Effect of Washing Methods on Gelation of Hybrid Catfish Ball with Red Curry Paste

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***Abstract*—This study compared washing methods for minced hybrid catfish meat, and improvements to the taste of the washed meat by the addition of red curry paste. The first experiment compared four different treatments methods: washing with cold water, washing with 0.3% (w/w) brine, protein isolation by alkaline solubilization (pH 10.0), and non-washing (control). The most successful method was 0.3% (w/w) brine washing, with a yield close to that of cold water washing. The fish ball made from brine-washed meat had a significantly higher gel strength than the cold water washed meat and lower expressible water than the unwashed meat. Red curry paste was then added at 0, 5, 7.5, 10, and 12% by minced fish weight. The 7.5% mixture had a higher gel strength than the control with no change in expressible water, and was higher in both fiber and ash. In all cases, the addition of curry paste increased sensory scores in color, flavor, taste, and overall liking.**

***Index Terms*—hybrid catfish, catfish ball, washing methods, brine washing, alkaline solubilization, red curry paste**

I. Introduction

Hybrid catfish (*Clarias macrocephalus* x *Clarias gariepinus*) is the product of insemination between a femeal broadhead catfish *(Clarias macrocephalus)*, which is highly tasty but has a slow growth rate, and a male African catfish (*Clarias gariepinus*) which has rapid growth and has strong resistance against disease. Hybrid catfish has rapid growth, is disease resistant, and can be farm well [1]. This catfish is therefore widely consumed and processed into many Thai delicacies.

Fish ball is a familiar food in Thailand due to its good taste and ease of consumption. Generally, fish ball is usually made from clown featherback and spotted mackerel, the former of which is a white and low fat meat fish. However, hybrid catfish is yellow and contains moderate fat. During the production of surimi (minced fish meat), washing to remove fat, blood, enzyme and pigment from the minced fish meat is necessary, especially from the dark meat [2]. Minced fish meat including hybrid catfish after washing has a whiter color and good gelation.

Conventional processing was done by washing minced fish meat with large volumes of water to remove sarcoplasmic protein and concentrate myofibrillar protein. The washing process can improve the gel-forming and sensory characteristics of minced fish [3]. However, conventional washing gives a low yield [4]. A novel process to recover protein by a pH-shift process had to be developed by [5]. An acid and alkaline solubilizing process was researched to overcome the problem of dark meat and pelagic species [6], [7]. The two mechanisms of this process are to solubilize the muscle protein at low and high pH values to separate the soluble proteins, bone, skin, connective tissue, and lipid [8]. The solubilized proteins are recovered by isoelectric precipitation [9].

Curry paste is an important ingredient in Thai food, which can be used to cook many different types of food. Paprika is the main composition in curry paste, together with herbs and spices. Due to the active composition, therefore, curry paste is considered good for health. The fiber, vitamins and minerals contained in curry paste also have a preventive effect against disease [10].

The objective of this study was to investigate an appropriate washing method of minced hybrid catfish meat and to improve the taste of the washed meat by the addition of red curry paste to produce hybrid catfish ball. This will produced a novel product: red curry fish ball.

II. Materials and Methods

A. Materials

Hybrid catfish (*Clarias microcephalus* x *Clarias gariepinus*, 500 g each) were purchased from Talad Thai (Pathum Thani, Thailand). The fish were packed in an ice box and immediately transported to the laboratory. All other general ingredients were bought from local supermarkets.

B. Preparation of Minced Fish Meat

The fish were gutted and washed with tap water. The fillet was minced using a meat grinder (2 mm hole diameter; AT950A, Kenwood, England). The minced fish

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was subjected to treatment at a ratio of washing solution to minced fish at 5:1 (w/w), and the mixture was stirred for 1 min with an idle time of 4 min, for the total of four sessions. Then, the mixture was filtered through cheesecloth and the minced fish meat was weighed. After moisture content determination [11], the minced fish was stored in a chilled room (4±2°C) until catfish ball preparation.

C. Preparation of Catfish Ball

To prepare the gels, 2.5% salt and 0.2% pepper were added to the minced fish and the moisture content adjusted to 80% by addition of iced water during the grinding of the mixture. Then, the batter was stuffed into a cellulose casing (2.5 cm diameter) and tightly sealed at both ends. The temperature of the batter was maintained below 12^{o}C. The gel was set at 40^{o}C for 30 min, followed by heating at 90^{o}C for 20 min. After heating, all gels were immediately cooled in iced water until the core temperature of the samples fell below 10^{o}C. The samples were stored at 4^{o}C overnight prior to further analysis.

