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Incorporation of surimi powder in wet yellow noodles and its effects on the physicochemical and sensory properties

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Abstract: The aim of this study was to produce a high-protein, wet yellow noodle by the incorporation of surimi powder as a protein source and evaluate the effects of the physicochemical and sensory properties of the noodle. The surimi powder was prepared by oven drying the wet surimi at 60°C until the moisture content was below 10%. Five concentration levels of surimi powder substitutions were used (0, 5, 10, 15 and 20%), and as a result, the noodles showed a trend that significantly increased ($P<0.05$) in the ash, protein, fat, lightness, redness, yellowness, stickiness and cooking yield as the levels of surimi powder increased. However, they had significantly decreased ($P<0.05$) carbohydrate content, pH, tensile strength, elasticity modulus and hardness. The results of the sensory study indicated that higher concentrations of surimi powder in the noodles reduced the acceptance of the color score, taste, aftertaste, hardness and elasticity as well as the overall acceptance. However, there was no significant difference ($p<0.05$) in the color, hardness and elasticity between the control and noodles incorporated with 5% surimi powder. Thus, a value of 5% surimi powder was considered the maximum concentration acceptable for incorporation into the noodles. The results of this study showed a potential application of surimi powder in wet yellow noodle production.

Keywords: Surimi powder, noodles, physicochemical properties, sensory evaluation

Introduction

Noodles are one of the most important foods in Asian cuisine. Approximately 40% of the total wheat flour consumed is in the form of noodles in Asia (Kruger *et al.*, 1996; Hou and Kruk, 1998). In addition to the wheat flour, noodles are made from simple ingredients like water and salt and contain carbohydrates, protein and small amounts of fatty acids. The classification of noodles is based on their ingredients and processing methods. Alkaline noodles or yellow noodles are popular foods in Southeast Asia, Southern China, and Japan (Ross *et al.*, 1997). However, a variety of alkaline noodles exist, and they are primarily differentiated in the final stages of manufacturing, where sheeted noodles are cut into strands. According to Kruger *et al.* (1996), the most popular types are “wet” or boiled noodles (“Hokkien” style), fresh noodles (“Cantonese” style), dried noodles, raw noodles that contain eggs (wonton or wantan), and instant noodles.

In recent years, various studies on the addition of different compounds to noodles have been performed to find a substitute for wheat flour for specified purposes. For example, previous studies have focused on the incorporation of ingredients, such as dried fish mince (Yu, 1990; Peranginangin *et al.*, 1995; Setiady *et al.*, 2007), sweet potato and soy flour (Collins and Pangloli, 1997), enriched hull-less barley flour (Hatcher *et al.*, 1999) and banana flour (Ramli *et al.*, 2009; Chong and Aziz, 2010) in noodles.

Currently, commercial noodles are rich in carbohydrates, but they are deficient in essential nutrients, such as proteins, dietary fiber and vitamins. For example, the protein deficiency problem could be solved by consuming noodles with foods that are rich in protein or by enriching noodles with protein. The protein enrichment can be achieved by the addition of dried meat powders, such as fish surimi powders, which are protein concentrates (Huda *et al.*, 2000; Park and Lin, 2005). Previous studies on the addition of dried minced fish to noodles have been performed from *Nemipterus* sp. and *Oreochromis mossambicus* (Yu, 1990), the supplement of wet minced fish and surimi from *Decapterus macrosoma* and *Congresox talabon* (Peranginangin *et al.*, 1995) and the incorporation of wet washed fish minced from *Oncorhynchus mykiss* (Setiady *et al.*, 2007). However, to our knowledge, there has not been a study performed on the incorporation of surimi powder into noodles. Hence, the incorporation of dried surimi powder (*Nemipterus* sp) into noodles is important to meet a void in research.

Materials and Methods

Surimi powder preparation

A threadfin bream (*Nemipterus* sp.) surimi block was purchased from a local surimi processor, transported to the laboratory and stored at -18°C. The surimi blocks were cut and dried at 60ºC overnight with a hot-air dryer (AFOS) until the moisture content

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was below 10%. The dried surimi was then ground to a powder with a blender (Panasonic MX-7995, Malaysia) and filtered using a commercial sieve. The surimi powders were then stored in airtight plastic packs at 4ºC for further processing (Huda *et al.*, 2001).

