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*Original Article*

# Development of rice porridge for elderly with dysphagia

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**Abstract**

To gather opinions on types and nutrition characteristics of products for Thai elderly with dysphagia, focus group interviews were conducted with a total of 40 participants involving doctors, nurses, nutritionists, physical therapists, and caregivers. The most interesting food was rice porridge (66.7%), followed by steamed egg (40.0%), and pumpkin soup (20.0%). The products should be ready to consume, with modified texture and fortified with protein, minerals, and vitamins. Therefore, a rice porridge was developed in 2 stages. Firstly, ratio of Jasmine rice (JR) and Riceberry rice (RB) was studied (100:0, 75:25, 50:50, 25:75 and 0:100). All the porridges demonstrated shear thinning flow. The sample with only RB (0:100) obtained the highest appearance, color, viscosity and taste liking scores ($p<0.05$) as judged by the elderlies (n=50). Secondly, the RB porridge was formulated with four chicken soups containing different ingredients, including rice bran oil, dried bean sheet, dried mushroom, and soymilk. The apparent viscosity of all porridges ranged within 725-1,188 cP, which complies with the International Dysphagia Diet Standardizations Initiative level 4 and National Dysphagia Diet level 3. The formulation had no effect on sensory acceptability ($p\geq0.05$). Thus, this RB porridge could be a recommended product for elderly with mild-oral dysphagia.

**Keywords**: acceptance test, dysphagia, product concept, rice porridge, rheological properties

## 1. Introduction

The global population of elderly aged 60 years and over has increased rapidly and will be 4 million in 2030, then double to 20% in 2050. Eastern and South-Eastern Asia will account for more than 60% of the global increase in the elderly (World Health Organization [WHO], 2023).

The ageing phenomenon results from changes in the body's physiology. This deterioration leads to a gradual loss in physical and mental capacity, along with mastication and swallowing dysfunction. Dysphagia refers to difficulty in the progression of food or liquid bolus from mouth to stomach. It is an important cause of concern for older individuals (Gupta, 2022). This symptom occurs in up to around 13% of the youngest adults (aged 65 to 70 years), 16% of the middle-aged adults (aged 70 to 79 years), and 33% of the oldest adults (aged 80 years and over) (Wirth *et al.*, 2016). Dysphagia is associated with poor nutritional status. Understanding the demands and functional needs of the elderly with dysphagia is significant to developing products that ensure their specific dietary needs and that comply with characteristics of dysphagia diets, according to the National Dysphagia Diet (NDD) and International Dysphagia Diet Standardizations Initiative (IDDSI) (Ko, Oh, Joo, & Cho, 2022).

Rice porridge is consumed in many Asian countries. Moreover, the characteristics in porridge are suitable for people who have chewing and swallowing problems or have lost their appetite, especially the elderly. The physical and sensory properties of porridge are influenced by a range of factors, including rice variety, cooking technique, and the proportions of functional ingredients. Various rice cultivars have different effects on rice texture because of differences in the ratios of amylose and amylopectin, fiber content, protein content, and aleurone layer thickness (Wu *et al.*, 2016). The unpolished pigmented rice has a harder texture due to the pericarp's barrier effect that reduces water absorption by the rice, and protein content.

Interactions between protein and starch inhibit swelling of starch granules which affects both the viscosity

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and the starch gelatinization rate (Srikaeo, & Sopade, 2010). Rice with high protein is less sticky, has harder texture, is less viscous, and has lower expansion than polished white rice (Kim, Hwang, Song, & Lee, 2017). According to functional properties, the plain white rice porridge has high Glycemic Index (GI) and also a low protein content of about 1%, which cannot fulfill the nutritional requirements of the consumer.

Riceberry rice (*Oryza sativa* L.) is dark purple rice crossbred between Thai Hom Nil (black Jasmine rice) and Jasmine rice (Lamberts *et al.*, 2007). It contains more protein (8.24%) and fiber (2.73%) compared to white rice, leading to a low or medium glycemic index (RS *et al*, 2021). Moreover, it is rich in iron (1.3-1.8 mg/100g), zinc (3.19 mg/100g), omega-3 (25.51 mg/100g), vitamin E (678 µg/100g), and folate (48.1 µg/100g) (RS *et al.*, 2021). The main bioactive compounds in RB are phenolic compounds including 4-vinylguaiacol and apigen, and anthocyanins, especially cyanidin-3-glucoside (C3G) and peonidin-3-glucoside (P3G) (Yamuangmorn, & Prom, 2021), carotenoids (β-carotene and lutein) gramisterol, and γ-oryzanol. Moreover, polyphenol, tannin, and catechin levels in Riceberry were found to be 3~10 times higher than those in normal brown rice. These compounds contribute several health benefits, including antioxidants, anti-inflammatory activities, anti-diabatic capacities, and antiproliferative and anticancer activity (Arjinajarn *et al.*, 2017; Chaiyasut *et al.*, 2016).