D. Effect of Washing Methods on the Gelation of Catfish Ball

Four treatments were investigated for the preparation of minced fish discussed in *Section B*: washing with cold water, washing with 0.3% (w/w) brine, protein isolation by alkaline solubilization (pH 10.0), and non-washing (control)

For the alkaline solubilization (Alkaline), a mixture of iced water and minced fish at a ratio of 5:1 (w/w) was stirred for 2 min, the pH was adjusted with 2N NaOH to 10.0 and the suspension was left to stand without stirring for 20 min. The insoluble part was removed and discarded by filtration through cheesecloth. After that, the soluble protein in the mixture was precipitated by the addition of 2N HCl to pH 5.5 and left to stand for 20 min. Then, the precipitated protein was collected, mixed with a little water and adjusted to pH 7.0 with 2N NaOH. The washing process was carried out at 4±2°C.

After washing, the pH of the washed and unwashed meat was determined and the meat was weighed to calculate the % yield after washing: the washed meat weight was divided by the unwashed meat weight and multiplied by 100. The fish balls were prepared using unwashed and washed meat and the best results (*Section F.*) were selected for the *Section E.*

E. Study of Optimum Amount of Red Curry Paste in Catfish Ball

Red curry paste at 0, 5, 7.5, 10 and 12% by washed minced fish weight was added into the batter after grinding with 2.5% salt and 0.2% pepper. Similar procedure was used to that mentioned above.

F. Analysis of Catfish Ball

1) Gel color

The color of gel samples (5 mm thickness, 2.5cm diameter) were evaluated using a HunterLab (ColorFlex CX2687, USA). D65 illuminant was used as the light source. CIE L*, a*, and b* values were evaluated.

2) Gel strength

Breaking force (g) and deformation (cm)) were evaluated using a texture analyzer (TA -XTPlus, Stable Micro Systems, Surrey, UK) with a spherical probe (5 mm diameter: 60 mm min^{-1} test speed). Gel samples were tested at room temperature. Five cylinder-shaped samples 2.5 cm in length were prepared from each gel. The gel strength (g.cm) was expressed as the breaking force (g) multiplied by the breaking distance (cm).

3) Texture Profile Analysis (TPA)

TPA was conducted using a texture analyzer with a cylinder probe (50 mm diameter). A test speed of 5 mm/sec was applied and each sample was compressed twice to 40% of its height [12]. Gel samples were tested at room temperature. Five cylinder-shaped samples 2.5 cm in length were prepared from each gel. Hardness, adhesiveness, springiness, cohesiveness, gumminess, and chewiness were reported.

4) % expressible water

The expressible water content was measured following the method of [13] with slight modification. Gel samples were cut into pieces of 0.5 x 1 x 0.5 cm^3, weighed (X), and placed between Whatman paper (No.1), three pieces of paper at the bottom and two pieces on the top. A standard weight (5 kg) was placed on the gel samples for 2 min and then removed. The samples were weighed again (Y). Expressible water was calculated using the following equation and expressed as a percentage of sample weight:

$$Expressible\ \ water(\%) = [(X - Y)/(X) \times 100$$

5) Sensory Evaluation

The catfish ball was heated at 75–80^{o}C for 15 min. After that, casing was removed and each gel was cut into 2.5 cm lengths. Thirty untrained panelists evaluated the gels on 9-point hedonic scale (9 = Like extremely, 5 = Neither like or dislike and 1 = Dislike Extremely) for appearance, color, flavor, taste, texture, and overall liking.

G. Proximate Analysis of Catfish Ball with an Appropriate Amount of Red Curry Paste

The chemical composition (moisture, protein, fat, crude fiber, and ash content) of catfish ball with an appropriate amount of red curry paste was determined following the method of [11] and compared with the control. The carbohydrate was expressed as 100 – (moisture – protein – fat – crude fiber – ash content).

H. Statistical Analysis

The experiment was designed using a completely randomized design (CRD). Data were subjected to analysis of variance (ANOVA). A Duncan's New Multiple Range Test was used to determine the differences among sample means at P = 0.05. All experiments were done in duplicate.

