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Nutritious elderly diet: Pigmented rice-porridge from shear-heat milling process

Chawakwan Nitikornwarakul[1]*, Rodjanawan Wangpradid[1], Chirat Sirimuangmoon[2], Somwang Lekjing[1], Akihiro Nishioka[3], Tomonori Koda[3]

[1]Faculty of Innovative Agriculture and Fishery Establishment Project, Prince of Songkla University Surat Thani Campus, Surat Thani, Thailand; [2]School of Agro-Industry, Mae Fah Luang University, Chiang Rai, Thailand; [3]Graduate School of Organic Materials Science, Yamagata University, Yonezawa, Yamagata, Japan

***Corresponding Author:** Chawakwan Nitikornwarakul, Department of Food Technology, Faculty of Innovative Agriculture and Fishery Establishment Project, Prince of Songkla University Surat Thani Campus, Surat Thani, Thailand Email: chukwan.t@psu.ac.th

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Abstract

The objective of this study was to develop nutritious elderly diet formulations. Each formulation contained three components, pigmented rice flours from shear-heat milling, freeze-dried protein bouillon cube, and sesame oil. The final products were tested with 100 panelists and monitored for quality changes (physical, chemical, microbial, and sensory properties) for 6 months. The three developed formulations provided a suitable ratio of the main nutrients and adequate energy. The products were highly accepted (95%) and easy to swallow (score 4.2/5), indicating a high potential for launching in the elderly market. The products can retain their quality and achieve microbiology safety during storage.

Keywords: elderly diet; pigmented rice; modified flour; shear and heat milling; rice porridge; consumer test

Introduction

The societal transitions due to aging populations are of imminent concern in many countries. It is estimated that by 2030, 70 million of the global population will be aged 60 years or older, and, by 2050, the age group of over 65-year-olds is predicted to be 88.5 million (Chernoff, 2016). These trends indicate that a growing population segment is at a high risk of disability and morbidity. The elderly population will become a major concern to be addressed in national policies on social, economic, and especially health aspects (Risonar *et al.*, 2009). Suitable nutrition is a key factor contributing to the good health of the elderly. When people age, there are substantial changes in the body, especially in the digestive system, such as a reduced ability to chew, swallow, and digest, due to problems with the teeth and gastrointestinal alterations (Gallego *et al.*, 2022; Leslie and Hankey, 2015), making consuming food more difficult. Reduction of total caloric intake can induce frailty of the body, which can result in vulnerability and functional decline (Clegg and Williams, 2018; Lammes *et al.*, 2012). Such cases are susceptible to malnutrition and sarcopenia. The design of elderly food products is essential, and they need to provide sufficient energy and nutrients to meet the maintenance needs and are presented in forms that facilitate consumption.

Rice, the main carbohydrate resource consumed by almost half of the world's population, is rich in many nutrients that are beneficial to the body (Jukanti *et al.*, 2020). However, most of the valuable micronutrients, fatty acids, and fiber are removed during dehulling (Bhattacharya, 2017; Park *et al.*, 2018). The nutritional quality of white rice is therefore dramatically below that of pigmented rice. The pigmented rice varieties are mainly black, red, or dark purple, and their coloring is in the outer aleurone layer that contains flavones, tannin, phenolics, sterols, tocols, γ-oryzanols, amino acids, and essential oils (Mbanjo *et al*., 2020). Many studies have reported on the functional properties of pigmented rice, such as anti-atherosclerosis, anti-allergic, anti-diabetic, anti-inflammatory, anticancer, and antitumor activities (Boue *et al.*, 2016; Ling *et al*., 2002; Nam *et al*., 2005; Punvittayagul *et al*., 2014). Thai pigmented rice varieties, such as Riceberry rice, Sangyod rice, Hom Nil rice, Munpoo rice, and Black sticky rice, have gained a lot of interest due to growing consumer demand for health-promoting food products (Ratseewo *et al*., 2019). The big challenge of applying pigmented rice on a diet for the elderly is the hard texture of the outer layer of rice grains that makes them difficult to chew and digest.

Katsuno *et al*. (2010) proposed a new method for rice processing using a shear and heat milling (SHM) machine. The process is a physical treatment applying mechanical shear, and heat during the milling. This promising technology can successfully modify the gelatinization properties of rice flour, resulting in amorphous rice starch without the addition of water during processing. The advantages of SHM over other methods are safety, simplicity, saving time, and low operating cost. The current study appears to be the first to apply this SHM technique to modify pigmented rice.