Preparation of noodles

The noodles were prepared with different percentages of surimi powder (SP), i.e., 0% (SP0); 5% (SP5); 10% (SP10); 15% (SP15) and 20% (SP20), as shown in Table 1. All treated noodles were analyzed by their physical, chemical, cooking and sensory properties.

Table 1. Formulations with different levels of surimi powder incorporated into the noodles (per 158 g)

Material (g)	Formulation				
	SP0	SP5	SP10	SP15	SP20
Wheat flour	100	95	90	85	80
Surimi powder	0	5	10	15	20
Kansui	1	1	1	1	1
Salt	2	2	2	2	2
Distilled water	55	55	55	55	55

The preparation of the laboratory noodles was similar to a previously described method (Kruger *et al.*, 1994). A solution of 1% kansui (sodium carbonates) was mixed with water and then added to 100 g of wheat flour in a Kitchen Aid mixer (Kitchen Aid Ltd, Benton, MI, USA). The mixture was mixed at speed 1, and the speed level was raised by one per subsequent minute until speed 6. The speed of the mixer was then slowed level by level almost every minute and was stopped at approximately the 10th min (Ramli *et al.*, 2009). The dough was allowed to rest at room temperature in a plastic container for 30 min (Kruger *et al.*, 1996) and then sheeted with a pasta machine (Home Plus, Quality Homeware, Malaysia) at an initial gap setting of width 7. The gap width was subsequently changed to widths 6 and then 5 until the desired noodle thickness was achieved using the noodle machine, and the noodles sheet was folded between passes to ensure its uniformity. The noodle strands were cut into square shapes using the same pasta machine. To prevent noodles from sticking together, they were usually coated with a thin layer of wheat flour. The noodles were pre-cooked in boiling water for 1 min, with a ratio of at least 1:10 noodles to water (Kruger *et al.*, 1996; Lim, 2006; Ramli *et al.*, 2009). The partially cooked noodles were subsequently rinsed with cool tap water. The cooked noodles were left to cool at room temperature, and 5% (w/w) cooking oil was added (Othman *et al.*, 1993) based on the weight of the noodles produced to prevent the noodles from sticking together. The partially cooked noodles were then ready for analysis.

Proximate composition, Color and pH value

The noodles were analyzed for moisture, protein, fat and ash content using standard procedures AOAC (2000). The color analysis of the partially cooked noodles was performed using a Minolta CM-3500d spectrophotometer (Konica Minolta USA Inc., Japan). The pH of a cooked noodle slurry was measured using a Hanna 211 microprocessor pH meter (Hanna Instruments, Malaysia), which was calibrated using buffered solutions of pH 4.0 and 7.0 (Ramli *et al.*, 2009).

Cooking properties analysis

Cooking yield

Modifications of a previously published method (AACC, 1976; Lim, 2006) were made and used to determine the cooking yield of the noodles. Distilled water (150 mL) in a beaker was heated on a hotplate (IKA RCT basic safety control, IKA Works (Asia) Sdn. Bhd., Petaling Jaya, Malaysia) until it started boiling. Samples of partial cooked noodles (10 g) were weighed with an analytical balance and put in the beaker. The noodles were cooked in boiling water for 10 min at a low stirring speed using a magnetic stirrer. During the cooking process, the beaker was covered with aluminum foil to prevent evaporation of the water. The cooked noodles were then separated from the cooking water, and the noodles were cooled for 15 min. The weight of cooked noodles was measured after cooling. The cooking yield was measured by the equation below:

$$\text{Cooking yield}\,(\%) = \frac{\text{weight of noodles after cooking}}{\text{weight of noodles before cooking}} \times 100$$