III. Results and Discussion

A. Effect of Washing Methods on the Gelation of Catfish Ball

1) Yield and pH of washed catfish meat

Washing with 0.3% brine and cold water showed no significant difference in % yield through the % yield was lower than that of the non-washing process (P>0.05, Table I). The washing process removed fat, blood, enzymes, and other substances from the fish meat [14]. The alkaline solubilization had the lowest % yield (42.40 ±0.83%, Table I). This might be due to the maximum removal of the connective tissue in the process of adjusting pH to 10.0. After that, separation of the connective tissue occurred before precipitation of the supernatant at pI of myosin (pH 5.2-5.5) [3]. Moreover, the alkaline solubilization required filtration of the minced fish two times, which was more than the other washing methods. Thus, the lowest yield was obtained.

pH from the alkaline solubilization process was the lowest (P≤0.05, Table I). It might be due to adjustment of the pH from pI (5.5) to 7.0.

TABLE I. % YIELD AND PH OF WASHED CATFISH MEAT WITH DIFFERENT WASHING METHODS

Washing Methods	Yield (%)	pH
Non-washing	100.00[a]	6.82±0.01[b]
Cold water	62.23±1.14[b]	6.95±0.04[a]
0.3% Brine	62.33±5.36[b]	6.87±0.03[b]
Alkaline solubilization	42.40±0.83[c]	6.53±0.11[c]

Each value is expressed as mean ± standard deviation (n = 5 for pH).
[a, b, c] Values with different letters in the same column are significantly different (P≤0.05).

2) Analysis of catfish ball

a) Gel color

Catfish ball made by washing with alkaline solubilization had the greatest lightness (L∗) (55.36± 1.49, Table II). This process was the most effective method for removing hemoglobin and other pigments. Reference [15] reported that myoglobin of mackerel had isoelectric point (pI) = 5.8-5.9, resulting in solubilization at pH above pI. Myoglobin was not co-precipitated at pI of myosin, used for muscle protein recovery. Therefore, the redness (a∗) was the lowest among all the samples (0.31±0.17, Table II). Washing with brine and cold water made the catfish ball non-significantly different in lightness (P>0.05), but gave more lightness than non-washing (P≤0.05, Table II). The cold and brine washing process showed no significant difference in redness (a∗) or yellowness (b∗) (P>0.05, Table II).

TABLE II. COLOR OF CATFISH BALL WITH DIFFERENT WASHING METHODS

Washing Methods	L∗	a∗	b∗
Non-washing	51.92±0.94[c]	0.70±0.32[a]	10.63±0.91[a]
Cold water	53.13±0.94[b]	-0.20±0.25[c]	9.61±0.90[b]
0.3% Brine	53.47±0.37[b]	-0.24±0.36[c]	9.37±1.00[b]
Alkaline	55.36±1.49[a]	0.31±0.17[b]	11.10±0.35[a]

Each value is expressed as mean ± standard deviation (n = 5).
[a, b, c] Values with different letters in the same column are significantly different (P≤0.05).

b) Gel strength and TPA

Catfish balls with alkaline washing had the maximum breaking force, deformation, and gel strength (Table III). The adjustment of pH to 10.0 may have solubilized the muscle protein at high pH, separating soluble proteins, bone, skin, connective tissue, and lipid [8]. Then, the myofibrillar protein was precipitated back at pH 5.5 [9]. The connective tissue protein, lipid and scale, which disrupted the gelation of the myofibrillar protein, were removed [3]. Therefore, the catfish ball with highest composition of myofibrillar protein had the highest gel strength (965.20±340.29, Table III). Catfish balls produced by brine washing had higher gel strength than those from the cold water washing (Table III). Salt can solubilize myofibrillar protein, increasing gel-forming ability and water retention [16].

TABLE III. BREAKING FORCE, DEFORMATION AND GEL STRENGTH OF CATFISH BALL WITH DIFFERENT WASHING METHODS

Washing Methods	Breaking force (g)	Deformation (cm)	Gel strength (g.cm)
Non-washing	496.36±101.36[b]	1.19±0.14[a]	584.43±121.86[b]
Cold water	416.71±24.50[b]	0.82±0.10[b]	344.19±58.01[c]
0.3% Brine	528.34±63.55[b]	1.01±0.19[a]	542.09±161.27[b]
Alkaline	968.79±298.93[a]	1.02±0.32[a]	965.20±340.29[a]

Each value is expressed as mean ± standard deviation (n = 5).
[a, b, c] Values with different letters in the same column are significantly different (P≤0.05).