Rice porridge is a popular dish in many Asian countries, especially in China, Korea, Taiwan, Japan, and Thailand. It is prepared by adding water to rice at volume proportions of 6–7 folds water to rice, and then boiling until complete gelatinization of starch is achieved (Rhim *et al*., 2011). The dish is particularly favored by the elderly due to the ease of chewing. Various rice porridges include ingredients like chicken, pork, fish, egg, seaweed, and vegetables, providing many options to the consumers. However, the rice portion is mostly made from white rice, which has fewer nutrients than pigmented rice. Moreover, the instant rice-porridge products available in the market are generally rich in carbohydrates but provide insufficient protein and fat.

The energy requirements of individuals differ and can be defined as the amount of energy needed to match energy expenditure, which is the sum of basal metabolic rate (BMR); thermic effect of food (TEF); and energy for physical activity. In the elderly, energy expenditure decreases with age resulting from a decreased resting energy expenditure and physical activity (Ritz, 2001).

There are limited products that are specially made for the elderly group. Therefore, the objective of this research was to develop nutritious elderly diet formulations with different energy levels that can provide sufficient energy and nutrients to meet the requirements, be presented in forms that facilitate consumption, and be acceptable to the target consumers.

Materials and Methods

Raw materials

Five commercial pigmented rice varieties, namely, Riceberry rice (Mah Boonkrong™), Sangyod rice (Chang Thong™), Hom Nil rice (Green nich™), Munpoo rice (Nature zone™), and black sticky rice (Be Herb™) were obtained from a local department store. Eggs, salmon, seaweed, pumpkins, and carrots were purchased from a local department store in Surat Thani province, Thailand.

Preparation of rice flour

The pigmented rice flour was obtained using a SHM process according to the method described by Kanke *et al*. (2021) with some modifications. A commercial milling machine (KGW-G015, West Co. Ltd., Japan) was applied as the Shear and Heat Milling Machine (SHMM) at Yamagata University, Yonezawa campus. The machine consists of two metal mortars (90 mm diameter) and a ring heater. The gap between the upper mortar and the lower mortar was adjusted to 10 μm. During milling, the lower mortar was rotated at 180 rpm, while the upper mortar connected to the heater was heated to 120°C.

Preparation of bouillon cube

Salmon was washed with potable water before cutting into small pieces. The egg was prepared as an omelet before being added to the soup base. The step of making the soup began with adding diced carrots, pumpkins, and corn into boiling water seasoned with seaweed. Then, the protein parts (omelet and salmon) were added and boiled until all ingredients were completely cooked. The soup was kept at room temperature before being weighed into portions according to the calculated formulation and was then frozen at −20°C. The frozen bouillon cube was then dried for 72 h using a freeze dryer (Christ, Beta 1–8 LSCplus, Osterode am Harz, Germany).

Preparation of elderly diet formulations

The current study proposes three elderly diet formulations generated at three caloric concentrations, namely, 380, 450, and 530 kcal per portion. The energy per portion was set based on the daily energy requirement at 1,500, 1,800, and 2,100 kcal (Jansen *et al*., 2017).

Proximate analysis

The main ingredients and porridge formulations were analyzed for the proximate composition of carbohydrate, protein, fat, ash, and moisture contents, following AOAC (1984) methods. To determine protein and fat content, the Kjeldahl and Soxhlet methods were used, respectively. The water content of each sample was determined using a moisture analyzer (Sartorius Moisture Analyzer, MA 37, Göttingen, Germany). To analyze the ash content, the sample was dried at 550°C in a muffle furnace until a white or light gray ash resulted. The total carbohydrate content of the sample was obtained using the following equation:

Total carbohydrate (%) = 100 –[moisture (%) + crude protein (%) + crude lipid (%) + total ash (%)]

Total energy

Caloric contents of the main ingredients and porridge formulations were determined using a Bomb Calorimeter (Leco, AC 500, USA). One gram of grounded sample was pressed to a pellet. Then it was analyzed for gross energy using the bomb calorimeter, which measures the amount of a sample's combustion heat generated under an oxygen atmosphere in a closed vessel.

Consumer testing

The consumer acceptance test of the developed porridge formulations and packaging designs in this study was evaluated by 100 panelists aged between 60 and 90 years, including both sexes. The panelists were interviewed to collect personal information on gender, age, health status, eating behavior, daily activities, choice of food, and purchase behavior. The estimated energy requirement (EER) was calculated according to the method suggested by the Institute of Medicine (2005) using equation [1] for males, equation [2] for females, and PA as indicated in table 1. Following calculation, a suitable recipe was selected accordingly.