Cooking loss

A previously published method (AACC, 1976) was used to determine the cooking loss of the noodles. The cooking water was separated from the cooked noodles, and the cooking water was poured into a 250-mL of volumetric flask; the volume was then topped off with distilled water. The volumetric flask was shaken to homogenize the cooking water solution. A 10 mL aliquot of the solution was pipette into an aluminum dish, and the sample was dried in an oven at 105°C until a constant weight was obtained. The cooking loss was measured by the equation below:

$$\text{Cooking loss}\,(\%) = \left\{\frac{A - B}{(\text{noodle sample weight} - C)} \times 100\%\right\} \times 25$$

where

A= weight of aluminum dish + dish + dry cooked water sample

B= weight of aluminum dish + dish

C= noodles moisture content

Analysis of physical properties

The physical properties of the partially cooked noodles were determined using a TA-TX2 model Texture Analyzer (Stable Micro Systems. Ltd., Surrey, UK). The tensile and compression tests were conducted using this instrument. The reproducibility of the noodles was low; thus, replicate studies were conducted (10 times), and a duplicate analysis of another batch of noodles with same formulation was also performed. For each analysis, 5 strains of noodles were selected and measured. Therefore, there were 10 data readings recorded for each formulation of noodles, and all of the data were used in statistical analysis.

Tensile test

The tensile test method was modified, and it measured the tensile strength and elasticity of the noodles (Lim, 2006; Ramli *et al.*, 2009). The load cell consisted of a 5 kg sample, and the spaghetti/noodles rig A/SPR was used. The distance of the rig was calibrated by 10 mm and the force was calibrated by 2 kg before starting the analysis. The distance the probe was allowed to move was set at 40 mm. The settings of the TA-XT2 were as follows (Lim, 2006):

Test mode : Tensile
Pre-test speed : 3.0 mm/sec
Test speed : 3.0 mm/sec
Post-test speed : 5.0 mm/sec
Distance : 75 mm
Trigger force : 0.05 N

Each noodle was tested individually by placing one end into the lower rig arm slot and winding the loosened arm sufficiently to anchor the noodle end. The arm was tightened, and the same procedure was performed to anchor the other noodle end to the upper arm. The tensile test was performed, and five measurements for each sample were collected. From the force (Newton)-displacement curve, the maximum slope was recorded by the software TA exponent 32. The tensile strength was calculated as follows:

$$\text{Tensile Strength (Pa)} = \frac{F}{A}$$

where F represents the maximum peak force (N) and A represents the cross-sectional area of the noodle strand (m^2). The width and thickness of the noodle was measured using a dial thickness gauge (Mitutoyo MI7305, Japan). The A value was calculated by multiplying the thickness and the width of the noodles.

$$\text{Elastic modulus} = \frac{Fl_o}{tA_o} \times \frac{1}{v}$$

where F/t is the initial slope (N/sec) of the graph (force vs. time), l_o is the original length of the noodles between the limit arms (0.04 m), A_o is the original cross sectional area of the noodles (m^2) and n is the rate of movement of the upper arm (0.003 m/sec).

Compression test

The compression test method (Lim, 2006) was modified from a previously published method. The compression test was conducted, and five measurements for each sample were collected. The load cell consisted of 5 kg, and the P/36R was used as probe. The heavy-duty platform was set up and used; the distance of the probe and the force were calibrated with 2 kg before starting the analysis. The distance the probe was allowed to move was set at 20 mm. The settings of the TA-XT2 were as follows (Lim, 2006):

Test mode : Compression
Pre-test speed : 2.0 mm/sec
Test speed : 2.0 mm/sec
Post-test speed : 2.0 mm/sec
Trigger force : 0.1 N
Strain : 75% deformation

Three strains of partial cooked noodles (15 cm long) were arranged in a straight manner on the heavy-duty platform. The strains of noodles were pressed until a deformation of 75% was reached, and the curve of force/time was obtained. Data pertaining to hardness (maximum peak force) and stickiness (total negative area under the curve) were obtained from the curves.

Sensory evaluation

Five types of noodle samples were boiled and cut into 8 cm pieces. The samples were stored in tightly covered plastic containers (Chong and Aziz, 2010), which were kept in a food warmer before testing. The sensory attributes of the cooked noodles were evaluated by 50 panelists consisting of students of the School of Industry Technology, Universiti Sains Malaysia. All samples were evaluated using a seven point hedonic scale, where “1” equaled “dislike very much” and “7” equaled “like very much”. Each noodle sample was served and presented with chicken soup in a white plastic cup coded with a random set of 3 digit numbers. The panelists were given drinking water to rinse their mouths before evaluating each sample. The attributes evaluated included color, taste, aftertaste, firmness, elasticity and overall acceptability (Collins and Pangloli, 1997; Eyidemir and Hayta, 2009; Chong and Aziz, 2010).