However, information on consumption behavior and needs on products, as well as development of porridge for Thai elderly with dysphagia has not been documented.

Thus, the purposes of this study were to investigate consumption habits and product concept, and to develop rice porridge formula with various Jasmine rice to Riceberry rice ratios and chicken soup formulations for the elderly with dysphagia.

## 2. Materials and Methods

### 2.1 Materials

#### 2.1.1 Sources of materials

For rice porridge preparation, Jasmine rice (JR, 100% Thai Hom Mali Rice, a new crop of special sort rice) and Riceberry Rice (RB, Mah Boonkrong Rice Brand, Patum Rice Mill and Granary Public Company Limited, Thailand) were purchased from local super market in Songkhla province, Thailand. The ingredients for chicken soup preparation consisted of chicken bone (CP brand), vegetables (Aro, Siam Makro Plc.), pepper (Nguan Soon Brand. Artchit International Pepper and Spice Co., Ltd.), rice bran oil (King rice bran oil Brand, Thai Edible Oil Co., Ltd.), dried soybean sheet, mushroom (Ek-Chai Distribution System Co., Ltd.), UHT unsweetened soymilk (Lactasoy brand, Lactasoy Co.,th), iodized salt (Prung Thip Brand, Saha Pathanapibul Ltd.) and soy sauce (Golden Mountain green cap, ThaiTheparos PLC.).

#### 2.1.2 Participants for focus group interview and acceptance test

The evaluation received ethics approval from the Health Science Human Research Ethics Committee of Prince of Songkla University, Thailand (HSc-HREC: 63-037-1-1). Due to limited ability of the elderlies with dysphagia to participate in the focus group interview, four types of target participants including doctors and nurses (n=10), nutritionists (n=11), physical therapists (n=10) and caregivers (n=9) who were extensively involved with the elderly with dysphagia were recruited from the hospital and nursing care in Songkhla province, Thailand. For the acceptance test, fifty panelists aged 60 and over were recruited from Hatyai, Songkhla Thailand.

### 2.2 Procedure of focus group

Participants were arranged by occupation related dysphagia into four sessions which took from 60-120 minutes. Each group was provided verbal and written information about the objectives of the research and signed an informed consent form. The trained moderator presented questions and processed the information. The moderator explained and began by the initial discussion and encouraged all participants to share and express his or her own view; however, the moderator would not answer questions. The session was followed in the same format with identical questions as shown in Figure 1.

### 2.3 Study of different ratios of JR to RB of rice porridge

#### 2.3.1 Preparation of rice porridge

Five samples with different ratios of JR to RB (100:0, 75:25, 50:50, 25:75, and 0:100) were prepared as follows. The rice was washed with rice to water ratio of 1:3, soaked for 30 minutes, and drained through a sieve. The soaked rice was then blended with blender (Electrolux, China) and sieved through 10 mesh. The rice was boiled with water (rice: water ratio of 1:6 and 1:10 for JR and RB, respectively) for 45 minutes until no excess was observed. The chicken stock (CP Chicken Broth Concentrate) was added into the boiled mixed rice to a ratio of 1:1, and boiled for 20 minutes. The seasoning was added and brought to a simmer for 5 minutes. Finally, the porridge was packed in polypropylene and cooled down. The porridges were subjected to analyses.

#### 2.3.2 Determination of rheological properties

The apparent viscosity was examined using a rheometer (HAAKE RS75, Germany) with parallel plates and 1 mm gap between the plates. The flow curves were obtained by registering shear stress ($\tau$) at various shear rates ($\dot{\gamma}$) ranging from 0.1-100 $s^{-1}$ in 300 s. The power-law model was used to describe the data of shear-induced behavior of rice porridge ($\tau=K\dot{\gamma}^{n}$), where K is the consistency coefficient ($Pa.s^{n}$) and n is the flow behavior index (Kim, Hwang, Song, & Lee, 2017).

