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Textural properties and sensory acceptability of texture-modified pork balls for the elderly

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Abstract

In the older adult population, malnutrition in the elderly can be caused by chewing and swallowing difficulties. This study aimed to formulate texture-modified pork balls for the elderly with different degrees of tooth loss according to the Eichner Index. The texture of the pork ball was modified by varying the percentage of pork, lard, and tapioca flour added from 31-37%, 20-24% and 1.5-3.5%, respectively. The physicochemical properties and sensory acceptability of the samples were investigated. The increase in pork level and decrease in lard and flour levels affected the textural properties of the samples by increasing hardness, springiness, cohesiveness, gumminess, chewiness and decreasing adhesiveness. The posterior occlusal contact or the Eichner index was used as a criterion to arrange the older panelists into three groups. All the developed texture-modified pork ball formulas had overall liking scores in ranges of like slightly to like moderately and also got just-about-right rating for color, taste and easy to chew. For the elderly who had contacts in four support zones, the suitable levels of pork, lard and tapioca flour were found to be at 37%, 20% and 1.5%, respectively. In addition, for the elderly who had one to three zones of contact or contact in the anterior region only or had no support zones, the suitable levels of pork, lard, and flour were found to be at 34%, 22% and 2.5%, respectively. This study demonstrates that this product combined with other food stuffs may have the potential for improving the nutritional status of the elderly.

Keywords: Texture-modified pork balls, Elderly, Tooth loss, Eichner index, Sensory

1. Introduction

Thailand has been advancing into an aging society since 2005 when the proportion of people of 60 years of age or above reached 10%, according to the United Nations and will achieve the status of "complete aging society" in 2021 when the elderly proportion of the population reaches 20% [1]. Changes related to aging have an effect on the food consumption patterns of the elderly. Some foods become troublesome to eat due to tooth loss and swallowing dysfunction that are observed frequently among older people. Tooth loss has been related to a lower intake of hard-to-chew foods, such as raw vegetables, unripe fruits, well-done meats, and crusty breads [2-3]. This problem has a negative impact on general health, thereby causing malnutrition, disability, loss of independency and poor quality of life [4].

In order to help and support the consumption of healthy foods in the elderly, modification of the texture of solid or liquid foods is highly important and required. Ideal food texture properties for the older adults should include those that are soft, moist and easily chewed with lowest mastication effort and provide the required nutrient density [5]. Meat and its derived products are generally recognized as nutritious food products because they contain both macronutrients, such as high biological value proteins and micronutrients, such as group B vitamins

and minerals, as well as other bioactive compounds [6-7]. The restructured meat products, such as meatballs and sausages, can be classified as convenience foods. These kinds of food products consist of a mixture of comminuted meat, protein, fat particles, carbohydrate and water [8]. There are several kinds of meatball available in the Asian markets, including Thailand. A meatball can be made from several types of meat, such as beef, pork, fish and chicken. Especially, minced pork balls are normally served with other foodstuffs, such as rice congee, rice porridge and soup. These kinds of food can be served to the elderly who have tooth loss.

However, the difference in raw materials, recipes and cooking methods used to prepare the minced pork balls may affect its textural properties, thereby affecting consumer acceptability. Hence, the development of texture-modified minced pork balls with a suitable texture has the potential to increase meat product consumption and to improve nutrition status in the elderly. The aim of this study was to formulate the texture-modified pork ball and also investigate the effect of a combination of pork tenderloin, lard and tapioca flour on characteristics of the formulated pork ball as a food for the elderly. Characterizations of the formulated park ball were carried out in terms of proximate composition, chemical properties, textural properties and sensory evaluation.

2. Materials and methods

2.1 Materials

Two types of pork materials, tenderloin pork with approximately 10% fat and lard were used as the main ingredients for the preparation of pork balls and additional ingredients, including tapioca flour, soy sauce, peppers, garlic powder, carrots, shitake mushrooms and spring onions, were obtained from a local supermarket in Nakhon Pathom, Thailand.

