

Original Research Article

## Effects of Different Concentrations of Iodized Salt on the Physicochemical Properties in *Euthynnus Affinis* Surimi

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**Abstract:** The increase in demand for a healthier protein diet has impacted fisheries resources and resulted in the depletion of several fish species, especially white flesh fish. To compensate for the depletion, red meat or dark muscle fish species such as *Euthynnus affinis*, can be used in the production of surimi. Salt is one of the most common additives used in surimi production. However, high sodium content salt are associated with significant health risks. Due to low sodium content, utilisation of iodized salt in the production of surimi is one of the alternatives. Therefore, the objectives of this study were to analyse the physicochemical properties of a red meat fish species for surimi, *E. affinis*, with the addition of 0.5% (w/w), 1.0% (w/w), and 1.5% (w/w) iodized salt. Physicochemical analyses conducted included proximate composition, pH, colour, water activity, water holding capacity, and cooking yield. Moisture and protein content of surimi were found to decrease significantly ( $p < 0.05$ ) with the increased concentration of iodized salt up to 1.0% (w/w). *E. affinis* surimi lightness value decreased significantly ( $p < 0.05$ ) when iodized salt concentration added increased up to 1.5% (w/w). Iodized salt also resulted in an increase in water-holding capacity and cooking yield of the surimi. It can be concluded that different iodized salt concentrations will significantly affect the physicochemical properties of *E. affinis* surimi.

**Keywords:** Myofibrillar protein; iodized salt; sarcoplasmic; *Euthynnus affinis*

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### 1. Introduction

Fish is a natural nutritious food that has high amounts of protein (15 to 24%), water (55 to 84%), fat (0.1 to 22%) and carbohydrate (0.1 to 0.3%) (Abu Bakar *et al.*, 2014). In

2018, the total fishery production of Malaysia was about 1.76 million tonnes, and the trend in fish consumption among Malaysians is increasing (Yusoff, 2015). The increase demand for fish is due to the increasing population and awareness of having a healthier daily diet that is rich in protein. Thus, the rising demand forces the usage of raw fish to be maximised in the processing and production of higher value-added products such as in the production of surimi. As a result, this phenomenon has led to the declination of fish stocks such as flounder, cod, hake, and other white flesh fish species. Meanwhile, several fish species are underutilised which are not suitable to be processed into highly-valued food products due to their colour appearance, flavour, odour, or texture.

Surimi is a concentrated myofibrillar protein from fish flesh added with certain additives which are necessary to enhance its functional properties and maintain its quality. It is commercially processed and prepared to increase shelf life by up to 6 months through a freezing process. Surimi is also known as an intermediate product produced by the seafood manufacturer to develop seafood-based products such as fish balls, fish cakes, crab-flavoured seafood, seafood salads and many more depending on their quality. Quality grades of surimi are based on the type of fish used, the amount of myofibrillar protein, and the food additive added. For high-grade surimi, the most common type of fish meat used is white flesh with low-fat content. The most popular examples of the white flesh meat are the Alaska Pollock and Pacific whiting (*Merluccius productus*). However, to overcome the decreasing resources of these fish, fish species whose portion of the red or dark muscle and high-fat content such as *Euthynnus affinis*, can be processed to produce low-grade surimi.

*E. affinis* is a red meat fish species which is also known as the ‘little tuna’ or ‘kawakawa’. It is a type of mackerel or fatty fish that is commercially available worldwide due to its delicacy and richness in protein and fats. This species is widely used as a useful ingredient in preparing food and pharmaceutical products due to its abundance of omega-3 fatty acids and fat-soluble vitamins (A and D) which is also a good source for the reduction of cardiovascular risk and cancer (Kromhout *et al.*, 2012).

In the production and manufacturing of surimi, salt is one of the common food additives used to enhance the quality and taste by extracting the myofibrillar proteins, and as a preservative to inhibit microbial growth and lower the water activity. However, improper selection of salt concentration in the production of surimi will be associated with health risks, including high blood pressure, heart disease, and stroke. Moreover, due to the current healthy eating lifestyle, consumers tend to take less sodium in their daily diet. Therefore, producing

surimi-based seafood products with low-sodium content food additives is beneficial to consumers.

Iodized salt is one of the low-sodium ( $\text{Na}^+$ ) content food additives that contains iodine which has health benefits, especially for humans with iodine deficiency (Carapeto *et al.*, 2018). Iodine is a component of the thyroid hormones, which are critical for metabolism, making it a necessary element for both human and animal growth and development. According to the WHO, about 31% (1900.0 million) of the global population is estimated to have insufficient iodine intakes, where, South-East Asia and Europe are the two regions that were most impacted (Rupali *et al.*, 2016). Thus, other than low sodium content, iodized salt is important to save human lives against iodine deficiency-related diseases like goitre (Carapeto *et al.*, 2018). Moreover, the iodized salt also is a relatively affordable public health measure. Therefore, due to the low-sodium content, its beneficial ingredient, and affordability, an in-depth study on the physicochemical properties of *E. affinis* surimi added with different concentrations of iodized salt is essential for consumer acceptance and market demand. Based on the commercial processing nature of surimi, the level of salt practices ranges between 1.2 and 2% (Park & Lin, 2005). In this investigation, the preferred iodized salt concentrations were 0.5%, 1.0% and 1.5% which were within the range of commercial surimi nature.

