, thus reducing the need for supplements (Reilly et al. 2013). As the research did not include participants with dysphagia and as the sensory elements of food were not examined separately, the effectiveness of these techniques for people with swallowing disability or which component had the greatest impact are unknown.

Designing the food temperature

Serving food at an appropriate temperature can affect the convenience (regarding food safety) and pleasure of mealtimes for people with dysphagia (see Figure 1). The importance of maintaining optimum temperatures for cold and hot foods (under 5 or over 60°C, respectively) is widely recognized (Cichero 2015). If the food is too hot, a person who struggles to transport food within their mouth may suffer thermal burns as the transport time is extended. In comparison, if the food is too cold, food may be less appealing, thus impacting mealtime engagement (Cichero 2015). In a quantitative experimental study, de Villiers et al. (2019) examined the importance of serving texture-modified food at the correct temperature for the food's safety. Specialized nutritious foods were made into IDDSI Level 4 Pureed food when mixed with either room-temperature or heated milk or water. The heated samples became lumpy upon cooling and no longer met the IDDSI requirements (de Villiers et al. 2019). The impact of temperature on the safety of texture-modified food is particularly relevant for residential care facilities and hospitals where food may cool before it is served (de Villiers et al. 2019).

Mealtime service

Designing the mealtime environment

Mealtime locations can be modified to improve engagement and pleasure for people with swallowing disability (Aguilera and Park 2017). Hung et al. (2015)

examined the impact of dining room renovations on mealtime experiences for people with dementia in aged care facilities. By building a small kitchen near the dining room, residents could enjoy the autonomy and choice of having a kitchen nearby. Participants could relax, and they stayed longer and interacted more in the dining area. Consequently, 72 per cent of residents gained weight (Hung et al. 2015). In another study of aged care residents with dementia, a small dining room for six people was more beneficial than a large dining room for 60 people. The smaller group enabled residents to share the dining experience with reduced noise, more choice and resident-led conversation (Roberts 2011). This highlights the importance of the environment on mealtime engagement for people with dementia, who often require texture-modified food (Hung et al. 2015; Roberts 2011).

Designing mealtime assistance

The provision of mealtime assistance may influence a meal's convenience (Aguilera and Park 2017). Hung and Chaudhury (2011) outlined the practices that should be upheld by the staff in aged care assisting at mealtimes, including appropriate pacing of the assistance, respect for the person, validation of beliefs, empowerment and inclusion within mealtime activities. When used, these practices had a greater impact on mealtime experiences than on mealtime environment (Hung and Chaudhury 2011). Similarly, Ruigrok (2006) highlighted how mealtime assistance could be dignified as it allowed the person to eat regular food, which they could not eat without support or supervision.

DISCUSSION

The results of this review demonstrate how the various components of texture-modified food can be designed during several stages of food preparation (food texture, flavour or nutritional value), formulation (visual appeal or temperature of food) or food service (mealtime environment or assistance) to help improve mealtime experiences and engagement of people with dysphagia. Each of these components relates to one or more elements of the Drivers of Food Choice model described by Aguilera and Park (2017) (see Figure 1).

Methodological limitations

The quality of studies included in this review was highly variable. The use of a second rater to determine the inclusion or exclusion of studies was implemented to reduce selection bias. However, within the studies, some sampling bias towards populations with acquired health conditions (e.g. stroke or dementia) was evident. These populations were much more likely to be included in research relating to dysphagia and mealtime experiences. And yet, the voices of people with dysphagia are still only faintly heard in the literature. Only half of the studies in this review included any participants with dysphagia (n = 17), and only one of these included participants with dysphagia associated with lifelong disability (e.g. cerebral palsy, intellectual disability) (Balandin et al. 2009). People with dysphagia, and particularly those with lifelong dysphagia, should be included in research on food structure and appeal, as they face ongoing difficulties in accepting texture-modified food, and their needs and perceptions may also change across the lifespan.