2.2 Preparation of texture-modified pork balls

Three formulations of the texture-modified pork balls, including soft texture (ST), medium texture (MT) and hard texture (HT), were formulated by varying the amount of minced pork tenderloin, lard and tapioca flour as shown in Table 1. To produce pork balls, frozen minced pork tenderloin and lard with a different ratio (31:24, 34:22 and 37:20) were minced for 2 min in a food processor (FPP230, KENWOOD, Long Beach, USA) and then mixed with different percentages of tapioca flour (3.5, 2.5 and 1.5% w/w) for 3 min. The mixture together with other ingredients, including cold water (20% w/w), coarsely chopped shitake mushrooms (7% w/w), coarsely chopped carrots (7% w/w), coarsely chopped spring onions (5% w/w), soy sauce (2% w/w), garlic powder (0.3% w/w) and white pepper (0.2% w/w), were continuously mixed in the machine for 3 min. The mixed ingredients of 4.0±0.5 g were moulded into a round shape by hand and quickly dropped into warm water (50±1 ˚C) for 15 min. Then, the pork balls were cooked in boiling water (90±1 ˚C) for 10 min, collected, kept in cold water (5±1 ˚C) for 15 min followed by air-drying. The texture-modified pork balls were then closely packed in a polypropylene bag. The products were stored in a refrigerator at 4±1 ˚C until analyses.

Table 1 Formulation of texture-modified pork balls with a different ratio of pork tenderloin, lard and tapioca flour.

Ingredient (% w/w)	Formulation		
	ST	MT	HT
Pork tenderloin	31.0	34.0	37.0
Lard	24.0	22.0	20.0
Tapioca flour	3.5	2.5	1.5
Cold water	20.0	20.0	20.0
Shitake	7.0	7.0	7.0
Carrot	7.0	7.0	7.0
Spring onion	5.0	5.0	5.0
Soy sauce	2.0	2.0	2.0
Garlic powder	0.3	0.3	0.3
Pepper	0.2	0.2	0.2

2.3 pH measurement

The pH value of the texture-modified pork ball was measured according to the AOAC (2005) procedure using a pH meter (STARTER 310, OHAUS, Shanghai, China). An homogenous sample was prepared by blending 5 g of the texture-modified pork ball with 45 ml distilled water.

2.4 Color measurement

The texture-modified pork ball samples were measured for color in the *L**, *a**, *b** system using a colorimeter (ColorFlexEZ, Hunter Associates Laboratory, Inc., Reston, USA). A white standard porcelain plate was used to calibrate the equipment.

2.5 Texture profile analysis (TPA)

Texture profile analysis (TPA) was conducted at room temperature (25±1 ˚C) using a Texture Analyzer (TA-XT Plus, Stable Micro Systems, Godalming, UK) equipped with a 100 mm diameter compression platen according to the method of Nurkhoeriyati et al., 2012 [9] with minor modifications. The sample was compressed using the test speed of 1.0 mm/s, post-test speed of 1.0 mm/s, and prefixed strain of 60%. After the first compression, the probe returned to the initial position and stopped for 2 s before the second compression started. The parameters of TPA, namely hardness, springiness, cohesiveness, gumminess, and chewiness were computed. Fifteen pork balls from each batch were analyzed.

2.6 Sensory evaluation

The sensory evaluation protocol was approved by Mahidol University Central Institutional Review Board (MU-CIRB) with the approval number 2016/171.2510. The sensory evaluation was performed at the Institute of Nutrition, Mahidol University, Thailand. For sample preparation, the texture-modified pork balls were cooked and added with clear soup at 70 ˚C. Then, the samples were served separately to 90 untrained elderly panelists in a well-lit sensory room.

The elderly panelists were classified into three groups by posterior occlusal contact (30 subjects per each group), according to the Eichner Index (EI). Group A had contacts in four support zones; group B had one to three zones of contact or contact in the anterior region only; and group C had no support zones, although some of the teeth might still remain. The appearance, color, flavor and overall acceptability were determined by a 5-points hedonic scale. Color, taste, and easy to chew ability were evaluated by using a 5-point just-about-right scale in order to determine appropriate formulation for each group. All samples were coded with randomly selected 3-digit numbers. The test was carried out under fluorescent lighting. Panelists were asked to cleanse their palates using drinking water before testing the next sample. The mean scores for each attribute were reported.