Sensory evaluation using the 5-point hedonic scale (1 = dislike very much, 2 = dislike slightly, 3 = neither like nor dislike, 4 = like slightly, and 5 = like very much) was performed to rate the appearance, color, flavor, taste, ease of swallowing, and overall acceptability of the rice porridge product. The packaging design was also judged on a similar scale for appearance, attractiveness, and overall acceptance.

$$\text{EER (k cal/day)} = 662 - (9.53 \times \text{Age[yr]}) + \text{PA} \times ((15.91 \times \text{Weight[kg]}) + (539.6 \times \text{Height[m]})) \quad (1)$$

$$\text{EER (k cal/day)} = 354 - (6.91 \times \text{Age[yr]}) + \text{PA} \times ((9.36 \times \text{Weight[kg]}) + (726 \times \text{Height[m]})) \quad (2)$$

Shelf life evaluation

Physical analysis

Rehydration was performed by adding hot water into the diet formulations in the ratio of 200 mL: 50 g, stirring with a spoon, and observing for 5 min.

Chemical analysis

The moisture content of the rice flour samples and bouillon cubes was obtained using a moisture analyzer (Sartorius Moisture Analyzer, MA 37, Göttingen, Germany). A water activity meter (Aqualab, CX3TE, USA) was applied for measuring the water activity (a_w) of the samples.

Microbial analysis

The samples were monitored for aerobic microorganisms and yeast and mold every month for 6 months. For total aerobic microorganisms, plate count agar (PCA) (Himedia, Mumbai, India) was used to enumerate the colonies. For yeast and mold counts, Potato Dextrose Agar (PDA) (Himedia, India) with 0.01% chloramphenicol was used. Colonies were counted and are reported as CFU/g.

Sensory evaluations

Sensory evaluation performed by 35 untrained panelists (aged between 20 and 50 years) was organized monthly during product storage. The porridge formulations were labeled with three-digit codes and randomly served to the panelists. Sensory evaluation using the 9-point hedonic scale (the maximum for "extremely liked" and the minimum for "extremely disliked") was evaluated on

Table 1. The physical activity (PA) coefficients used to determine energy needs.

Group	Physical activity coefficient			
	Sedentary (PAL 1.0–1.39)	Low Active (PAL 1.4–1.59)	Active (PAL 1.6–1.89)	Very Active (PAL 1.9–2.5)
Males	1.0	1.13	1.26	1.42
Females	1.0	1.16	1.31	1.56

appearance, color, flavor, taste, ease of swallowing, and overall liking.

Statistical analysis

The data from the consumer acceptance test of the products and packaging design were assessed for analysis of variance (ANOVA). The other experimental data from proximate, physical, chemical, microbial, and sensory analyses are presented as means of three replications with standard deviation. Statistical analysis was performed using ANOVA and Duncan's multiple range test to compare the means at P < 0.05 required for significance. SPSS v22 for Windows (IBM, Armonk, NY, USA) was used for all analyses of variance.

Results and discussion

The ingredients for developing an elderly diet in this research were exquisitely selected based on their health benefits. The proximate compositions of the main ingredients are presented in Table 2. The mixture of five pigmented rice flours was a good source of carbohydrates and rich in dietary fiber, which is in agreement with prior studies (Sati and Singh, 2019; Seechamnanturakit *et al*., 2018). Furthermore, many studies have reported this ingredient as a source of bioactive compounds such as anthocyanin, proanthocyanidins, phenolic acids, flavonoids, vitamin E, and minerals (Chen *et al*., 2016; Yodmanee *et al*., 2011). Egg and salmon contained 13.20 and 16.98% protein, respectively. Rehault-Godbert *et al*. (2019) and Reksten *et al*. (2022) also reported similar findings. The chosen ingredients, especially salmon, egg, and pigmented rice flour also provide good levels of fat content. Food with polyunsaturated and monounsaturated fats is recommended for elderly people, while cholesterol sources should be avoided to reduce the risk for coronary heart disease (Chernoff, 2016). Nechev *et al.* (2022) revealed natural omega-3 polyunsaturated fats such as eicosapentaenoic acid (EPA; 20:5 n-3), docosapentaenoic acid (DPA; 22:5 n-3), and docosahexaenoic acid (DHA; 22:6 n-3) in salmon. Moreover, high content of EPA + DHA at 10.29–26.92 mg/g was reported in salmon (Tan *et al*., 2020). Other ingredients such as pumpkin, corn, carrot, and seaweed were added to the formulations because of their abundance in vitamins and minerals (Maqbool *et al*., 2021; Onwude *et al*., 2017). According to the results, these ingredients had ash contents of 7.98, 6.62, 3.75, and 2.76%, respectively. Apart from the main ingredients presented in Table 2, sesame oil was included in a separate package to provide energy from fat as well as a nice flavor.