#### 2.3.3 Determination of color properties

Color of the porridges was determined using a colorimeter with CIE-LAB color scale ($L^*$= lightness, $a^*$=redness and greenness and $b^*$=yellowness and blueness value) (C04-1005-631 ColorFlex, HunterLab, Reston, VA, USA). Calibration with light tap and white standard plate

**Introduction**
Q1 Welcome and explanation about the objectives of the study
Q2 Explanation about the way the group discussion works
Q3 Self-introductions (Name, Area of residence, job position)

**Rapport/ Reconnaissance:** Elderly food consumption habit
Q4 Tell us what are the general food consumption habits/practices and concerns of the elderly?
Q5 Problem of eating food/preparation
Q6 Reasons for consumption of specific elderly food
Q7 The food characteristics give the elderly most pleasure?
Q8 What would help the elderly increase enjoyment and appetite?

**In-depth investigation:** Development of product for elderly with dysphagia
Q9 According to your work related to elderly with dysphagia, between National Dysphagia Diet standard NDD 2 and NDD 3, which standard level should be firstly developed for the elderly?
Q10 Have you ever heard the term "Thickened liquid and Texture modified food"
If not, give the definition of each term.
Thickened liquid is a medical dietary adjustment by thickening the consistency of fluids.
Texture modified food is food with soft texture and/or reduced particle size.
If yes, what characteristic about Thickened liquid and Texture modified food is the most important?
Q11 What are types of commercial thickened liquid and texture modified food that you prepared/purchased for the elderly recently? Explain
Q12 Which types of beverages and food are suitable for the elderly (In terms of popularity and nutrition supplement)
Beverages (Choose only 3 products and rank accordingly the suitable) (1=the most suitable)
- Meal replacement smoothies such as Protein shake etc.
- Cereal/Nut milk such as Job's Tear Milk, Corn milk, Soy milk, Sesame milk, Almond milk etc.
- Milk beverages such as Ovaltine etc.
- Drinking yogurt
- Vegetable/fruit beverages
- Herb beverages such as Chrysanthemum Tea

Foods (Choose only 3 products and rank accordingly the suitable) (1=the most suitable)
- Thick rice porridge, Oat porridge with milk, Thick soup, Clear soup, Corn/pumpkin soup, Potato/tuber/vegetable puree, Custard, Jelly, Soybean curd, Ice cream, Steamed egg , etc.

Q13 What form of thickened liquid and texture modified food do you choose for the elderly? (In terms of convenience of use)
- Ready-to-eat, powder and sheet

Q14 Which type of package and amount of serving do you select for the elderly in thickened liquid and texture modified food? (In terms of convenience of use)
- Packaging (Can, Retort pouch, Plastic can/box, bottle) and serving size per meal

Q15 Please rank the important factors influenced on consuming of thickened liquid and texture modified food of the elderly? (1= the most important, 7= the least important)
- Taste, benefits and nutritional values, price, packaging, convenience to purchase, food additives and food standard

Q16 What nutrients or functional ingredients should be added in thickened liquid and texture modified food for elderly with dysphagia?
- Vitamin and mineral, calcium, protein, collagen, prebiotic, fiber, antioxidant, fatty acid, and omega 3 etc.

Q17 Which ingredients/food additives do you concern: probe questions?
(Fat; animal fat, plant-base fat/ sugar/ caloric/ functional ingredient/ organic)
Q18 How long should the products be kept for?
Q19 Willingness to pay
- If you are a person who involves with elderly patients with dysphagia, would you recommend these products to dysphagia patients and to the hospital?
- Do you think that the patients would like to consume or not?
- Please suggest the places for selling these products. (Hospital, department store, health care store, online)

**Closure (5 min)**
Q20 Do you have any other thoughts or comments that you would like to share with us about thickened liquid and texture modified food added with nutrition and functional ingredients? Have we missed anything?

Figure 1. Interview guide for focus group sessions

($L^*$=93.59, $a^*$=−0.98, $b^*$=0.35) was conducted (Lamberts *et al.*, 2007).

### 2.3.4 Acceptance test

The porridge rice samples at 50-60°C were judged by elderly panelists (n=50) recruited from Hatyai, Songkhla, Thailand. Appearance, taste/flavor, mouth-feel and overall liking were evaluated using 9-point hedonic scale (Meilgaard *et al.*, 2007).