Statistical analysis

The data were analyzed with a Statistical Package for Social Science (SPSS) (SPSS 17.0 for Windows, SPSS Incorporated, Chicago, Illinois, U.S.A.). A one-way analyses of variance (ANOVA) was conducted to determine the significance difference between each of the 5 treatments. Any value that was considered significantly different (P<0.05) was subjected to Duncan's multiple range tests.

Results and Discussion

Proximate composition

The proximate composition of the noodles, such as the moisture, protein, fat, ash and carbohydrate contents, is shown in Table 2. The control noodle sample was similar to commercially available wet noodles in Malaysia in terms of its protein (8.67%) and carbohydrate (87.67%) contents (Tee *et al.*, 1997). The addition of surimi powder into the noodles will increase the requirement of water and fat content in the noodle to form the dough properly and prevent its strands from sticking together, respectively; thus, the control noodle's formulation was changed. Therefore, the control noodle's moisture and fat contents were higher and its ash content was lower than commercial noodles (Kruger *et al.*, 1996; Tee *et al.*, 1997).

Table 2. Mean (n=6) of proximate composition of noodles incorporated with surimi powder

Sample	Moisture (%)	Protein* (%)	Fat* (%)	Ash* (%)	Carbohydrate*(%)
SP0	62.58 ± 2.21^{a}	7.92 ± 0.76^{a}	3.27 ± 0.14^{a}	1.39 ± 0.04^{a}	87.43 ± 0.74^{e}
SP5	63.02 ± 1.11^{ab}	10.12 ± 1.13^{b}	3.78 ± 0.19^{b}	1.46 ± 0.15^{ab}	84.65 ± 1.20^{d}
SP10	63.22 ± 1.69^{ab}	13.60 ± 0.73^{c}	4.69 ± 0.37^{c}	1.51 ± 0.24^{ab}	80.20 ± 0.53^{c}
SP15	64.51 ± 0.49^{b}	15.10 ± 1.66^{d}	4.99 ± 0.20^{cd}	1.60 ± 0.03^{bc}	78.32 ± 1.56^{b}
SP20	64.65 ± 0.91^{b}	18.11 ± 1.10^{e}	5.15 ± 0.48^{d}	1.69 ± 0.01^{c}	75.04 ± 1.12^{a}

* Expressed on a dry basis as the mean ± standard deviation.

a-e Mean values with different letters within the same column are significantly different (p<0.05).

The moisture content of the noodles significantly increased (p<0.05) when the surimi powder reached 15%. The surimi might have increased the levels of water absorption rates due to its water holding capacity (Zayas, 1997) during the mixing and cooking steps. As expected, the protein content increased significantly (p<0.05) with the substitution of different levels of fish surimi powder. Similar trends have also been reported with fish minced noodles (Yu, 1990) as well as with boiled and dry noodles supplemented with surimi or minced fish (Peranginangin *et al.*, 1995). The surimi powder primarily consists of myofibrillar proteins (a good source of protein), while wheat flour contains a lower amount of protein. Hence, surimi powder could make a significant contribution of protein to noodles.

The fat content showed a significant increase (p<0.05) in all the noodle samples that had been supplemented due to the remaining fat in the surimi powder. Although most of the fat in the surimi has already been removed during the washing step, the residual fat in the surimi powder might have contributed a certain amount of fat to the noodles. The ash in the surimi-substituted noodles significantly increased (p<0.05) when 15% surimi powder was added to the noodles. The ash consisted of minerals in the surimi powder, i.e., phosphorus, sodium, potassium, and magnesium (Dallas, 2004-2006).

As can be seen in Table 2, the carbohydrate content was significantly reduced (p<0.05) in the noodles. This outcome was due to the carbohydrate level in the surimi powder, which was approximately 16.8-17.5% and was lower than the wheat flour (74.0%) (Huda *et al.*, 2001). Hence, the addition of surimi powder into noodles will greatly reduce its carbohydrate level.