The elderly diet formulations were generated at three caloric concentrations, which were 380, 450, and 530 kcal per portion. The energy per portion was defined based on the daily energy requirement at 1,500, 1,800 and 2,100 kcal according to the elderly diet study suggested by Jansen *et al*. (2017). The diet formulations were generated regarding the macronutrients requirement for the elderly; carbohydrate 55–60%, protein 10–35%, and fat 30% of total energy intake (Chernoff, 2016). A deficit of essential nutrients has become a common finding in elderly groups (Chernoff, 2016). The research carried out by Risonar *et al*. (2009) also revealed that the protein and fat intakes of the studied elderly group were only 24–51% of the recommended daily levels. A properly developed diet, therefore, needs to have adequate macronutrients and energy. The three formulations were calculated and constructed based on the proximate compositions of all ingredients, to provide suitable amounts of carbohydrate, protein, and fat. The developed elderly diet with three main components, namely, mixed pigmented rice flour from the SHM process, freeze-dried bouillon cube, and sesame oil is shown in Figure 1. The results from proximate analysis and total energy of the elderly diet formulations are presented in Table 3. The three formulations

Table 2. The proximate compositions of ingredients in an elderly diet formulation.

Ingredient	Nutritional content (%)				
	Carbohydrate	Protein	Fat	Ash	Total dietary fiber
Mixed pigmented rice flour	74.78 ± 0.95^{a}	9.68 ± 0.07^{c}	3.37 ± 0.96^{b}	1.67 ± 0.09^{e}	1.52 ± 0.04^{b}
Egg	0.07 ± 1.50^{d}	13.20 ± 0.22^{b}	3.74 ± 0.09^{b}	0.63 ± 0.01^{f}	0.61 ± 0.08^{f}
Salmon	0.45 ± 1.11^{d}	16.98 ± 0.27^{a}	9.39 ± 0.49^{a}	0.38 ± 0.15^{f}	0.99 ± 0.07^{d}
Seaweed	0.08 ± 0.90^{d}	6.90 ± 0.14^{d}	0.63 ± 0.01^{d}	2.76 ± 0.21^{d}	1.62 ± 0.04^{b}
Pumpkin	1.71 ± 0.42^{d}	2.8 ± 0.09^{e}	1.85 ± 0.10^{c}	7.98 ± 0.48^{a}	1.27 ± 0.07^{c}
Carrot	4.53 ± 0.93^{c}	0.97 ± 0.02^{g}	0.15 ± 0.07^{d}	3.75 ± 0.96^{c}	0.52 ± 0.03^{f}
Corn	11.43 ± 0.79^{b}	2.32 ± 0.05^{f}	1.80 ± 1.04^{c}	6.62 ± 0.30^{b}	0.86 ± 0.03^{e}

n = 3. Values are presented as mean ± standard deviation.
Values with the same superscript within the same column are not significantly different (P ≥ 0.05).

Figure 1. Components of elderly diet (A), elderly product from pigmented rice (B), packaging design of the elderly diet products formulation I (380 kcal) (C), formulation II (450 kcal) (D), and formulation III (530 kcal) (E).

had similar percentages of the main nutrients; carbohydrate (45%), protein (17%), and fat (22%), which are fit for elderly body requirements (Berner, 2019; Lecerf, 2019). The difference among the formulations is the amount of each ingredient and the total energy per portion, in which the analytical calories of formulations I, II, and III were 379, 453, and 528 kcal/portion, respectively. According to the survey study on eating behavior, the result interestingly demonstrated that the consumers over 65 years were being more careful to eat healthy than other younger groups (Bolek, 2021). In general, instant porridge products available in the market are usually abundant in carbohydrates but cannot supply enough protein and fat (Akonor *et al.*, 2021; Mahgoub *et al.*, 2020). In addition, the current research on the elderly diet has focused on the development of food ingredients, snacks, or beverages, e.g., a low-fat bologna-type meat product (Reyes-Padilla *et al.*, 2018), a high-protein yoghurt (Kersiene *et al.*, 2020), and a ready to drink product from Riceberry (Jaroenwanit *et al.*, 2021). There is limited study on a complete meal product that is specifically designed for the elderly. The new porridge formulations in this study were created to respond to this demand. All three formulations have suitable proportions of carbohydrates, protein, and fat, and are presented in a form that is convenient to prepare and consume.

