DEVELOPMENT OF CALCIUM, THIAMINE AND RIBOFLAVIN FORTIFIED SNACK FOR THE ELDERLY

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Abstract

Micronutrient deficiency problem in the elderly is being addressed worldwide. This research aims to formulate snack containing calcium, thiamin and riboflavin in the range of 20-30% of the Thai Recommended Daily Intakes. Tri-calcium phosphate was fortified to the product. Black sesame seed was added as a source of thiamine and riboflavin. In addition, texture of the snack is concerned for easy chewing and swallowing. The process of formulation including calculation of nutritive values by the INMUCAL program, and in-house sensory evaluation using a seven-point hedonic test and a five-point just-about-right test. The fortified snack recipe consists of 44% (w/w) black sesame seed, 22% (w/w) full fat soy flour, 14% (w/w) coconut milk, 13% (w/w) sugar, 0.3% (w/w) tri-calcium phosphate and 6.7% (w/w) of butter, egg and flavoring agent. The snack was baked at 230°C for 7 min. Sensorial color was evaluated as too dark due to the color of black sesame seed which in agreement with the L* value of 28.2. Hardness of the developed snack (827 g force) measured by a texture analyzer was lower than that of the control (4634 g force). It is noted that one serving of the fortified snack (55 g) provided calcium, thiamine and riboflavin at 85, 26 and 30% of Thai RDI, respectively. Moreover, protein content increased from 4.7 g to 12.6 g when compared to the control.

Keywords: complementary food, sesame seed, tri-calcium phosphate, elderly

Introduction

The elderly population in Thailand is growing rapidly as a result of a decreasing of mortality rate. The number of elderly population in 2011 demonstrate that Thailand becomes an aging society as the proportion of the elderly aged 60 years or over is more than 10% of the whole population (Swanson et al., 2004). This highlights a concern of the elderly health care which should be increased to improve the elderly health well-being. Pongpaew *et al.* (2000) have shown that both male and female elderly presented lower intakes of calcium, phosphorus, thiamine and riboflavin compared to the Thai Recommended Daily Allowance (Thai RDA) (Pongpaew et al., 2000). Moreover, Assantachai and Lekhakula (2005) also reported concordant data of low vitamin intake to the previous study (Assantachai et al., 2005). According to the research of Pongchaiyakul *et al.* (2008), there were more than half of the participants who had an average daily calcium intake less than 400 mg/day (Pongchayakul et al., 2008)(Thai RDI for calcium is 800 mg/day). Data also showed a significant decrease in average calcium intake in the elderly age. Insufficiency calcium consumption of the Thai elderly affects bone situation for instance osteoporosis. Furthermore, poor denture health can contribute to the unpleasant quality of the elderly life as low nutrition intake, terrible emotional expression and impure physical appearance. Moreover, not only the inadequate intake of nutrients when become advancing age the elderly aged 60 years and over, also face degenerative diseases such as cardiovascular diseases and diabetes (Wibulpolprasert et al., 2008). Therefore, the elderly should have awareness to their eating behavior and should strict to what they eat that may be promote risk of their life.

Soybean has been considered as an important source of plant protein with low price. Soybean is suitable for the elderly because it contains good quality of protein and less saturated fatty acid content (Leiner, 1972). Isoflavone, a bioactive compound found in soybean, is considered to help preventing the risk of many diseases such as coronary heart disease, colon cancer, and osteoporosis (Dixon, 2004). Because of its benefits, there are many products from soybean for aging population to prevent degenerative diseases. Sesame seed is a great source of thiamine and riboflavin in plant source which provides 0.97 mg thiamine and 1.11 mg riboflavin/100 g (Puwastien et al., 1999). In addition, sesame seed also has bioactive compounds namely sesamin and sesamolin. These two compounds have activities as antioxidant (Kang et al., 1998; Yamashita et al., 1992; Sirato-Yasumoto et al.,2001), blood pressure reducer (Mutumura et al., 1995; Hirose et al., 1991; Mutumura et al., 1998), and serum lipid lowering (Hirose et al., 1991; Hirata et al., 1996). However, high content of phytate in sesame seed have been a serious problem in regard to the absorption of cation minerals including Ca , Mg, Fe, Zn and Cu. Nonetheless some studies reported that phytic acid may act as an antioxidant that is beneficial to health by preventing degenerative disease (Halliwell, 1997; Rice-Evans and Diplock 1993).

This research aims to develop soy snack, a complementary food, containing high amounts of calcium, thiamine and riboflavin. Calcium was fortified to the products in a form of tri-calcium phosphate. Sesame seed was added to the products as a source of thiamine and riboflavin.