There was also some sampling bias within the studies towards populations living in aged care facilities as opposed to community or group home

environments. People with dysphagia living independently in the community or in group homes should also be included in research examining the structure and visual appeal of food, as they may be much more likely to engage in food preparation at home. For example, there is a greater chance that they are involved in menu planning, shopping, selecting, preparing and cooking food. These experiences and their engagement may further influence their views on texture-modified foods and acceptability in terms of the food's structure, shape and visual appeal. Furthermore, people with dysphagia who live in the community may also be more likely to be involved in the preparation, production and consumption of meals to share with others (e.g. family or friends), further influencing their food choices. Overall, further research is needed on food structure and appearance in dysphagia management across a broader range of populations and settings.

Impact of findings

In this review, various studies report on the manipulation of the food's visual appeal through the use of food moulds, 3D food printing, piping bags, spherification, gelification and emulsification (Liu et al. 2018; Reilly et al. 2013; Ullrich et al. 2014). The number of strategies identified in the included studies highlights the importance of improving the visual appeal of food for people with dysphagia. However, there are gaps in the research; for example, 3D food printing is promoted as a solution for pureed food presentation, but there is no evidence yet to support this claim (Hemsley et al. 2019; Sungsinchai et al. 2019). Further research should demonstrate how novel technologies, including 3D food printing, can be paired with nutritional fortification strategies to create nutrient-rich meals. This research may also benefit people with other eating problems or disorders where high-nutrient and easy-to-swallow meals are required. For example, 3D food printing could be used in creating highly nutritious, pureed or soft foods for people recovering from a gastric bypass surgery. The benefits of food-printing technologies should also be examined for people with the avoidant-restrictive food intake disorder or for children presenting with food selectivity (e.g. children with autism spectrum disorder) to increase their interest in food and activities surrounding its preparation and consumption (Marí-Bauset et al. 2014).

This review highlights the importance of food temperature and texture on maintaining mealtime pleasure and the safety of people with dysphagia (Milte et al. 2017; Ilhamto et al. 2014). Maintaining appropriate food temperature and texture is essential for the convenience and safety of texture-modified foods and cannot be altered without a potential compromise to meal's safety. Technologies used to modify the food's visual appeal (e.g. 3D food printing) need to be accessible for people with dysphagia who also have cognitive or communication impairments, which may reduce their ability to engage in mealtime activities. Consequently, people with these disabilities should be included in future research examining food temperature and texture (Hung et al. 2015; Roberts 2011).

Finally, this review highlights the importance of the location of meals and the type of mealtime assistance provided to enhance mealtime enjoyment (Hung et al. 2015; Roberts 2011). As environmental changes influence the dignity and inclusion of people with dysphagia, it is likely that manipulating the food's structure and appearance is not sufficient to improve mealtime-related quality of life if the wider mealtime environment is not conducive to an enjoyable meal.

CONCLUSION

This review demonstrates the increased research interest in how the structure and appeal of texture-modified food can impact mealtime experiences and engagement of people with dysphagia. The review also highlights the benefits of concurrently changing multiple elements of the meal. For example, Okkels et al. (2018) modified both the taste and the temperature of texture-modified foods to improve mealtime experience. The lack of attention to the experiences of people with dysphagia, particularly those with lifelong dysphagia, indicates an urgent need to discover more about their views on these common interventions. Technological advances in texture-modified food production should continue to drive improvements in the visual appeal, flavour, texture and nutrition of texture-modified foods, and continued research is required to determine the effectiveness of these technologies. People with dysphagia should be included in future studies examining the appearance and appeal of food, as the opinions of people without dysphagia do not generalize to those with dysphagia (Ettinger et al. 2014). As mealtimes are an essential component of social and cultural events (Balandin et al. 2009), further advances in modifying the food structure and appearance for people with dysphagia are essential for continued dignified community engagement. Future research should also examine the social and emotional influences on mealtime experience for people with dysphagia.

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REFERENCES

Aguilera, J. and Park, D. (2017), 'Bottom-up approaches in the design of soft foods for the elderly', in M. Axelos and M. Van De Voorse (eds), *Nanotechnology in Agriculture and Food Science*, Weinheim: John Wiley & Sons, pp. 153–66.

Balandin, S., Hemsley, B., Hanley, L. and Sheppard, J. (2009), 'Understanding mealtime changes for adults with cerebral palsy and the implications for support services', *Journal of Intellectual and Developmental Disability*, 34:3, pp. 197–206.