In the current study, the consumer acceptance test of the developed elderly diet (formulations I, II, and III) and their packaging designs (Figure 1) involved 100 panelists aged between 60 and 90 years. The panel group was 68% female and 32% male. The majority were in the age range of 60–69 years, which accounted for 67%. In the age ranges of 70–79 years and 80–90 years, there were 23 and 10 subjects, respectively. The panelists were interviewed for personal information, eating behavior, physical activities, gender, age, occupation, number of meals per day, and daily activities. After obtaining the information, the total energy need was estimated and the suitable formulation was served to each individual. The results of consumer acceptance are summarized in Tables 4 and 5. According to the score on the product's visual quality (appearance and color), the panelists rated it as like slightly (score 3.8–4.0). According to the hedonic scores after testing the product, all porridge formulations had well accepted flavor, taste, and texture with an overall acceptability score of 4 out of 5 (slightly liked). Moreover, the panel perceived this as an easily swallowed product (score 4.7–4.8/5), which is the highlight of this elderly diet. The packaging design of each formulation provided complete product information (name of the product, ingredient list, nutrition table, and allergen information) presented in a nice design (Figure 1). The hedonic scores on appearance, attractiveness, and overall acceptance of the packaging designs had their means in the range of 4.8–4.9, which translates into "like very much."

The developed elderly diet formulations were monitored for physical, chemical, microbiological, and sensorial quality for 6 months at ambient storage. The porridge products can be easily prepared within 2–3 min by adding hot water. The water uptake ability was constant during the 6 months. The moisture content and water activity of the products (Figure 2) increased over the storage period, but the values still complied with dry product regulations (Laullen, 2018; Prabhakar and Mallika, 2014). The moisture content of mixed rice flour and bouillon cube increased significantly, indicating moisture uptake from the atmosphere inside the packaging and the environment outside through diffusion of vapors. This increasing trend is related to the high relative humidity of the air. So moisture is constantly absorbed from the environment to the product (Techakanon and Tangrujiwatanachai, 2019). Khan *et al*. (2014) reported the same finding in an instant wheat porridge mix product. Instant soup mix products also had increased moisture during storage for 6 months (Dhiman *et al*., 2017). The water activity of the product is a principal factor affecting product stability and its shelf life. The same increasing trend was also observed in water activity. However, each component of the porridge products had a_w below 0.5 throughout the storage period, indicating a low tendency of microbial growth. Accordingly, no microbials (aerobic bacteria and yeast, and mold) were detected in the samples, confirming product safety for up to 6 months of storage at ambient temperature (results not shown). Table 6 shows the sensory quality results of the three porridge formulations for 6 months. The shelf life of a food product containing fat is often limited by the development of rancidity, which consumers find unpleasant (Heinio *et al*., 2016). Although salmon in the bouillon cube contained a good amount of lipids (9.39%), the lower water activity after freeze-drying (0.17–0.29) can help prevent lipid oxidation (Sun *et al*., 2002). More than 80% of the fatty acids in sesame oil are unsaturated, e.g., oleic, linoleic, palmitic, stearic, and linolenic acids (Mujtaba *et al*., 2020). However, it is reported to be very resistant to oxidation rancidity due to natural antioxidants such as sesamin, sesamol, sesamolin, and tocopherols (Aslami *et al*., 2018; Hegde, 2012). Therefore, pigmented rice flour was the key ingredient that could provoke a rancid smell as perceived by the panelists. This finding is in agreement with the study of colored rice reported by Paiva *et al*. (2014). The hedonic scores on flavor attributes of formulations I, II, and III significantly decreased after storage for 5, 3, and 3 months, respectively. Chen *et al*. (2019) described that dehulling to produce brown rice disrupts the outer bran layers, allowing lipase and lipoxygenases in the pericarp and aleurone layers to be in contact with lipids, and thus trigger lipid oxidation. One other factor contributing to rancidity was the atmosphere in the packaging, which had oxygen participating in the hydrolysis and oxidation reactions of lipids (Klaykruayat *et al.,* 2020). Although changes in the flavor of the product were detectable, the panelists still rated the flavor attribute of the three formulations as like

Table 3. The proximate compositions and total energy of elderly diet formulations.