Methodology

Preparation of the control formula

The control snack formula was modified from Khanom Ping formula obtained from the Step-by-Step Thai Desserts cookbook (Hongvivat, 2005). Tapioca flour was roasted on a pan for 3 minutes and cooled down to room temperature (approximately 28°C). Tapioca flour and full-fat soy flour (DOI KHAM™) was mixed at a ratio of 2 to 1 (w/w), and sifted through a flour sieve. Coconut syrup was prepared by simmering sugar and coconut milk for 5 minutes then butter was added and the syrup was cooled down to room temperature. Coconut syrup, egg yolk, and vanilla flavor were added to the sifted flour. The mixture was kneaded until the dough was form. The dough was cut into pieces (sized about 5.5-cm diameter and 0.5-mm thickness) then incubated in a refrigerator for 3 hours. The dough pieces were baked in a baking oven at 232°C (450°F) for 7 minutes. The snack was cooled to room temperature and kept in plastic bags.

Formulation of the fortified snack

To formulate the calcium, thiamine and riboflavin fortified snack, calcium was fortified in a form of tri-calcium phosphate and sesame seed was added as a source of thiamine and riboflavin. Total nutrient contents of the snack were calculated using the INMUCAL program. Tri-calcium phosphate and black sesame seed were added until calcium, thiamine and riboflavin contents are more than 20% of Thai RDI. Two different fortified snack formulas were performed as follows: Formula A-a sesame seed to flour mixture ratio of 1 to 1 (w/w) was used, and Formula B- black sesame seed was substituted tapioca flour at the level of 100%. Black sesame seed (RAITIP^{TM}) was prepared by washing with water at the ratio of 1 to 1 (w/w). The seed was roasted for 3 minutes at low heat level, and cooled to room temperature before grinded with a coffee seed grinder for 10 seconds. Tri-calcium phosphate was added to the flour before sifting. The following step is the same as mention for the control formula.

Sensory Evaluation

In-house acceptability test: A hedonic test was used to evaluate general appearance and overall acceptability of the control snack and the formulated snack. A randomized complete block design was conducted using twenty five panelists including staffs and graduate students of the Institute of Nutrition, Mahidol University (INMU). Sensory evaluation was performed at the Sensory Science Laboratory, INMU. The scale has seven points, and the descriptions range from 7 (like extremely) to 1 (dislike extremely). A formula with the highest score and more than 5 of overall acceptability would be acceptable.

Just-about-right test: A just-about-right test was used to evaluate the suitability of product characteristics including color, odor, sweetness and texture. A five-point scale is a bipolar scale with 5 (too much), 3 (just-about-right), and 1(too little).

Physical analysis

Color: Color values were determined using a spectro-colorimeter model JS555 (Color Techno System Corporation, Japan). L*, a* and b* values represent darkness/light (0:black, 100:Light), greenness/redness (-a: greenness, +a: redness) and blueness/yellowness (-b: blueness, +b yellowness), respectively.

Texture: Texture was evaluated using a texture analyzer TA.XT plus (Stable Micro Systems Ltd., UK) attached with a three-point bend rig. Each snack piece was pressed at 1 $m.s^{-1}$ pre-test speed and 5 $m.s^{-1}$ test speed. Hardness of ten snacks was measured as the peak of breaking force (g) and fracturability of the snack was determined by the distance compressed before breaking (mm).

Statistical analysis

In-house acceptability data was analyzed by descriptive analysis. One-sample t-test was used to determine suitability of product characteristics for a just-about-right test. One-way ANOVA was used to evaluate the significant difference between mean values of physical properties. When significant difference in one-way ANOVA was detected, means were compared using the Duncan's Multiple Range test. Significant difference was determined at $p \leq 0.05$. All data were expressed as mean±SD.

Results and Discussion

The calcium, thiamine and riboflavin fortified snack was formulated into two formulas. Formula A consisted of a black sesame seed to flour mixture ratio of 1 to 1 (w/w). For Formula B, black sesame seed was substituted tapioca flour at the level of 100% therefore a sesame seed to full-fat soy flour ratio of 2 to 1 (w/w) was used. The overall acceptability scores of the control formula, and the fortified snack Formula A and B were 4.1 4.9 and 5.2 (out of 7), respectively (Table 1). When compared the score of color with score of 3 (just-about-right score), the results showed that the color scores of both Formulas A (4.0) and B (3.8) was significantly different from score of 3. This indicated that addition of black sesame seed to the snack provided too dark in color. The odor of the control and Formulas A and B was characterized as "just right" while sweetness was evaluated as "not sweet enough" with scores ranged between 2 and 3. However, this slightly sweet taste may be suitable for the elderly who are at risk of overweight and obesity. The results of texture in Table 1 show that the control snack and snack Formula B had "just right" texture while texture of Formula B was defined as "too hard" (score of 3.6). According to the overall acceptability score, formula B was chosen because its overall acceptability score was more than 5 (like slightly). The fortified snack Formula B consists of 44% (w/w) black sesame seed, 22% (w/w) full fat soy flour, 14% (w/w) coconut milk, 13% (w/w) sugar, 0.3% (w/w) tri-calcium phosphate and 6.7% (w/w) of butter, egg and flavoring agent.

Table 1 Sensory scores of the control snack (CS) and the fortified snacks[1].