## 2.4 Preparation of chicken soups

According to Table 1, vegetables were boiled with chicken bones to water ratios of 1 to 5. Seasoning was added and further simmered until the concentration of soup reached 6°Brix using hand refractometer (HR140, OPTIKA Microscopes, Italy). The solid ingredients were removed and the stock was strained with sieve lined with dampened cheesecloth. Chicken stock was poured into polypropylene and cooled completely before freezing. The stock replaced the CP Chicken stock in porridge preparation (Part 2.3.1). The samples were subjected to rheological, color determination and sensory evaluation as described in 2.3.2, 2.3.3 and 2.3.4, respectively.

## 2.5 Statistical analysis

The data from focus groups were analyzed qualitatively. The questions were divided into open-ended questions and closed-ended questions. The responses to the open-ended questions were gathered to similar response into grouping word/phase and reported as frequencies. Closed-ended questions were separate multiple choice questions reported with frequencies. Physical properties and acceptance test were performed with the complete randomized design (CRD) and randomized complete block design (RCBD), respectively. Data were subjected to analysis of variance (ANOVA), and comparison of means with Duncan's multiple range test. The significance level was set at $p<0.05$. All data were analyzed using SPSS package (SPSS version 10.0 for Windows, SPSS Inc., Chicago, IL, USA).

Table 1. Chicken soup formulations

| Formulation | Ingredients (%) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Chicken bone | Water | Vegetables | White pepper | Iodized salt t | Soy sauce | Rice bran oil | Dried bean sheet | Dried mushroom | Unsweetened soy milk | Total |
| F1 | 14.0 | 70.0 | 14.6 | 0.1 | 0.1 | 0.5 | 0.3 | 0.4 | - | - | 100 |
| F2 | 14.0 | 70.0 | 14.6 | 0.1 | 0.1 | 0.5 | 0.3 | - | 0.4 | - | 100 |
| F3 | 14.0 | 70.2 | 14.6 | 0.1 | 0.1 | 0.5 | - | - | - | 0.5 | 100 |
| F4 | 14.0 | 70.7 | 14.6 | 0.1 | 0.1 | 0.5 | - | - | - | - | 100 |

## 3. Results and Discussion

### 3.1 Consumption habits and product concept development for elderly with dysphagia

A total of 40 participants including doctors and nurses (n=10), nutritionists (n=11), physical therapists (n=10), and caregivers (n=9) were divided into different groups due to experience and skills of participants. The eating habits and dietary choices of elderly are influenced by physiological, psychological and social changes. Health conditions associated with ageing relate to dental conditions, ingestion, absorption and metabolism, influencing the dietary habits and nutrition status (Creech *et al.*, 2019). The results from the survey demonstrated that number of meals/day was three meals per day (36.7%) or 4-5 meals/day (23.3%). According to an increased risk of nutrient deficiencies among the elderly, participants referred to restrictions of elderly consumption as important parts of getting adequate nutrition. Portion serving size of 200-250 gram per meal (66.7%) was suitable for the elderly because nutrients and amount of serving met elderly daily energy requirements. Oral health problems including tooth decay, using dentures, and difficulty swallowing were the most important cause (44.7%) of low intake by the elderly, followed by changes in taste and smell senses (21.3%), food characteristics (appearance and texture) (17.0%), lack of understanding of food preparation for elderly (in terms of meal portion, raw materials, and food additives) (14.9%), and appetite, mood and pathological diseases such as diabetes and heart disease (2.1%). The important factors for considering elderly food choices were the nutritional value (39.8%), ease of chewing and swallowing (23.5%), texture (19.1%), taste related pathology (13.2%), preparation (2.9%) and price (1.5%). In terms of the crucial feature that might improve elderlies' mood and appetite, food appearance (28.4%) was shown to be the most potent sensory attribute for appetite, followed by serving temperature (20.3%). Acquainted taste (14.9%) and easy preparation (15.3%) enhanced happiness. The other factors included food odor (9.5%), meal portion (5.4%), environment and a relation in family (4.1%), nutritional value (2.7%) and price (1.4%). Elderly with dysphagia are at risk of malnutrition and choking, therefore development of such product for this consumer group should be concerned with texture and nutrition as well as acceptability. Ko *et al*., (2022) reported that the concerns of the elderly individuals, aged 50 years or above, both with (n=148) and without (n=156) dysphagia were focused on food product selection attributes, nutritional status, and the potential depression associated with dietary habits. Furthermore, most patients (65.3%) consumed less of their meals (half a bowl or less).