2.7 Statistical analysis

A one-way analysis of variance (ANOVA), followed by the Duncan multiple range test were used to establish the significance of differences ($p<0.05$) among the mean values. The SPSS version 18.0 (SPSS Inc., Chicago, Illinois, U.S.A) was used to perform statistical analyses.

3. Results and discussion

3.1 pH and color of pork ball

The pH values and color of all formulated pork balls with different ratios of pork tenderloin, lard and tapioca flour are shown in Table 2. The appearance of three formulas of texture-modified pork balls is shown in Figure 1. The pH values were statistically different ($p<0.05$) among samples with various ratios of pork tenderloin, lard and tapioca flour. The pH values were increased, when the ratio of pork tenderloin increased and the lard and tapioca flour decreased in the formulation. After slaughter, glycogen in the muscles is transformed by anaerobic to lactic acid, resulting in the decline of pH [10]. The pH decline rate and extent varies with species, muscle type, antemortem factors and temperature [11]. Moreover, the differences in pH of the samples may be due to the initial pH of raw vegetables and tapioca flour used in the formulations.

Table 2 pH, color, and texture profile of texture-modified porkballs with a different ratio of pork tenderloin, lard, and tapioca flour.

Properties	Formulation		
	ST	MT	HT
pH	5.28±0.02[a]	6.22±0.02[b]	6.27±0.02[c]
Color			
*L**	67.84±0.10[a]	66.10±0.06[b]	65.37±0.08[c]
*a**	4.96±0.11[a]	4.92±0.09[a]	4.31±0.10[b]
*b**	21.01±0.04[a]	20.03±0.06[b]	21.27±0.08[a]

Properties	Formulation		
	ST	MT	HT
Texture			
Hardness (g)	302.12±38.91^{c}	352.44±42.42^{b}	464.21±65.60^{a}
Adhesiveness (g.s)	-21.85±9.35^{a}	-12.94±5.22^{b}	-7.67±3.67^{c}
Springiness	0.35±0.04^{c}	0.43±0.06^{b}	0.57±0.09^{a}
Cohesiveness	0.27±0.02^{c}	0.30±0.02^{b}	0.34±0.03^{a}
Gumminess	82.93±13.67^{c}	105.21±16.55^{b}	156.20±25.37^{a}
Chewiness	29.59±7.49^{c}	45.56±11.96^{b}	89.01±22.17^{a}

Mean±standard deviation values in the same row followed by different superscripts are statistically different (p<0.05).

Figure 1 Appearance of texture-modified pork ball with different ratio of pork tenderloin, lard, and tapioca flour (ST-soft texture; MT-medium texture; HT-Hard texture).

All color measurements were performed after the samples were freshly cooked. Statistical analysis indicated that the lightness was statistically different (p<0.05) for the various texture-modified pork ball formulations, while a* and b* values were not significantly different among samples. It is clearly seen that the L* value decreased when the pork tenderloin increased while lard and tapioca flour decreased. The results showed that the texture-modified pork balls with higher ratios of lard and tapioca flour were slightly lighter and redder than those with higher ratios of pork tenderloin. This is because the natural color of lard, that is a semi-soft white fat compared to pork tenderloin which is a red color. The tapioca flour did not affect the color of the samples. According to Yi et al., (2012) [12], the color of beef patties added with glutinous rice flour was not significantly different. The different results may be related to materials and the processing used.