Formula[2]	Overall acceptability[3]	Color[4]	Odor[4]	Sweetness[4]	Texture[4]
Control	4.1±1.6	2.9±0.6	2.9±0.8	2.5±0.8[a]	2.9±1.5
Formula A	4.9±1.5	4.0±0.8[a]	3.1±0.7	2.7±0.6[a]	3.6±1.0[a]
Formula B	5.2±1.4	3.8±0.7[a]	3.2±0.5	2.5±0.6[a]	3.0±1.0

[1]Mean±SD, n=30.
[2]Control: tapioca flour to full-fat soy flour ratio = 2 to 1 (w/w), Formula A: sesame seed to flour mixture = 1 to 1 (w/w), Formula B: sesame seed to full-fat soy flour ratio = 2 to 1 (w/w)
[3]seven-point hedonic scale (7 = like extremely, 4= neither like nor like, 1 = dislike extremely)
[4]five-point just-about-right scale (5 = too much, 3 = just right, 1 = too little)
[a]Significant different from the score of 3 (just-about-right score).

The results of physical analysis of the control and the fortified snacks presented in Table 2 show that both fortified snack formulas had softer texture than the control. When compared between the fortified formulas, texture of snack Formula B (827 gram force) was softer than that of Formula A (3001 gram force) which implies that Formula B may be suitable for the elderly who have a dental problem. Moreover fracturability distance of the fortified snacks was 1.6 mm which was lower than that of the control snack. It was noticed that Formulas A and B had b* values lower than the control which in agreement with the "too dark" just-about-right score of color.

Table 2 Physical properties of the control snack and the fortified snacks[1].

Formula[2]	Texture		Color value		
	Hardness force (g)	Fracturability distance (mm)	L*	a*	b*
Control	4309±864[c]	2.1±0.5[b]	75.3±0.8[b]	+4.4±0.3[c]	+30.2± 0.9[c]
Formula A	3001±700[b]	1.6±0.3[a]	48.5±0.4[b]	+1.9±0.2[b]	+13.1±0.3[b]
Formula B	827±70[a]	1.6±0.3[a]	28.2±0.6[a]	+0.07±0.01[a]	+5.7±0.1[a]

[1]Mean±SD of three replications

[2] Control: tapioca flour to full-fat soy flour ratio = 2 to 1 (w/w), Formula A: sesame seed to flour mixture = 1 to 1 (w/w), Formula B: sesame seed to full-fat soy flour ratio = 2 to 1 (w/w)
[a-c] Values in the same column with different letters are significantly different ($p \le 0.05$).

Nutrient contents per serving of snack (55 grams) calculated by the INMUCAL program are presented in Table 3. The fortified formulas provided higher energy than the control snack. High energy of the developed snacks is due to high fat content which came from black sesame seed. Black sesame seed also increased dietary fiber, thiamin, and riboflavin contents of the fortified snacks especially in Formula B where dietary fiber content is twice as much as the control which accounts for 24% of Thai RDI, and thiamine and riboflavin contents are 26 and 30% of Thai RDI respectively.

Total calcium contents of snack Formulas A and B were 14 and 18 times of that of the control respectively which account for 69 and 85% of Thai RDI. Total calcium in the developed snacks came from black sesame seed and tri-calcium phosphate. However, Kamchan *et al.* have reported that calcium from sesame seed has low bioavailability because it is in a form of calcium phytate (Kamchan et al., 2004). When exclude amount of calcium from black sesame seed, calcium contents of both Formulas A and B were 210 mg or 26% of Thai RDI.

Table 3 Nutrient compositions of the control snack and the fortified snacks per serving (55 grams).

Nutrient	Control		Formula A		Formula B	
	Content	%Thai RDI	Content	%Thai RDI	Content	%Thai RDI
Energy (kcal)	196	9.8	295	14.7	304	15.2
Protein (g)	4.7	9.4	9.2	18.4	12.6	25.2
Carbohydrate (g)	26.3	8.8	28.1	9.3	19.3	6.4
Fat (g)	8.4	13	18.1	27.8	22.2	34.1
Dietary Fiber (g)	3.1	12.4	4.3	17.2	6.0	24
Thiamine (mg)	0.085	5.7	0.28	18.7	0.39	26
Riboflavin (mg)	0.16	9.4	0.38	22.3	0.52	30.6
Calcium (mg)	38.1	4.8	559.0	69	679.0	85

[1] Total calcium in formulated snack; [2] Calcium content by adding sesame seed; [3] Calcium content by adding tri-calcium phosphate
[2] Control: tapioca flour to full-fat soy flour ratio = 2 to 1 (w/w), Formula A: sesame seed to flour mixture = 1 to 1 (w/w), Formula B: sesame seed to full-fat soy flour ratio = 2 to 1 (w/w)

Conclusion

Snack developed for the elderly in this study consists of full fat soy flour, coconut milk, sugar, butter, egg and flavoring agent which tri-calcium phosphate is fortified as a source of calcium and black sesame seed is added as a source of thiamine and riboflavin. It is noted that one serving of the fortified snack (55 g) provided calcium, thiamine and riboflavin at 85, 26 and 30% of the Thai RDI, respectively. Even though the color was evaluated as too dark due to the color of black sesame seed, the snack texture is soft which is suitable for the elderly.

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