NDD and IDDSI established global standardized terminological definitions of individual's dysphagia for foods and fluids. According to ageing process and deterioration of the swallowing action, most of the participants (93.3%) responded accordingly to develop liquid product at NDD 2 and a solid product at NDD 3 or IDDSI 4, which are for the individuals with mild to moderate oral and/or pharyngeal dysphagia. Individuals tongue force can move the bolus within their mouth and be used to separate small, soft particles in this texture. The product can prevent a choking hazard and reduce tube feeding option (Creech *et al.*, 2019). Texture attribute (47.2%) was remarkably important for developed foods, followed by taste (34.0%), appearance (9.4%) and odor (9.4%), respectively. The suitable beverages ranked from most to least were cereal/nut milk (56.7%), vegetable/fruit beverages (40%) and milk beverages (Dairy beverage) (30.0%). In addition, the ordered ranks of suitable food for elderly were thick rice porridge (66.7%), steamed egg (40.0%) and corn/pumpkin soup (20.0%), respectively. The results were highly consistent across the participants; thickened liquids/drinks in powder form (66.7%) packed in a plastic pouch (30.0%), while textured modified-foods in ready-to-eat form (53.3%) were packed in plastic can or box (60.0%). The most important factors influencing consumption of thickened liquid and texture modified food by the elderly with dysphagia were in descending order nutritional values (66.7%), taste (53.4%), price (43.3%), convenience to purchase (36.7%), food additives (30.0%), food standard (26.7%), and packaging (23.3%). The most important nutrients or functional ingredients supplemented in the products were protein (66.7%), calcium (40.0%) and vitamins and minerals (33.3%). Dysphagia and malnutrition are apparently associated (Lin, Kao, Tsai, & Chang, 2013). The elderly consume inadequate nutrients, especially protein, dietary fiber and calcium (Chernoff, 2013). Moreover, the elderly women are deficient in vitamins A, B12, C, and D, and in iron and zinc. The requirements of vitamin A are 900 and 700 mcg retinol activity equivalents (RAE) according to Thai RDA for men and women, respectively. Vitamins B12, D and folate are recommended at 2.4, 5.5 and 240 mcg, respectively (Skully, 2014).

In conclusion, the product concepts for elderly with dysphagia were powder form of cereal/nut milk beverage and ready–to-eat rice porridge fortified with protein, calcium, vitamins and minerals. The product should have modified texture related to liquid product at NDD 2 and a solid product at NDD 3 or IDDSI 4 and packed in retort pouch for drink and plastic can or box for food with portion size of 200-250 g.

### 3.2 Development of porridge formula with various JR to RB ratios

#### 3.2.1 Rheological properties

Rheological characteristics of food and composed bolus are related with the swallowing process and promoting safe swallowing for dysphagia (Zargaraan, Rastmanesh, Fadavi, Zayeri, & Mohammadifar, 2013). Based on oral evaluation of viscosity, the change of shear rate and shear stress conditions judged as viscous by the mouth depend on the sample viscosity indicated (Sherman, 1969). Viscosity at the different rice ratios tended to decrease with shear rate as shown in Table 2. The flow behavior indexes (n) ranged in 0.29-0.34. Moreover, all samples also exhibited shear-thinning flow, which could be explained by breakage of H-bonds between amylose molecules or rearrangement of starch granules resulting in reduction of flow resistance and viscosity (Lin, Kao, Tsai, & Chang, 2013). In particular, the increasing RB ratios showed lower shear-thinning flow and increased n-values, which correlated with the sensory properties ($p<0.05$). A low n-value was required if high viscosity and good mouth-feel (less slimy) characteristics were desired in food (Marcotte, Hoshahili, & Ramaswamy, 2001). Therefore, lower n-values with high proportion of JR are more desirable to RB. Furthermore, the higher consistency coefficients (K) indicate more viscous character of rice porridge. The K-values (11.1-17.1 Pas) tended to decrease with RB level. The 0:100 sample showed the lowest value which indicated that the sample had low viscosity or was less resistant to flow.