Color properties

The color of the boiled noodles is presented in Table 3. The color of the noodles is the most vital quality parameter. Alkaline noodles should have a clear yellow color without any spots and discolorations. The yellowish color of the noodles is attributed to the presence of natural flavonoid pigments, which are colorless at acidic pH levels but turn yellow at alkaline pH levels (Fu, 2008). The color of the partially cooked noodles was analyzed after the noodles were produced. Desirable alkaline noodles have a lightness value (L^*) higher than 60 but no higher than 100; they should show low redness ($+a^*$) values and high positive values for b^*.

Table 3. Mean (n=12) of color properties (L^*, a^* and b^*) of noodles incorporated with surimi powder

Sample	Color		
	L^*	a^*	b^*
SP0	70.33 ± 0.79^{a}	-2.14 ± 0.21^{a}	19.27 ± 0.80^{a}
SP5	72.05 ± 0.53^{b}	-1.64 ± 0.38^{b}	19.74 ± 0.84^{ab}
SP10	72.72 ± 0.66^{c}	-1.15 ± 0.24^{c}	19.85 ± 0.33^{b}
SP15	73.06 ± 0.60^{c}	-0.49 ± 0.27^{d}	20.06 ± 0.44^{bc}
SP20	74.99 ± 0.51^{d}	-0.22 ± 0.14^{e}	20.49 ± 0.32^{c}

*Data are reported as the mean ± standard deviation.

a-d Mean values; different letters within the same column are significantly different (p<0.05)

As seen in Table 3, the lightness (L^*), yellowness (a^*) and redness (b^*) increased significantly (p<0.05) as a function of increasing amount of surimi powder in the noodles. The color of the different levels of surimi powder-substituted noodles was roughly distinguished by the eyes. Due to the hygroscopic property of surimi powder, it might have absorbed much of the free water and lowered the water activity A_w of the noodles. The decreasing value of A_w decreased the browning activity of the polyphenol oxidase enzyme, which is present in noodles; hence, it helped lighten the color of the noodles. During the washing step, almost all of the red blood cells were washed and removed from the surimi. However, some blood still remained in the surimi powder, which might have contributed to some of the red color of the surimi substituted-noodles. A significant increase ($p<0.05$) in the yellow color was observed when the surimi powder reached 10% in the noodles due to the non-enzymatic Maillard reaction of amino acids between the myofibrillar proteins and the reducing sugars from the cryoprotectant. The reducing sugars react with proteins and produce yellow-browning compounds through the Maillard reaction during mild heating (70-100°C) (Billaud *et al.*, 2004). The yellow-browning Maillard reaction could have occurred during the production of the surimi powder, which contributed to the yellow color of the surimi-substituted noodles.

pH and cooking properties

The pH and cooking properties of the boiled noodles is presented in Table 4. The pH of the noodles was significantly reduced ($p<0.05$) when supplemented with different levels of fish surimi powder. A similar trend was reported by Yu (1990). The typical pH value of yellow alkaline noodles ranges between 9 and 11 (Kruger *et al.*, 1996). The pH of surimi is 6-7 (Lin and Park, 1998) or 6.97-7.06 (Sakura *et al.*, 1993). Because the surimi has a nearly neutral pH, the pH of the yellow noodles was expected to possibly drop after the surimi powder was incorporated.

Table 4. Mean (n=6) of pH and cooking properties (cooking yield and loss) of noodles incorporated with surimi powder

Sample	pH	Cooking Properties	
		Cooking Yield (%)	Cooking Loss (%)
SP0	8.08±0.05^{e}	187.69±6.05^{a}	12.61±0.69^{a}
SP5	8.03±0.05^{d}	205.24±15.83^{b}	13.51±1.41^{a}
SP10	7.94±0.03^{c}	211.54±12.46^{bc}	15.11±1.52^{ab}
SP15	7.88±0.02^{b}	214.88±7.25^{bc}	16.89±2.43^{b}
SP20	7.76±0.06^{a}	220.86±3.68^{c}	19.45±3.21^{c}

Data are reported as the mean ± standard deviation.