Nutritional content (%)	Formulation		
	I	II	III
Carbohydrate^{ns}	45.35 ± 0.09	45.05 ± 0.12	45.00 ± 0.06
Protein^{ns}	16.77 ± 0.24	17.03 ± 0.36	17.31 ± 0.31
Fat^{ns}	22.64 ± 0.18	22.29 ± 0.21	21.84 ± 0.41
Moisture content^{ns}	5.59 ± 0.25	6.06 ± 0.32	6.15 ± 0.29
Ash^{ns}	5.32 ± 0.34	5.37 ± 0.33	5.34 ± 0.47
Total Dietary Fiber^{ns}	4.33 ± 0.07	4.20 ± 0.10	4.36 ± 0.05
Total Energy (kcal)	379 ± 0.2	453 ± 0.2	529 ± 0.1

Values are presented as mean ± standard deviation.
ns = Values are not significantly different in the same row (P ≥ 0.05).

Table 5. The consumer rating of product's package on a 5-point hedonic scale.

Formulation	Attribute		
	Appearance^{ns}	Attractive^{ns}	Overall acceptability^{ns}
I	4.88 ± 0.33	4.88 ± 0.33	4.91 ± 0.29
II	4.82 ± 0.39	4.82 ± 0.39	4.88 ± 0.33
III	4.88 ± 0.33	4.91 ± 0.29	4.94 ± 0.24

Values are presented as mean ± standard deviation.
ns = Values are not significantly different in the same column (P ≥ 0.05).

Table 4. The consumer rating of each elderly product on a 5-point hedonic scale.

Formulation	Attribute						
	Appearance^{ns}	Color^{ns}	Flavor^{ns}	Taste^{ns}	Texture^{ns}	Ease of Swallowing^{ns}	Overall acceptability^{ns}
I	4.03 ± 0.81	4.00 ± 0.61	3.91 ± 0.72	3.73 ± 1.04	3.82 ± 0.78	4.70 ± 0.47	3.88 ± 0.89
II	3.82 ± 0.67	4.06 ± 0.78	3.65 ± 0.85	3.59 ± 1.08	3.82 ± 0.67	4.76 ± 0.43	3.85 ± 0.78
III	3.82 ± 0.77	3.79 ± 0.74	3.82 ± 0.73	3.64 ± 0.96	3.94 ± 0.75	4.76 ± 0.44	3.85 ± 0.80

Values are presented as mean ± standard deviation.
ns = Values are not significantly different in the same column (P ≥ 0.05).