3.2 Texture profile analysis

Results on the textural properties of pork balls are shown in Table 2. Significant differences (p<0.05) between formulas were found in all textural parameters. The hardness, springiness, cohesiveness, gumminess and chewiness values were increased while adhesiveness values were decreased, when the amount of pork tenderloin increased and the lard and tapioca flour decreased in the formulation. The degree of comminuting and myofibrillar protein extracted, stromal protein content, as well as level and type of non-meat ingredients are the critical factors accountable for the textural quality and properties of restructured processed meat [13]. The main ingredients of the texture modified pork balls were pork tenderloin and lard whereas the minor ingredient was tapioca flour. Thus, the differences in all textural parameters of pork balls were affected by the ratio of pork tenderloin and lard. Banon et al. (2008) [14] reported that an increase in the ratio of fat to lean meat caused a decrease in gel strength, thereby decreasing hardness, springiness, cohesiveness, gumminess and chewiness values. This result can be explained by the lower or insufficient emulsifier from salt-soluble proteins, for example myosin, which may result in lower quality characteristics in the sausages. The increase in protein concentration generated more rigid structures, thereby increasing hardness, chewiness and gumminess values [15]. However, the addition of starch as a binder in meat products showed the ability to increase water binding properties [16-18]. However, Hsu and Chung (1998) [19] suggested that there was a positive correlation between hardness and overall acceptability rated by panelists, which means that panelists actually preferred the harder texture. In fact, the higher values for all textural parameters, such as hardness, cohesiveness, elasticity and chewiness do not necessary mean better quality. Yu and Yeang (1993) [20] explained that there is a certain value above which the texture of meatballs would not be acceptable. Therefore, to find out the preferable and best textural qualities of the texture-modified pork balls, the texture profile analysis should be performed together with sensory evaluation by target panelists.

3.3 Sensory evaluation

Table 3 presents the scores of sensory attributes for each formulation. The result showed that there were no significant differences (p<0.05) among three formulations with different ratios of pork tenderloin, lard, and tapioca flour. The appearance, color, flavor, taste and overall acceptability scores of HT formula, which were rated by group A panelists, showed the highest score and was in the range between like slightly and like moderately. While group B and C panelists rated the sensory attribute scores with the same trend, MT formula showed the highest score in appearance, color, flavor, taste and overall acceptability, that were in the range between like slightly and like moderately.

Table 3 Sensory evaluation of texture-modified porkballs with different ratios of pork tenderloin, lard and tapioca flour.

Group	Formulation	Sensory attribute scores[1]				
		Appearance	Color	Flavor	Taste	Overall acceptability
A	ST	3.54±1.10	3.58±1.06	3.79±1.02	3.54±1.14	3.35±1.06
	MT	3.29±1.02	3.42±1.06	3.58±0.93	3.50±1.02	3.73±1.18
	HT	4.08±0.97	4.04±0.91	3.83±0.92	3.96±0.91	4.01±0.93
B	ST	4.17±0.89	4.14±0.81	3.94±0.97	3.60±1.12	3.60±1.05
	MT	4.03±0.79	4.06±0.84	4.09±0.85	3.77±1.26	4.33±1.22
	HT	3.86±1.03	3.91±0.89	3.91±101	3.80±1.11	3.86±1.09
C	ST	4.22±0.98	4.19±0.88	4.06±1.00	4.00±1.23	3.90±1.17
	MT	4.21±1.00	4.28±0.92	4.30±0.96	4.31±1.13	4.59±1.12
	HT	4.11±0.91	4.05±0.91	4.29±0.97	4.21±1.03	4.17±1.01

[1] The sensory score was performed using 5-points hedonic scale (1; did not like at all, 3; neither like nor dislike, 5; liked very much).

The percentages of panelists rating on 5-points just-about-right scale for color, taste, and, easy to chew attributes of the texture-modified pork balls are shown in Table 4. The sensory attributes with more than 70% of the just-about-right (JAR) score means that they were accepted by the panelists and did not need to be improved. The results showed that the percentages of panelists from group A, B and C that perceived the color of the texture-modified pork balls of different formulations as 'just-about-right', were mostly more than 70%, so all formulations did not need to be improved. While the percentages of panelists from each group that rated the taste of all formulations as 'just-about-right' were less than 70%. The taste of the texture-modified pork balls might be affected by the clear soup, which was formulated with a controlled amount of sodium. The easy to chew attribute is an important factor for evaluating the suitable texture of the samples for each group. The results indicated that the percentage of panelists from group B and C that perceived the easy to chew attribute of the MT sample as 'just-about-right' was 70%, indicating that its texture was suitable for group B and C while the percentage from group A that rated easy to chew as 'just-about-right' was less than 70% for all formulations. The result pointed out that the ST sample had the highest percentages of panelists that rated 'much too weak', indicating that its texture was too soft for group A. The MT sample showed the highest percentages at JAR, whereas the HT sample had equal percentages of panelists that rated 'too weak' and 'just-about-right', indicating that the texture of these two formulations was suitable for group A. However, group A panelists rated the HT sample with the highest overall acceptability score using the hedonic scale.