The apparent viscosities of porridges with ratios of 100:0 and 0:100 obtained the highest and lowest values ($p<0.05$), respectively, while those at other ratios were not significantly different ($p\geq0.05$). According to NDD or IDDSI standard the porridges were in honey-like range (351-1750 cP, NDD 2) or IDDSI level 3. The flow properties and viscosity of porridges resulted from different JR and RB ratios and led to different properties including swelling power and amylose content of the starch. JR, polished white rice contained 20.67-21.93% amylose, while RB, unpolished pigmented rice contained 15.2-15.4% amylose on dry basis (Thiranusornkij, Thamnarathip, Chandrachai, Kuakpetoon, & Adisakwattana, 2019). The amylose and amylopectin are associated with both swelling power and solubility. During heating, the high amylose content and long chains of amylopectin can strengthen the granule structure of the starch and inhibit the swelling of granules (Juemanee, Meenune, & Kijroongrojana, 2018). Consequently, RB has higher swelling power and lower solubility than JR due to the low amylose content. The amylose molecules in starch are linear and extensively hydrogen bonded, requiring more energy to break these bonds. Moreover, RB has high amounts of protein and fat inhibiting hydration of starch granules and leading to a lower viscosity. JR with the higher amylose content had less amorphous regions and is more crystalline, lowering gelatinization temperature and water absorption (Zavareze, Storck, De Castro, Schirmer, & Dias, 2010).

#### 3.2.2 Color properties

The results presented in Table 2 show significant differences in lightness ($L^*$), redness ($a^*$) and yellowness ($b^*$) ($p<0.05$). Increasing RB proportions led to decrease in $L^*$ and increase in $a^*$. This result is in line with Khuenpet *et al.*, (2019), who studied an instant Riceberry rice porridge with and without addition of Jasmine rice or sticky broken rice. The changes of porridge color might be due to the physico-chemical reactions including disintegration of rice structure and dissolved components of pigment into soup phase. RB is unpolished rice and contains many pigments such as anthocyanin, carotenoid, gamma oryzanol, mainly anthocyanins, which is a group of reddish to purple water-soluble flavonoids (Deng *et al.*, 2013).

#### 3.2.3 Acceptance test

The appearance, color, odor, viscosity, and taste liking scores tended to increase with proportion of RB ($p<0.05$) as shown in Table 3. The sample with JR to RB ratio of 0:100 obtained the highest scores but these were not significantly different from 25:75, and 50:50 samples. Panelists judged the porridge appearance properties, not only geometrical (size, shape, uniformity and mass) and the optical (surface gloss) but also the nature and pigment intensity of rice. Moreover, the volatile compounds of surface layer of the rice grain have an important role in the formation of odor of cooked rice (Juliano, 1992). The aldehydes provide the dominant aroma in cooked rice. Vanilla, smoky note, clove, spicy, smoky, and sweet, candy, fruity, berry were the main aroma-active effects in RB (Kullananant, Chaiseri, & Lorjaroenphon, 2020). Besides chemical analysis, the RB aroma profiles with trained descriptive panelists had strong dark grain note, whereas cooked JR having 2-Acetyl-a-pyrroline (2AP) compound had strong pandan or popcorn note aroma (Paule, & Power, 2006).

Furthermore, viscosity liking scores tended to increase as viscosity decreased. Although the viscosity values of 50:50, 25:75 and 0:100 samples were significantly different ($p<0.05$), the differences did not affect the viscosity liking score ($p<0.05$). The boiled RB used in the experiment was sieved through a 10 mesh, which could reduce roughness of outer layer of the rice grain. However, different amounts of RB did not affect mouth-feel liking, as no difference in overall liking score was observed among the samples with different rice ratios ($p\geq0.05$).

### 3.3 Development of rice porridge formula with various chicken soup formulations

#### 3.3.1 Rheological properties

The shear stress-shear rate data were well-fit by a power law model ($R^2>0.82$) as demonstrated in Table 4. The data are shown as average values and had significant differences ($p<0.05$). Porridges with different soup formulations were shear thinning: apparent viscosity decreased with shear rate. Moreover, the flow behavior index (n) ranged within 0.30-0.33. The consistency coefficient (K) of different chicken formulas in porridges was 10.5-15.9 Pas.