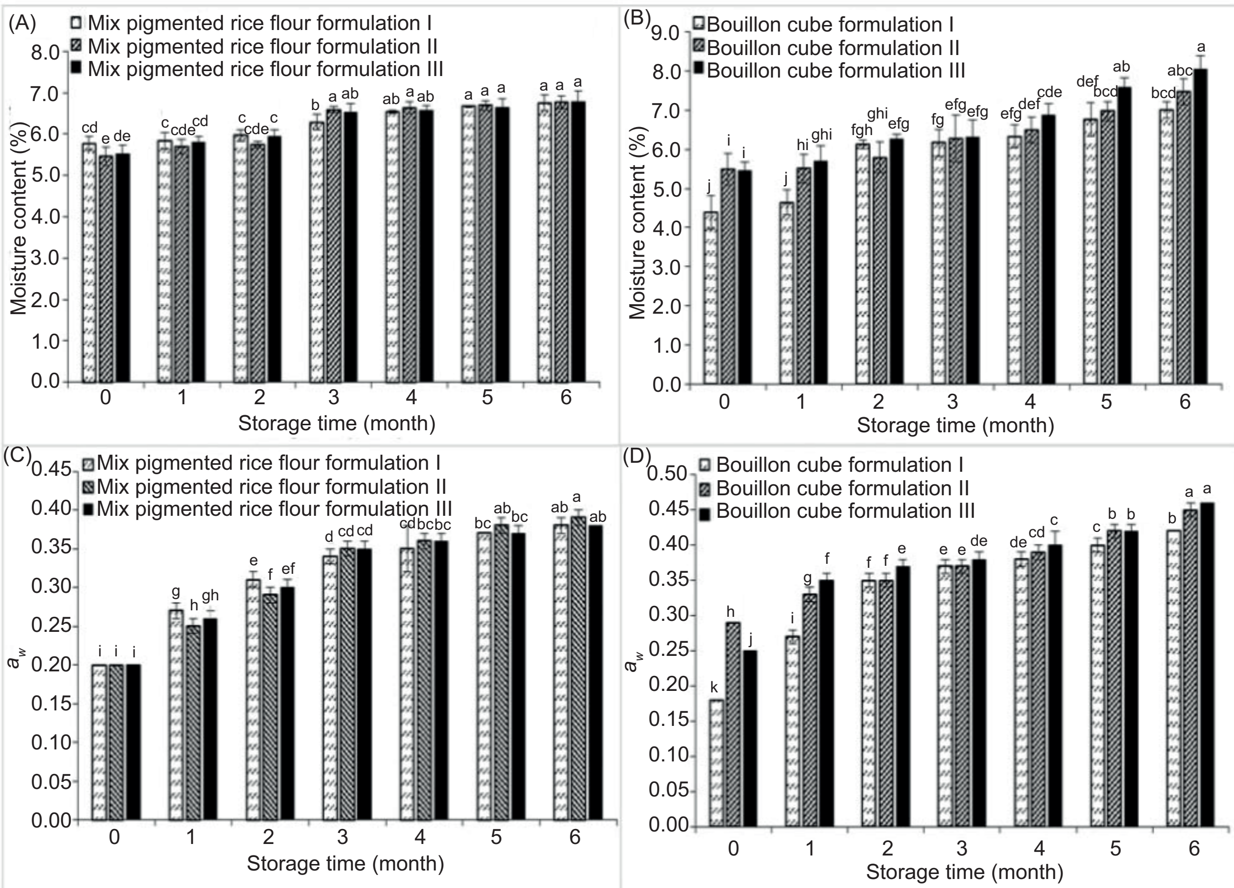

Figure 2. The moisture content of each component (A). Mixed pigmented rice flour and (B). Bouillon cube and the a_w of each component (C). Mixed pigmented rice flour and (D). Bouillon cube in three formulations of elderly product during 6 months of storage. Different letters above bars indicate significant differences (P < 0.05).

slightly at the end of the storage period (average score of 5.6). During the study, the visual characters of the products (appearance and color attributes) were rated as 5.7–6.6 (like slightly – like moderately). The scores for taste were higher throughout the storage, 7–7.9. Similar to the consumer acceptance test, the panel liked the products for their ease of swallowing with a high score of 8 out of 9 (like very much). The testers rated the porridge formulations for the elderly as overall "moderately liked to liked very much" until the end of the tested storage period.

Conclusion

The developed elderly diet was provided in three components (mixed pigmented rice flour, freeze-dried bouillon cube, and sesame oil) and had a nutritional balance of 45% carbohydrate, 17% protein, and 22% fat. Three formulations were generated at three caloric concentrations and provided 379, 453, and 528 kcal per portion. According to the consumer acceptance test, the newly developed diet was well accepted by 100 panels, with an overall acceptance score of 4 out of 5 for product and 5 out of 5 for packaging design. This showed high potential for launching to target the elderly product market with its key properties being easy and rapid preparation and ease of swallowing. The product can retain its quality for at least 6 months with only a minor change in odor. The elderly diet formulations were moderately liked in terms of overall acceptance and achieved microbiological standards during 6 months of storage at ambient temperature. To improve the product's qualities and prolong the shelf life (reduce moisture uptake and unpleasant flavor development), the selection of suitable packaging materials and packing conditions are suggested for future study.

Conflict of interest

The authors declare no conflict of interest.

Table 6. The sensory evaluations of elderly product formulation I, II, and III during 6 months of storage on a 9-point hedonic scale.