The catfish balls produced by alkaline solubilization had the highest hardness (6216.87±700.61, Table IV) and the lowest adhesiveness (-2.67±2.52, Table IV). Different washing methods showed no significant difference in springiness (data not shown). The catfish ball produced by alkaline solubilization was lowest in cohesiveness and significantly different from the other washing methods (0.77±0.03, Table IV). The cohesiveness expressed the cross-linking within the three dimensional network of the fish ball, and the alkaline solubilization produced the lowest cross-linking. These might be due to the denaturation of myofibrillar protein during alkaline solubilization.

TABLE IV. HARDNESS, ADHESIVENESS AND COHESIVENESS OF CATFISH BALL WITH DIFFERENT WASHING METHODS

Washing Methods	Hardness (g)	Adhesiveness (g.s)	Cohesiveness
Non-washing	2870.95±320.85[d]	-38.68±35.44[b]	0.80±0.01[a]
Cold water	3833.04±341.12[b]	-59.64±23.08[b]	0.80±0.01[a]
0.3% Brine	3379.55±335.38[c]	-35.04±32.89[b]	0.81±0.01[a]
Alkaline	6216.87±700.61[a]	-2.67±2.52[a]	0.77±0.03[b]

Each value is expressed as mean ± standard deviation (n = 5).
[a, b, c] Values with different letters in the same column are significantly different (P≤0.05).

For gumminess and chewiness (Table V), the catfish balls from the alkaline solubilization had the highest value, followed by washing with cold water, brine, and non-washing. Chewiness expresses the energy required for chewing before swallowing. The alkaline solubilization can recover high amounts of the protein content. The catfish gel was more compacted but showed less cross-linking within the gel network, the high value in hardness and chewiness. The lowest value in cohesiveness was obtained for the gel from alkaline solubilization. This gel also required higher energy for chewing.

c) Expressible water

The alkaline solubilization yielded the catfish ball the highest in % expressible water (27.89±6.28, Table V), which indicated the lowest in water holding capacity. This result was in agreement with the cohesiveness results (Table IV) and might be due to the denaturation of the myofibrillar protein at high pH, as noted in *2.2*. Brine washing produced the catfish ball with the lowest % expressible water (16.61±3.72, Table V), suggesting that the gel was high in water holding capacity. This result was in agreement with the cohesiveness results (Table IV).

TABLE V. GUMMINESS, CHEWINESS AND % EXPRESSIBLE WATER OF CATFISH BALL WITH DIFFERENT WASHING METHODS

Washing Methods	Gumminess (g)	Chewiness (cm)	Expressible water (%)
Non-washing	2307.91±242.28[d]	2153.87±242.80[d]	21.03±4.01[b]
Cold water	3054.08±244.62[b]	2868.05±230.00[b]	17.22±2.58[bc]
0.3% Brine	2742.79±257.95[c]	2558.31±243.70[c]	16.61±3.72[c]
Alkaline	4744.75±437.96[a]	4398.53±428.04[a]	27.89±6.28[a]

Each value is expressed as mean ± standard deviation (n = 5).
[a, b, c] Values with different letters in the same column are significantly different ($P \leq 0.05$).

From the above results, it was found that the alkaline solubilization produced the catfish ball with highest gel strength, hardness and % expressible water, but the lowest % yield of washing, cohesiveness. Therefore, the alkaline solubilization is not appropriate for the production of catfish ball. Brine washing gave a high % yield and produced the catfish ball with the lowest % expressible water. Moreover, the gel strength was second to that of the alkaline solubilization. Therefore, 0.3% (w/w) brine was shown to be the most appropriate washing method for the production of catfish ball.

B. Study of Optimum Amount of Red Curry Paste in Catfish Ball

1) pH of batter

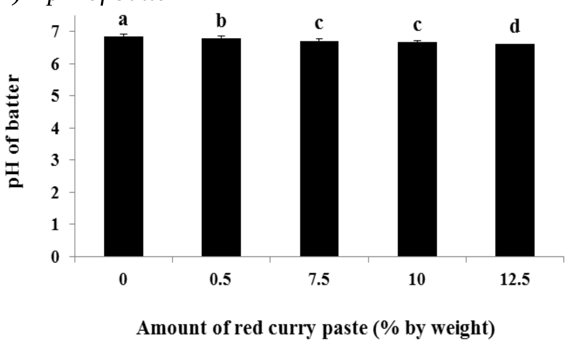

Figure 1. pH of catfish batter with different amounts of red curry paste
Each bar is expressed as mean ± standard deviation (n = 5).
[a, b, c] Values with different letters are significantly different ($P \leq 0.05$).