The K values of F3 and F4 were higher than those of F1 and F2 ($p<0.05$). The dispersion of oil ingredients in F1 and F2 led to decrease in consistency or less viscous porridge. The apparent viscosity of F3 was the highest due to solubility and dispersion of protein from soy milk ($p<0.05$). An increase

Table 2. Color and rheology of rice porridges with different Jasmine rice (JR) to Riceberry rice (RB) ratios

| Ratio of Jasmine rice: Riceberry rice | Color characteristics | | | Rheological characteristics | | | |
|---|---|---|---|---|---|---|---|
| | *L** | *a** | *b** | Viscosity at shear rate of 50 $s^{-1}$ (mPa•s) | Consistency coefficient (K) | Flow behavior index (n) | $R^2$ |
| 100:0 | 73.98±0.06$^{a}$ | -1.78±0.00$^{d}$ | 7.71±0.04$^{a}$ | 1,150±55$^{a}$ | 17.10±1.09$^{a}$ | 0.29±0.02$^{c}$ | 0.86 |
| 75:25 | 45.55±0.36$^{b}$ | 6.00±0.10$^{c}$ | 3.59± 0.04$^{e}$ | 1,051±90$^{b}$ | 16.1±0.53$^{a}$ | 0.31±0.00$^{bc}$ | 0.85 |
| 50:50 | 36.67±0.27$^{c}$ | 8.41±0.07$^{b}$ | 4.97±0.05$^{c}$ | 1,021±25$^{b}$ | 16.5±1.33$^{a}$ | 0.33±0.01$^{ab}$ | 0.87 |
| 25:75 | 30.16±0.06$^{d}$ | 9.44±0.04$^{a}$ | 5.13±0.02$^{b}$ | 1,017±59$^{b}$ | 14.8±0.47$^{a}$ | 0.32±0.00$^{bc}$ | 0.87 |
| 0:100 | 26.92±0.04$^{e}$ | 9.40±0.04$^{a}$ | 4.48± 0.04$^{d}$ | 898±30$^{c}$ | 11.1±0.36$^{b}$ | 0.34±0.02$^{a}$ | 0.92 |

Values are expressed as mean ± S.D, n=9. Different superscripts in the same column indicate significant differences ($p<0.05$), ns: non-significant

Table 3. Mean acceptance scores on 9-point hedonic scale of porridges with different Jasmine rice (JR) to Riceberry rice (RB) ratios

| Ratio of Jasmine rice: Riceberry rice | Appearance | Color | Odor | Mouth-feel$^{ns}$ | Viscosity | Taste | Overall$^{ns}$ |
|---|---|---|---|---|---|---|---|
| 100:0 | 6.90±1.92$^{bc}$ | 6.80±1.83$^{bc}$ | 6.57±1.91$^{b}$ | 6.40±2.08 | 5.97±2.06$^{b}$ | 6.47±2.10$^{b}$ | 6.93±2.05 |
| 75:25 | 6.70±2.23$^{c}$ | 6.30±2.14$^{c}$ | 6.40±1.96$^{b}$ | 6.40±2.13 | 6.13±2.10$^{b}$ | 6.50±2.24$^{b}$ | 6.83±2.18 |
| 50:50 | 7.17±1.72$^{abc}$ | 7.20±1.63$^{ab}$ | 7.00±1.72$^{ab}$ | 6.70±2.04 | 6.60±1.65$^{ab}$ | 7.00±1.82$^{ab}$ | 7.03±2.09 |
| 25:75 | 7.53±1.33$^{ab}$ | 7.33±1.58$^{ab}$ | 7.33±1.42$^{a}$ | 6.73±1.76 | 6.67±1.85$^{ab}$ | 7.53±1.41$^{a}$ | 7.20±1.86 |
| 0:100 | 7.80±0.93$^{a}$ | 7.53±1.43$^{a}$ | 7.27±1.39$^{a}$ | 6.87 ±1.50 | 6.90±1.32$^{a}$ | 7.60±1.30$^{a}$ | 7.70±1.18 |

Values are expressed as mean ± S.D, n=50. Different superscripts in the same column indicate significant differences ($p<0.05$), ns: non-significant

Table 4. Color and rheological characteristics of rice porridge with different chicken soup formulations