Biozoon (2020), 'Texturizers', https://biozoon.de/de/. Accessed 12 January 2021.

Burger, C., Kiesswetter, E., Alber, R., Pfannes, U., Arens-Azevedo, U. and Volkert, D. (2019), 'Texture modified diet in German nursing homes: Availability, best practices and association with nursing home characteristics', *BMC Geriatrics*, 19:1, pp. 284–95.

Cassens, D., Johnson, E. and Keelan, S. (1996), 'Enhancing taste, texture, appearance and presentation of pureed food improved resident quality of life and weight status', *Nutrition Reviews*, 54:1, pp. S51–54.

Cichero, J. (2015), 'Texture-modified meals for hospital patients', in J. Chen and A. Rosenthal (eds), *Modifying Food Texture, Volume 2: Sensory Analysis, Consumer Requirements and Preferences*, Cambridge: Elsevier, pp. 135–62.

Cichero, J. (2017), 'Unlocking opportunities in food design for infants, children and the elderly: Understanding milestones in chewing and swallowing

across the lifespan for new innovations', *Journal of Texture Studies*, 48:2, pp. 271–79.

Cichero, J., Lam, P., Steele, C., Hanson, B., Chen, J., Dantas, R., Duivestein, J., Kayashita, J., Lecko, C., Murray, J., Pillay, M., Riquelme, L. and Stanschus, S. (2017), 'Development of international terminology and definitions for texture-modified foods and thickened fluids used in dysphagia management: The IDDSI framework', *Dysphagia*, 32:2, pp. 293–314.

Colodny, N. (2005), 'Dysphagic independent feeders' justifications for noncompliance with recommendations by a speech-language pathologist', *American Journal of Speech-Language Pathology*, 14:1, pp. 61–70.

Dick, A., Bhandari, B. and Prakash, S. (2019), '3D printing of meat', *Meat Science*, 153, pp. 35–44.

Ettinger, L., Keller, H. and Duizer, L. (2014), 'A comparison of liking of pureed food between two groups of older adults', *Journal of Nutrition in Gerontology and Geriatrics*, 33:3, pp. 198–209.

Farrer, O., Olsen, C., Mousley, K. and Teo, E. (2016), 'Does presentation of smooth pureed meals improve patients consumption in an acute care setting: A pilot study', *Nutrition & Dietetics*, 73:5, pp. 405–09.

Flavour Creations (2020), 'Shape it moulds', https://www.flavourcreations.com.au/. Accessed 12 January 2021.

Germain, I., Dufresne, T. and Gray-Donald, K. (2006), 'A novel dysphagia diet improves the nutrient intake of institutionalized elders', *Journal of the American Dietetic Association*, 106:10, pp. 1614–23.

Gustafsson, B. (1995), 'The experiential meaning of eating, handicap, adaptedness and confirmation in living with esophageal dysphagia', *Dysphagia*, 10:2, pp. 68–85.

Hall, G. and Wendin, K. (2008), 'Sensory design of foods for the elderly', *Annals of Nutrition and Metabolism*, 52:1, pp. 25–28.

Hemsley, B., Palmer, S., Kouzani, A., Adams, S. and Balandin, S. (2019), 'Review informing the design of 3D food printing for people with swallowing disorders: Constructive, conceptual and empirical problems', *Proceedings of the 52nd Annual Hawaii International Conference on System Sciences (HICSS 52)*, University of Hawai'i at Manoa, Honolulu, HI, 8 January, Atlanta, GA: AIS eLibrary, pp. 5735–44.

Higashiguchi, T. (2013), 'Novel diet for patients with impaired mastication evaluated by consumption rate, nutrition intake and questionnaire', *Nutrition*, 29:6, pp. 858–64.

Hori, K., Hayashi, H., Yokoyama, S., Ono, T., Ishihara, S., Magara, J., Taniguchi, H., Funami, T., Maeda, Y. and Inoue, M. (2015), 'Comparison of mechanical analyses and tongue pressure analyses during squeezing and swallowing of gels', *Food Hydrocolloids*, 44, pp. 145–55.