The texture-modified pork balls with higher ratios of lard and tapioca flour were rated as "much too weak" and "too weak" by all the panelists groups, due to the increase in fat levels associated with higher tenderness. In general, fat contributes tenderness, juiciness, flavor, and physical appearance particularly in processed and fabricated products where its contribution to the overall meat quality attributes is important [21]. From the result, there was a close relationship between the number and distribution of teeth remaining and the chewable quality of the texture-modified pork balls in each formula. Food texture properties that are ideally suited to older adults include those that are soft, moist and simply reduced with minimal mastication effort. Easy to chew attributes in this study refers to tenderness in the sample, which is a desirable quality in meat products.

Table 4 Just-about-right (JAR) (%) of texture-modified porkball formula with different ratios of pork tenderloin, lard and tapioca flour.

Group	Formulation	Just-about-right[1] (JAR) (%)														
		Color					Taste					Easy to chewing				
		Much too weak	Too weak	JAR	Too strong	Much too	Much too weak	Too weak	JAR	Too strong	Much too	Much too weak	Too weak	JAR	Too strong	Much too
A	ST	0.0	23.3	76.7	0.0	0.0	43.0	43.3	13.7	0.0	0.0	50.0	16.7	33.3	0.0	0.0
	MT	13.3	30.0	50.0	6.7	0.0	20.0	40.0	40.0	0.0	0.0	30.0	20.0	50.0	0.0	0.0
	HT	3.3	13.3	80.0	3.4	0.0	26.7	20.0	50.0	3.3	0.0	16.7	40.0	40.0	3.3	3.3
B	ST	3.3	13.4	80.0	3.3	0.0	20.0	43.3	36.7	0.0	0.0	13.3	40.0	46.7	0.0	0.0
	MT	0.0	16.7	83.3	0.0	0.0	26.7	26.7	46.6	0.0	0.0	10.0	13.3	73.4	3.3	0.0
	HT	0.0	13.3	86.7	0.0	0.0	10.0	33.3	56.7	0.0	0.0	6.7	33.3	60.0	0.0	0.0
C	ST	3.3	3.3	86.7	6.7	0.0	20.0	26.7	53.3	0.0	0.0	43.3	6.7	50.0	0.0	0.0
	MT	0.0	6.7	90.0	3.3	0.0	13.3	23.3	63.4	0.0	0.0	0.0	30.0	70.0	0.0	0.0
	HT	0.0	6.7	90.0	3.3	0.0	16.6	26.7	56.7	0.0	0.0	36.7	6.6	56.7	0.0	0.0

[1]Sensory score was performed using 5-point just-about-right (1; too weak, 3; just-right, 5; too strong).

4. Conclusion

In conclusion, the suitable formulation of the texture-modified pork balls for the elderly who had contact in four support zones was found to be the hard texture (HT) formula containing pork, lard and tapioca flour at 37%, 20% and 1.5%, respectively. In addition, the medium texture (MT) formula containing pork, lard, and tapioca flour at 34%, 22% and 2.5%, respectively, was found to be suitable for the elderly who had one to three zones of contact or contact in the anterior region only as well as those who had no contact zones, although a couple of teeth might still remain. The increase in the fat (lard) level in the formula is associated with higher tenderness and an easy to chew attribute. The overall acceptability score was in the range between like slightly and like moderately. These texture-modified pork balls can be used in combination with rice, soup, or rice porridge for increasing the nutrition values of food for the elderly.

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