| Formulation | Color coordinate | | | Rheological characteristic | | | |
|---|---|---|---|---|---|---|---|
| | *L** | *a** | *b** | Viscosity at shear rate of 50 $s^{-1}$ (mPa•s) | Consistency coefficient (K) | Flow behavior index (n) | $R^2$ |
| F1 | 29.71±0.05$^{c}$ | 6.69±0.09$^{d}$ | 6.53±0.02$^{b}$ | 879±79$^{c}$ | 12.1±0.27$^{b}$ | 0.33±0.01$^{a}$ | 0.89 |
| F2 | 28.07±0.09$^{d}$ | 7.56±0.04$^{a}$ | 6.66±0.12$^{a}$ | 725±3$^{bc}$ | 10.5±1.39$^{b}$ | 0.32±0.00$^{a}$ | 0.87 |
| F3 | 31.12±0.03$^{a}$ | 7.04±0.02$^{b}$ | 6.21±0.02$^{c}$ | 1,188±18$^{a}$ | 15.9±0.18$^{a}$ | 0.31±0.01$^{ab}$ | 0.84 |
| F4 | 30.40±0.13$^{b}$ | 6.98±0.04$^{c}$ | 5.99±0.66$^{d}$ | 1,013±91$^{b}$ | 14.5±0.04$^{a}$ | 0.30±0.00$^{b}$ | 0.82 |

Values are expressed as mean ± S.D, n=9. Different superscript letters in the same column indicate significant differences ($p<0.05$), ns: non-significant

in viscosity was due to structural changes of soy protein, i.e. unfolding, aggregation, and interactions with lipids and other constituents. The friction of protein molecules rubbing against each other also contributed to viscosity (Liu, & Chang, 2007). Moreover, heating caused protein polymerization to some extent (Liu, & Chang, 2003). The viscosity of all porridges was in the range of NDD 2 or IDDSI 4.

### 3.3.2 Color properties

The colors of porridges with different soup formulations were significantly different ($p<0.05$). F1 obtained the highest redness (*a**). It had slightly lower lightness (*L**) but higher yellowness (*b**) than F3 and F4. F1 had yellowish dried bean sheets made from heated soymilk that contributed to the color of the porridge sample. F2 had the lowest lightness, but the highest redness and yellowness, which were possibly contributed by the shiitake mushroom in the formulation (Hauman, 1984).

### 3.3.3 Acceptance test

No differences in odor, mouth-feel, viscosity, taste and overall liking scores were noticed among the samples ($p\geq0.05$) as shown in Table 5. This indicates that the ingredients including soy sheet, mushroom, and soy milk did not affect acceptability of the porridge. However, F1 tended to obtain the highest scores in all attributes. F1 contained dried bean sheet with 55 % protein and 25 % vegetable oil on a dry weight basis (Sathe, 2002). The dried bean curd sheet might contribute to the flavor and the intense color of the sample resulting in a high acceptability.

## 4. Conclusions

A focus group interview revealed that porridge was the most appropriate product for elderly with dysphagia. The product should be ready to consume, with modified texture and supplemented with protein, calcium and vitamins. The

Table 5. Mean acceptance scores on 9-point hedonic scale of various soup formulations added in Riceberry rice porridge

| Formulation | Appearance | Color | Odor$^{ns}$ | Mouth-feel$^{ns}$ | Viscosity$^{ns}$ | Taste$^{ns}$ | Overall$^{ns}$ |
|---|---|---|---|---|---|---|---|
| F1 | 7.60±1.48$^{a}$ | 7.67±1.37$^{a}$ | 7.47±1.14 | 7.13±1.66 | 7.13±1.94 | 7.37±1.96 | 7.63±1.87 |
| F2 | 7.20±1.35$^{ab}$ | 7.10±1.45$^{b}$ | 7.30±1.24 | 6.60±1.57 | 6.47±1.61 | 7.13±1.25 | 7.27±1.55 |
| F3 | 7.00±1.16$^{ab}$ | 6.93±1.60$^{b}$ | 7.03±1.35 | 6.60±1.89 | 6.67±2.01 | 7.00±1.78 | 7.20±1.55 |
| F4 | 6.70±1.62$^{b}$ | 6.63±1.99$^{b}$ | 6.80±1.71 | 6.67±1.81 | 6.63±2.04 | 7.10±2.02 | 7.47±1.53 |

Values are expressed as mean ± S.D, n=50, Different superscripts in the same column indicate significant differences ($p<0.05$), ns: non-significant

development of the rice porridge showed that the porridge prepared from RB (0:100) and soup formula consisting of chicken bone, vegetables, seasoning, rice bran oil, and dried bean sheets had the highest overall acceptance scores. The viscosity at shear rate of 50 $s^{-1}$ of the porridge was in range of NDD 2 or IDDSI 4. The product has an appropriate texture in terms of viscosity or particle sizes to assure safe swallowing by the elderly with mild to moderate oral and/or pharyngeal dysphagia. However, the nutritional value of the porridge should be enhanced and balanced to meet the specific needs of the consumers.

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