The pH of the batter after addition of red curry paste 0-12.5% by minced fish weight were determined, and are shown in Fig. 1. It was shown that the pH decreased as the concentration of red curry paste increased. As the pH of red curry paste was 5.72, the addition of paste in the higher amounts decreased the pH of the batter. The batter with 12.5% red curry paste exhibited the lowest pH (6.61 ± 0.01, Fig. 1)

2) Analysis of Catfish Ball

a) Gel color

Lightness (L∗) decreased as the amount of red curry paste increase. In contrast, redness (a∗) and yellowness (b∗) increased, the amount of red curry paste increased. Catfish with 12.5% red curry paste showed the lowest value in lightness (41.32±0.48) but the highest redness and yellowness (15.65±0.16 and 23.97±0.78, respectively, Table VI). The red curry paste was dark red in color, therefore, the addition of higher amounts gave the catfish ball more redness.

TABLE VI. COLOR OF CATFISH BALL WITH DIFFERENT AMOUNTS OF RED CURRY PASTE

Amount of red curry paste (% by weight)	L∗	a∗	b∗
0 (Control)	52.65±0. 47[c]	-0.03±0.05[e]	10.54±0.36[c]
5.0	44.85±1.36[b]	11.79±0.25[d]	22.33±1.43[b]
7.5	43.38±0.33[c]	13.67±0.08[c]	23.16±0.99[ab]
10.0	42.11±0.40[d]	15.09±0.96[b]	23.83±0.78[a]
12.5	41.32±0.48[e]	15.65±0.16[b]	23.97±0.78[a]

Each value is expressed as mean ± standard deviation (n = 5).
[a, b, c] Values with different letters in the same column are significantly different ($P \leq 0.05$).

b) Gel strength and TPA

Breaking force, deformation and gel strength of catfish ball increased with the addition of greater amounts of red curry paste. The catfish balls with 12.5% red curry were the highest in breaking force, deformation and gel strength (Table VII). This might be due to the filler effect of the red curry paste. However, the addition of 10 and 12.5% red curry paste had no significant effect on breaking force ($P > 0.05$, Table VII). The addition of 7.5-12.5% red curry paste had no significant effect on deformation or gel strength ($P > 0.05$, Table VII).

TABLE VII. BREAKING FORCE, DEFORMATION AND GEL STRENGTH OF CATFISH BALL WITH DIFFERENT AMOUNTS OF RED CURRY PASTE

Amount of red curry paste (% by weight)	Breaking force (g)	Deformation (cm)	Gel strength (g.cm)
0 (Control)	396.16±26.50[d]	0.72±0.02[c]	283.87±24.13[d]
5.0	452.28±36.64[c]	0.76±0.04[b]	345.53±43.46[c]
7.5	505.27±40.07[b]	0.80±0.05[a]	404.32±53.27[b]
10.0	543.46±19.28[a]	0.80±0.04[a]	436.95±32.93[ab]
12.5	551.42±37.35[a]	0.83±0.04[a]	458.07±52.09[a]

Each value is expressed as mean ± standard deviation (n = 5).
[a, b, c] Values with different letters in the same column are significantly different ($P \leq 0.05$).

Hardness increased with the addition of greater amounts of red curry paste and was highest at 7.5% red curry paste (4301.88±138.80, Table VIII). The addition of 10-12.5% red curry paste decreased the hardness of the gel. Red curry paste comprises many spices which contain mainly crude fiber. When crude fiber adsorbs water, it swells and act as filler within the matrix of the protein gel network. Therefore, fish ball with higher amounts of red curry paste had higher friction force against the probe during measurement of TPA, and the hardness increased. However, the addition of high amounts of red curry paste disrupted the gel network decreasing the hardness at the highest value of % expressible water of the 12.5% red curry paste (Fig. 2). Reference [17] reported that the addition of cellulose powder 0.06% to Alaska pollock surimi made its gel higher in hardness and chewiness, but lower in springiness and cohesiveness. Reference [18] suggested that the addition of fiber to fish product increased its hardness. Because the fiber has a swelling ability after water adsorption and gelation, the gel sample requires more compression force than the control. The adhesiveness and springiness decreased with the increase in red curry paste (Table VIII).