Hung, L. and Chaudhury, H. (2011), 'Exploring personhood in dining experiences of residents with dementia in long-term care facilities', *Journal of Aging Studies*, 25:1, pp. 1–12.

Hung, L., Chaudhury, H. and Rust, T. (2015), 'The effect of dining room physical environmental renovations on person-centered care practice and residents' dining experiences in long-term care facilities', *Journal of Applied Gerontology*, 35:12, pp. 1279–301.

Ilhamto, N., Anciado, K., Keller, H. and Duizer, L. (2014), 'In-house pureed food production in long-term care: Perspectives of dietary staff and implications for improvement', *Journal of Nutrition in Gerontology and Geriatrics*, 33:3, pp. 210–28.

Keller, H., Chambers, L., Niezgoda, H. and Duizer, L. (2012), 'Issues associated with the use of modified texture foods', *Journal of Nutrition, Health & Aging*, 16:3, pp. 195–200.

Keller, H. and Duizer, L. (2014), 'What do consumers think of pureed food? Making the most of the indistinguishable food', *Journal of Nutrition in Gerontology and Geriatrics*, 33:3, pp. 139–59.

Kumar, S. (2010), 'Swallowing and dysphagia in neurological disorders', *Reviews in Neurological Diseases*, 7:1, pp. 19–27.

Lepore, J., Sims, C., Gal, N. and Dahl, W. (2014), 'Acceptability and identification of scooped versus molded pureed foods', *Canadian Journal of Dietetic Practice and Research*, 75:3, pp. 145–47.

Liu, C., Ho, C. and Wang, J. (2018), 'The development of 3D food printer for printing fibrous meat materials', *Second International Conference on Innovative Engineering Materials*, Philadelphia, PA, 21–23 October 2017, Bristol: IOP Publishing Ltd, pp. 1–9.

Liu, Z., Zhang, M., Bhandari, B. and Wang, Y. (2017), '3D printing: Printing precision and application in food sector', *Trends in Food Science & Technology*, 69:part A, pp. 83–94.

Marí-Bauset, S., Zazpe, I., Mari-Sanchis, A., Llopis-González, A. and Morales-Suárez-Varela, M. (2014), 'Food selectivity in autism spectrum disorders: A systematic review', *Journal of Child Neurology*, 29:11, pp. 1554–61.

McHugh, M. (2012), 'Interrater reliability: The kappa statistic', *Biochemia Medica*, 22:3, pp. 276–82.

Milte, R., Shulver, W., Killington, M., Bradley, C., Miller, M. and Crotty, M. (2017), 'Struggling to maintain individuality: Describing the experience of food in nursing homes for people with dementia', *Archives of Gerontology and Geriatrics*, 72, pp. 52–58.

Ochs, E. and Shohet, M. (2006), 'The cultural structuring of mealtime socialization', *New Directions for Child and Adolescent Development*, 2006:111, pp. 35–49.

Okkels, S., Saxosen, M., Bügel, S., Olsen, A., Klausen, T. and Beck, A. (2018), 'Acceptance of texture-modified in-between-meals among old adults with dysphagia', *Clinical Nutrition ESPEN*, 25, pp. 126–32.

Ott, A., Senger, M., Lötzbeyer, T., Gefeller, O., Sieber, C. and Volkert, D. (2019), 'Effects of a texture-modified, enriched and reshaped diet on dietary intake and body weight of nursing home residents with chewing and/or swallowing problems: An enable study', *Journal of Nutrition in Gerontology and Geriatrics*, 38:4, pp. 361–76.

Piwnica-Worms, K., Omar, R., Hailstone, J. and Warren, J. (2010), 'Flavour processing in semantic dementia', *Cortex*, 46:6, pp. 761–68.

Pouyet, V., Giboreau, A., Benattar, L. and Cuvelier, G. (2014), 'Attractiveness and consumption of finger foods in elderly Alzheimer's disease patients', *Food Quality and Preference*, 34, pp. 62–69.