$^{a\text{-}d}$Mean values; different letters within the same column are significantly different ($p<0.05$)

The cooking properties were tested and consisted of the cooking yield and cooking loss. The cooking yield was defined as the percentage of noodle weight after cooking to the weight of the raw noodles. Hence, it represented the ability of the noodles to absorb water from the cooking medium. A higher value for the cooking yield and a lower cooking loss typically represents good-quality alkaline noodles. A higher weight gain of noodles during cooking is negatively proportional to the flour protein content (Hou, 2010). As seen in Table 4, the incorporation of surimi powder into noodles significantly increased ($P<0.05$) the cooking yield. This result might have been due to the presence of surimi powder in the noodles. The surimi powder is hygroscopic and might have had the ability to absorb and hold water during heat treatment (Zayas, 1997). During the cooking process, the surimi content in the surimi-substituted noodles might have also gelatinized in addition to the starch. The gelatinization of both surimi and starch during the cooking process might have contributed some water, which increased the weight of the noodles after cooking.

The cooking loss represented the particles that diffused out from the noodles into the cooking medium during cooking. The cooking loss property reflects the surface characteristics of the noodles. According to Shiau and Yeh (2001), the higher the cooking loss is, the stickier the noodle surface. High cooking loss is undesirable because it means that there was a high starch content in the cooking medium and that the noodles had a low cooking tolerance (Chakraborty *et al.*, 2003). As can be seen in Table 4, the cooking loss showed a significant increase ($P<0.05$) when the surimi powder reached 15% in the noodles. This result might due to the surimi powder; when incorporated into the noodles, the surimi powder might be weaker and disturb the formation of the protein gluten network. As a result, surimi-substituted noodles have softer and weaker internal structures. Once these noodles were cooked, much finer particles were released from the surface of the noodles, contributing to a greater value for the cooking loss.

Texture properties

Tensile strength represents the consumption quality of noodles, and it also corresponds to elasticity and tenacity for the strain of noodles (Chakraborty *et al.*, 2003), whereas the elasticity modulus refers to the slope of its stress-strain curve. The addition of surimi powder at 10% significantly decreased ($p<0.05$) the tensile strength and elasticity of the noodles, as shown in Table 5. This result might be due to the softer and weaker internal structures as well as its molecule binding. When more surimi powder was incorporated into the noodles, it might have created more of a disturbance and weakened the protein gluten network as well as the hydrogen binding of the molecules. As a result, the surimi-substituted noodles were less elastic and easily broke when the strand of noodle was torn.

The hardness of the noodles was measured based on the peak of the compression curve. The addition of surimi powder significantly reduced ($P<0.05$) the hardness of the noodles sample when surimi powder

Table 5. Mean (n=10) of tensile strength, elasticity modulus, hardness and stickiness of noodles incorporated with surimi powder

Sample	Tensile Test		Compression Test	
	Tensile Strength (kPa)	Elasticity Modulus (kPa)	Hardness (N)	Stickiness (Nsec)
SP0	30.76 ± 8.71^{c}	41.01 ± 11.61^{c}	25.19 ± 2.35^{b}	0.15 ± 0.05^{a}
SP5	26.19 ± 6.37^{bc}	34.92 ± 8.50^{bc}	23.72 ± 2.03^{ab}	0.27 ± 0.10^{b}
SP10	24.54 ± 3.66^{ab}	32.72 ± 4.88^{ab}	23.10 ± 1.35^{a}	0.38 ± 0.06^{c}
SP15	24.05 ± 2.58^{ab}	32.06 ± 3.44^{ab}	22.92 ± 1.32^{a}	0.46 ± 0.07^{d}
SP20	20.71 ± 4.49^{a}	27.61 ± 5.98^{a}	22.44 ± 1.28^{a}	0.51 ± 0.09^{d}

Data represent the mean ± standard deviation.
$^{a-d}$Mean values; the different letters within the same column represent significantly different values (p<0.05)

reached 10%, as shown in Table 5. The decreasing value of noodle hardness might have been due to the water-absorbing property of surimi. The increased amount of water absorbed into the noodles might have weakened the gluten networks that formed the dough; thus, a softer noodle was produced compared to the control (SP0). However, when the surimi powder exceeded 10% (to 20%), there was an insignificant reduction (P<0.05) in the hardness of the noodles.