TABLE VIII. HARDNESS, ADHESIVENESS AND SPRINGINESS OF CATFISH BALL WITH DIFFERENT AMOUNTS OF RED CURRY PASTE

Amount of red curry paste (% by weight)	Hardness (g)	Adhesiveness (g.s)	Springines s
0 (Control)	4109.70±135.40^{ab}	-52.91±33.28^{c}	0.94±0.01^{a}
5.0	4101.28±207.72^{ab}	-43.23±31.93^{c}	0.92±0.02^{a}
7.5	4301.88±138.80^{a}	-16.99±20.45^{ab}	0.93±0.01^{a}
10.0	3316.01±1321.10^{b}	-41.14±34.84^{bc}	0.76±0.19^{b}
12.5	3407.37±1309.81^{b}	-5.98±2.41^{a}	0.77±0.17^{b}

Each value is expressed as mean ± standard deviation (n = 5).
$^{a, b, c}$ Values with different letters in the same column are significantly different (P≤0.05).

Cohesiveness increased with the addition of higher amounts of red curry paste (Table IX). Gumminess and chewiness increased with the addition of up, then decreased with the addition of 10-12.5% red curry paste (Table IX). This is similar to hardness (Table VIII).

TABLE IX. COHESIVENESS, GUMMINESS AND CHEWINESS OF CATFISH BALL WITH DIFFERENT AMOUNTS OF RED CURRY PASTE

Red curry paste (% by weight)	Cohesivene ss	Gumminess (g)	Chewiness (g)
0	0.79±0.01^{b}	3263.28±108.15^{ab}	3057.56±88.60^{a}
5.0	0.79±0.01^{b}	3261.11±161.08^{ab}	3001.64±182.08^{a}
7.5	0.80±0.00^{b}	3422.56±105.14^{a}	3181.50±87.76^{a}
10.0	0.84±0.04^{a}	2735.81±967.66^{b}	2233.96±1256.46^{b}
12.5	0.83±0.05^{a}	2733.82±934.83^{b}	2275.96±1193.80^{b}

Each value is expressed as mean ± standard deviation (n = 5).
$^{a, b, c}$ Values with different letters in the same column are significantly different (P≤0.05).

c) % expressible water

The addition of 12.5% red curry paste showed the significantly highest % expressible water (28.10 ±2.57, Fig. 2). This suggested that the lowest water holding capacity in the gel network occurred when 12.5% red curry paste was added. The addition of 0-10% red curry paste made the catfish ball non-significantly different in % expressible water (P>0.05, Fig. 2). As mentioned above, addition of higher amounts of red curry paste might disrupt the gel network, reducing the water holding capacity.

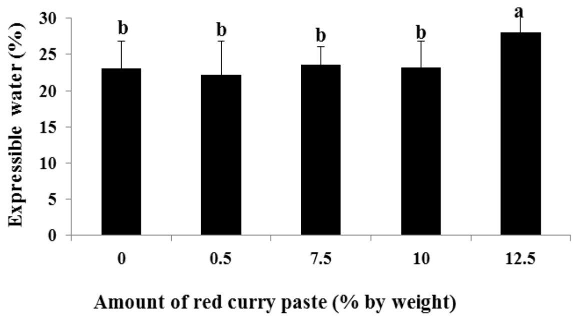

Figure 2. % Expressible water of catfish ball with different amounts of red curry paste
Each bar is expressed as mean ± standard deviation (n = 5). $^{a, b}$ Different letters on bar are significantly different (P≤0.05).

d) Sensory evaluation

The addition of 5-7.5% red curry paste made the sensory score in appearance increase from that of the control, then, gradually decrease with the addition of 10-12.5% (Fig. 3). Sensory scores in color, flavor, taste, and overall liking with 5-12.5% red curry paste were not significantly different, but were significantly above those of the control sample (Fig. 3-4). The panelists liked the color, flavor, and taste of the catfish ball with the addition of curry paste more than without it. Red curry paste might make the color of the catfish ball more attractive. Moreover, red curry paste comprises many spices which could decrease the fishy odor of catfish. However, the panelists did not detect differences in texture between different amounts of red curry paste. Therefore, sensory scores in texture were not significantly with the addition of 0-12.5% red curry paste (P>0.05, Fig.4).