Reilly, R., Frankel, F. and Edelstein, S. (2013), 'Molecular gastronomy: Transforming diets for dysphagia', *Journal of Nutritional Health & Food Science*, 1:1, pp. 1–6.

Reimer, H. and Keller, H. (2009), 'Mealtimes in nursing homes: Striving for person-centered care', *Journal of Nutrition for the Elderly*, 28:4, pp. 327–47.

Reissig, P. (2017), 'Food design education', *International Journal of Food Design*, 2:1, pp. 3–13.

Ricci Maccarini, A., Filippini, A., Padovani, D., Limarzi, M., Loffredo, M. and Casolino, D. (2007), 'Clinical non-instrumental evaluation of dysphagia', *Acta Otorhinolaryngologica Italica*, 27:6, pp. 299–305.

Robbins, J., Nicosia, M., Hind, J., Gill, G., Blanco, R. and Logemann, J. (2002), 'Defining physical properties of fluids for dysphagia evaluation and treatment', *Perspectives on Swallowing and Swallowing Disorders (Dysphagia)*, 11:2, pp. 16–19.

Roberts, E. (2011), 'Six for lunch: A dining option for residents with dementia in a special care unit', *Journal of Housing for the Elderly*, 25:4, pp. 352–79.

RTDS Group (2015), https://www.rtds-group.com/. Accessed 13 January 2021.

Ruigrok, J. (2006), 'Life enrichment programme: Enhanced dining experience, a pilot project', *International Journal of Health Care Quality Assurance*, 19:5, pp. 420–29.

Ryan, R. and Cochrane Consumers and Communication Review Group (2013), 'Data synthesis and analysis', Cochrane Consumers and Communication, 20 June, https://cccrg.cochrane.org/. Accessed 13 January 2021.

Smith, R., Bryant, L. and Hemsley, B. (2022), 'Dysphagia and quality of life, participation, and inclusion experiences and outcomes for adults and children with dysphagia: A scoping review', *Perspectives of the ASHA Special Interest Groups*, 7:1, pp. 181–96.

Spence, C., Levitan, C., Shankar, M. and Zampini, M. (2010), 'Does food color influence taste and flavor perception in humans?', *Chemosensory Perception*, 3:1, pp. 68–84.

Stahlman, L., Garcia, J., Chambers, E., Smit, A., Hoag, L. and Chambers, D. (2001), 'Perceptual ratings for pureed and molded peaches for individuals with and without impaired swallowing', *Dysphagia*, 16:4, pp. 254–62.

Stahlman, L., Garcia, J., Hakel, M. and Chambers, E. (2000), 'Comparison ratings of pureed versus molded fruits: Preliminary results', *Dysphagia*, 15:1, pp. 2–5.

Sungsinchai, S., Niamnuy, C., Wattanapan, P., Charoenchaitrakool, M. and Devahastin, S. (2019), 'Texture modification technologies and their opportunities for the production of dysphagia foods: A review', *Comprehensive Reviews in Food Science and Food Safety*, 18:6, pp. 1898–912.

Tan, C., Chua, C., Li, L. and Wong, G. (2018a), 'Enhancing 3D printability of pureed food by addition of hydrocolloids', in C. Chua, W. Yeong, M. Tan, E. Liu and S. Tor (eds), *Proceedings of the Third International Conference on Progress in Additive Manufacturing*, Singapore, 14–17 May, Singapore: Nanyang Technological University, pp. 662–66.

Tan, C., Toh, W., Wong, G. and Li, L. (2018b), 'Extrusion-based 3D food printing: Materials and machines', *International Journal of Bioprinting*, 4:2, pp. 1–13.

Ullrich, S., Buckley, J., Crichton, J. and Esterman, A. (2014), 'An exploratory study of the mealtime experience of older people with dysphagia', *Journal of Aging Research and Clinical Practice*, 3:4, pp. 229–36.

de Villiers, M., Hanson, B., Moodley, L. and Pillay, M. (2019), 'The impact of modification techniques on the rheological properties of dysphagia foods and liquids', *Journal of Texture Studies*, 51:1, pp. 154–68.

Zampollo, F. (2016), 'Welcome to food design', *International Journal of Food Design*, 1:1, pp. 3–9.

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