Attribute	Storage time (month)						
	0	1	2	3	4	5	6
Formulation I							
Appearance	5.7 ± 1.0[b]	6.0 ± 0.6[a]	5.9 ± 0.7[a]	5.9 ± 0.5[a]	5.9 ± 0.5[a]	5.9 ± 0.4[a]	5.9 ± 0.5[a]
Color	6.1 ± 0.9[a]	6.0 ± 0.8[a]	5.9 ± 0.7[a]	6.0 ± 0.4[a]	5.9 ± 0.3[a]	5.9 ± 0.4[a]	5.9 ± 0.2[a]
Flavor	6.8 ± 0.4[a]	6.8 ± 0.4[a]	6.6 ± 0.5[a]	6.6 ± 0.4[a]	6.3 ± 0.4[ab]	5.8 ± 0.5[b]	5.6 ± 0.3[c]
Taste	7.2 ± 0.9[a]	7.1 ± 0.9[a]	7.2 ± 0.8[a]	7.1 ± 0.5[a]	7.1 ± 0.5[a]	7.1 ± 0.5[a]	7.1 ± 0.4[a]
Ease of swallowing	7.8 ± 0.8[a]	8.0 ± 0.8[a]	8.0 ± 0.8[a]	8.0 ± 0.6[a]	8.0 ± 0.7[a]	8.0 ± 0.5[a]	8.0 ± 0.5[a]
Overall liking	7.3 ± 0.8[b]	7.4 ± 0.7[b]	7.9 ± 0.8[a]	7.5 ± 0.5[a]	7.4 ± 0.5[a]	7.4 ± 0.4[a]	7.2 ± 0.7[a]
Formulation II							
Appearance	6.6 ± 0.8[b]	6.6 ± 0.8[a]	6.7 ± 0.7[a]	5.9 ± 0.4[c]	5.9 ± 0.5[c]	5.9 ± 0.4[c]	5.9 ± 0.5[c]
Color	6.2 ± 0.8[a]	6.3 ± 0.7[a]	6.4 ± 0.6[a]	6.0 ± 0.4[b]	5.9 ± 0.3[b]	5.9 ± 0.4[b]	5.9 ± 0.6[b]
Flavor	7.2 ± 0.8[a]	7.4 ± 1.0[a]	7.6 ± 0.9[a]	6.6 ± 0.5[b]	6.3 ± 0.4[b]	5.8 ± 0.5[c]	5.6 ± 0.3[c]
Taste	7.7 ± 0.9[a]	7.7 ± 0.9[a]	7.9 ± 0.9[a]	7.1 ± 0.5[b]	7.1 ± 0.5[b]	7.1 ± 0.5[b]	7.1 ± 0.4[b]
Ease of swallowing	7.9 ± 0.7[a]	7.9 ± 0.6[a]	7.8 ± 0.7[a]	8.0 ± 0.6[a]	8.0 ± 0.7[a]	8.0 ± 0.5[a]	8.0 ± 0.5[a]
Overall liking	8.0 ± 0.6[a]	8.1 ± 0.6[a]	8.0 ± 0.6[a]	7.5 ± 0.5[b]	7.4 ± 0.5[b]	7.3 ± 0.3[b]	7.2 ± 0.7[c]
Formulation III							
Appearance	6.4 ± 1.4[a]	6.2 ± 1.1[b]	6.0 ± 1.1[b]	5.9 ± 0.3[c]	5.9 ± 0.6[c]	5.9 ± 0.4[c]	5.9 ± 0.9[c]
Color	6.2 ± 1.0[a]	6.1 ± 0.9[a]	6.3 ± 0.9[a]	6.0 ± 0.8[b]	6.0 ± 0.7[b]	5.9 ± 0.6[b]	5.9 ± 0.6[b]
Flavor	7.4 ± 0.8[a]	7.5 ± 0.8[a]	7.6 ± 0.9[a]	6.6 ± 0.5[b]	6.2 ± 0.6[bc]	5.6 ± 0.3[c]	5.6 ± 0.6[c]
Taste	7.4 ± 1.0[a]	7.5 ± 0.9[a]	7.7 ± 0.9[a]	7.1 ± 0.4[b]	7.1 ± 0.4[b]	7.0 ± 0.5[b]	7.0 ± 0.9[b]
Ease of swallowing	7.9 ± 1.1[a]	7.8 ± 1.0[a]	7.9 ± 0.8[a]	8.0 ± 0.3[a]	8.0 ± 0.4[a]	7.9 ± 0.4[a]	7.9 ± 0.3[a]
Overall liking	7.4 ± 0.9[b]	7.6 ± 0.9[a]	7.6 ± 0.7[a]	7.5 ± 0.5[ab]	7.5 ± 0.6[b]	7.3 ± 0.6[b]	7.3 ± 0.4[b]

Values are presented as mean ± standard deviation.
Values with the same superscript within the same roll are not significantly different ($P \geq 0.05$).

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