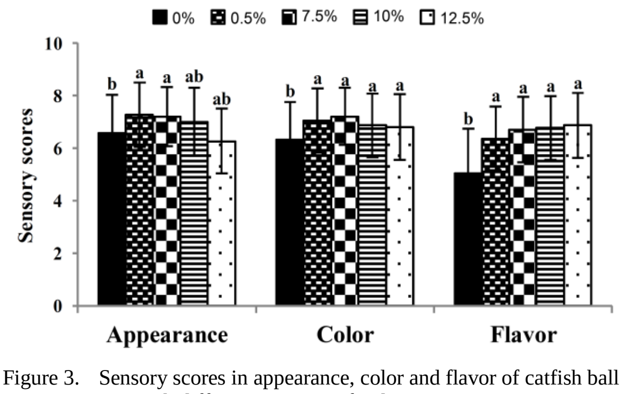

Figure 3. Sensory scores in appearance, color and flavor of catfish ball with different amounts of red curry paste
Each bar is expressed as mean ± standard deviation (n = 30).
$^{a, b}$ Different letters in the same sensory characteristic are significantly different (P≤0.05).

It was found that the addition of 7.5% red curry paste made the gel strength significantly greater than that of the control (P≤0.05, Table VII) and produced the highest hardness (P≤0.05, Table VIII). The expressible water of the catfish ball with 7.5% was not significantly different from that of the control (P≤0.05, Fig. 2). Sensory scores in appearance, color, flavor, taste and overall liking were more than those of the control (Fig. 3-4). Therefore, the appropriate amount of red curry paste in the production of catfish ball is 7.5% by minced fish weight.

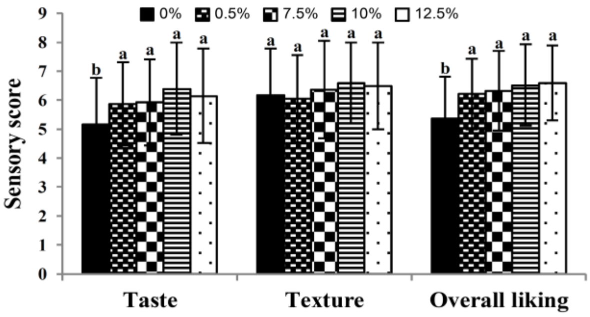

Figure 4. Sensory scores in taste, texture and overall liking of catfish ball with different amounts of red curry paste
Each bar is expressed as mean ± standard deviation (n = 30).
[a, b] Different letters in the sensory characteristic are significantly different ($P \leq 0.05$).

C. Proximate Analysis of Catfish Ball with an Appropriate Amount of Red Curry Paste

The addition of 7.5% red curry paste increased the crude fiber and ash amounts compared with the control ($P \leq 0.05$, Table X). There was owing to the many spices in the red curry paste, as these were composed of crude fiber and ash. However, the moisture, protein, fat, and carbohydrate content between the two samples were not significantly different ($P > 0.05$, Table X). (% by wet basis)

TABLE X. PROXIMATE ANALYSIS OF CATFISH BALL WITHOUT AND WITH 7.5% RED CURRY PASTE

Chemical composition	(% by wet basis)	
	Control sample	7.5% red curry paste
Moisture content^{ns}	78.47±0.46	78.06±0.50
Protein^{ns}	17.18±0.78	16.28±1.57
Fat^{ns}	0.28±0.04	0.30±0.05
Crude fiber	0.01±0.00^{b}	0.32±0.04^{a}
Ash	1.55±0.06^{b}	1.76±0.20^{a}
Carbohydrate^{ns}	2.52±0.31	3.29±1.36

Each value is expressed as mean ± standard deviation (n = 3).
[a, b, c] Values with different letters in the same line are significantly different ($P \leq 0.05$).
ns = Non-significantly different ($P > 0.05$)

IV. CONCLUSIONS

The washing method that was most suitable for improving the gel-forming ability of catfish ball, was 0.3% (w/w) brine. The texture of catfish ball was improved by the addition of red curry paste. The appropriate amount of red curry paste was found to be 7.5% by minced fish weight. The addition of red curry paste did not only improve the color, flavor, and taste of the catfish ball, but also produced more crude fiber and ash content than that of the control.

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