Table 5 also shows that the stickiness significantly increased (P<0.05) when the surimi powder was incorporated. This result might have been due to the hygroscopic nature of the surimi powder, which tends to absorb water during the cooking process. Surimi powder can also act as a humectants', absorbing moisture from the environment and producing the sticky surface on the noodles. The higher values of stickiness were caused by the higher cooking loss of the noodles, which resulted because a significant amount of amylose had diffused out from the noodle surface (Shiau and Yeh, 2001).

Sensory evaluation

The sensory evaluation results showed that there were significant reductions (p<0.05) in the color, hardness and elasticity as noted by the panelists when the substitution of surimi powder reach 10% (Table 6). The panelists failed to differentiate the color between SP0 and SP5. A significant reduction (P<0.05) was also noted in the taste, aftertaste and overall acceptance of the noodles when the surimi powder reached 5%. All sensory attributes of SP0 noodles that served as the control were significantly the highest (p<0.05) among all samples; the SP20 noodles showed the lowest score among all samples in all sensory attributes except in the color category. Generally the sensory score of noodles prepared in this study was lower, whether due to the lack of formulation used or the unfamiliar of panelists participated in this study. The overall acceptance score for SP0 was only 5.10 (72.86%) compared to higher score 7.0 (100%). The more surimi powder was added to the noodles, the less acceptable the noodles were to the panelists. The overall acceptance of the noodles was in the following order: SP20<SP15<SP10<SP5<SP0. The increase in surimi powder might have contributed a much fishier taste and aftertaste to the noodles as well as a softer and less elastic texture; these characteristics might not have been favorable to the panelists, especially for those who dislike seafood. The reduction overall acceptability of noodles incorporated with surimi powder SP5, SP10, SP15 and SP20 compared to control (SP0) was 10.14, 17.26, 23.93 and 30.89%, respectively. The overall acceptance data showed that the noodles made with 5% and 10% surimi powder were still accepted by consumers. This trend was similar to data obtained by Yu (1990), whereas noodles formulated with 5 and 10% of dried fish mince *Oreochromis mossambicus* and *Nemipterus* sp. were not significantly different from the control. However, the SP10 noodle texture received a hardness score of 3.82 and elasticity score of 3.90, which were less preferred than the SP5 noodles (hardness score=4.32 and elasticity score=4.30).

Table 6. Mean (n=50) of sensory attributes of noodles incorporated with surimi powder

Sample	Color	Taste	Aftertaste	Hardness	Elasticity	Overall Acceptance
SP0	5.12^{b}	5.20^{d}	5.16^{d}	4.70^{c}	4.68^{c}	5.10^{d}
SP5	4.86^{ab}	4.70^{c}	4.38^{c}	4.32^{bc}	4.30^{bc}	4.58^{c}
SP10	4.58^{a}	4.38^{bc}	4.12^{bc}	3.82^{ab}	3.90^{ab}	4.22^{bc}
SP15	4.42^{a}	3.90^{ab}	3.80^{ab}	3.76^{ab}	3.84^{ab}	3.88^{ab}
SP20	4.50^{a}	3.72^{a}	3.48^{a}	3.26^{a}	3.40^{a}	3.52^{a}

"1" equaled "dislike very much" and "7" equaled "like very much".
Data represent the mean values (n = 50).
$^{a-d}$ Mean values; the different letters within the same column are significantly different (p<0.05)

Conclusion

The incorporation of surimi powder (SP) had an impact on the physicochemical and sensory properties of noodles. The incorporation of surimi powder significantly increased (P<0.05) in the ash, protein, fat, lightness, redness, yellowness, stickiness and cooking yield as the levels of surimi powder increased. However, they had significantly decreased (P<0.05) carbohydrate content, pH, tensile strength, elasticity modulus and hardness. The sensory evaluation result showed there were reductions in all parameter with the increasing incorporation of surimi powder. The level of overall acceptance reduction for SP5, SP10, SP15 and SP20 compared to SP0 was 10.14, 17.26, 23.93 and 30.89%, respectively. SP5 noodles represented an acceptable preference in term of sensory evaluation based on all individual and overall sensory attributes compare than SP10. SP15 and SP20. In conclusion, this study provides useful functional information for the future development of surimi powder-based food products.

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