Therefore, the present work is possible to investigate the influence of iodized salt with different concentrations added into *E. affinis* surimi and its effect on the physicochemical properties of the surimi during processing. Moreover, a comparison between iodized salt concentration towards surimi's attributes and physical characteristics must be taken into account for it to be accepted by consumers.

## 2. Materials and Methods

### 2.1. Materials

Fresh *E. affinis* fish were purchased from the nearest local supermarket (Pasaraya CS, Bangi Avenue, Bangi, Selangor, Malaysia) and were packed in a polystyrene-type cold box. The fresh fish then were stored in the chiller overnight at 4°C temperature.

### 2.2. Surimi Preparation

Fresh *E. affinis* fish were gutted, beheaded, and washed manually in chilled freshwater before deboning. A debone machine (Fish Deboner Machine, Asasemarak (M) Sdn. Bhd., Kuala Lumpur, Malaysia) was used to remove the skin and bones and to separate

the fish mince. The minced fish meat was then washed with 4°C chilled distilled water using a washing tank (Fish Leaching Tank, SWE-FLST 75, Safe World Enterprise, Selangor, Malaysia) for 5 min with constant agitation. The washing ratio used was 3:1 (w/w) of water to fish mince, as stated by Park and Lin (2005). The washed fish minced excess water was then extracted out using a centrifugal decanter machine (Bean Servering Machine, Ban Hing Holding Sdn. Bhd., Kuala Lumpur, Malaysia) for 30 min. The surimi was then prepared with different concentrations of iodized salt (0%, 0.5%, 1.0%, and 1.5%) as described in Table 1. Each surimi sample was weighed and packed in airtight zip-lock polyethene bags ( $500 \pm 0.1$  g) with labels. The sample was then stored in the freezer at a temperature of  $-18^{\circ}\text{C}$ .

**Table 1.** Concentration of iodized salt used in the formulation

Salt concentration (%)	Ingredients			
	Fish mince (g)	Iced water (g)	Iodized salt (g)	Total (g)
0	328	72	0	400
0.5	326	72	2	400
1.0	324	72	4	400
1.5	322	72	6	400

### 2.3. Physicochemical Analysis

#### 2.3.1 Chemical composition

*E. affinis* surimi samples were determined and measured based on the standard method as described by the Association of Official Analytical Chemists (AOAC, 2000). The samples were homogenised before initiating the measurement. The sample composition analysis has been determined through proximate analysis which included the moisture content percentage, crude protein (Kjeldahl,  $\text{N}\% \times 6.25$ ), crude fat contents (Soxhlet extraction method), and ash. The analysis was done in triplicates.

#### 2.3.2 pH determination

For the pH determination, frozen *E. affinis* surimi was thawed for 1 hr at room temperature. About 5 g of thawed surimi was weighed. A measured amount of 25 mL distilled water was poured into the weighed surimi and was further stirred to ensure homogenisation. The pH meter (Basic Bench Top pH Meter PB-10, Sartorius, Gottingen, Germany) was used to measure the sample pH. The measurement analysis was conducted in triplicates.

### 2.3.3 Colour evaluation of surimi

Surimi samples were equilibrated at a room temperature of 25°C for 1 hr before colour evaluation (Zhou *et al.*, 2017). The colourimeter (Minolta CR-410, Japan) was used to determine the colour measurement value of the surimi samples. The analysis was conducted in triplicates. The values of Lightness ( $L^*$ ), redness ( $a^*$ ), and yellowness ( $b^*$ ) at 20 mm diameter were recorded. The whiteness (W) value was calculated following Equation 1 (Yang *et al.*, 2014):

$$\text{Whiteness (W)} = 100 - [100 - L^*]^2 + a^{*2} + b^{*2}]^{1/2} \quad (1)$$

### 2.3.4. Water activity measurement

Frozen surimi samples were thawed for 1 hr at a room temperature of 25°C. About 1 g of the thawed surimi was placed into the drawer of the water activity meter (AquaLab Series 3 TE, Washington, USA). The measurement was done in triplicates and the final results were recorded.

### 2.4 Water Holding Capacity Measurement

Water holding capacity measurement was done using the practices done by Gao *et al.* (2019). Fish surimi gel of 2 g was weighed as  $W_1$  and put into the Whatman filter paper no. 2. The sample was then centrifuged in a 50 mL centrifuge tube for 10 min at 4000 rpm speed at 4°C. The final weight left in the filter paper was weighed and recorded as  $W_2$ . The water holding capacity was measured by calculating the percentage of the fish surimi gel left after centrifuge divided by the initial weight of fish surimi gel before the centrifugation process according to Equation 2. The experiment analysis was done in triplicates.

$$\text{Water holding capacity} = 100\% - (W_1 - W_2) \times 100\% W_1 \quad (2)$$

### 2.5 Cooking Yield Measurement

Cooking yield measurement was done by preparing an amount of 100 mL of boiled water in a pot. Then, 2 g samples of fish surimi were weighed using an analytical balance and recorded as  $W_1$ . The weighed samples were then placed into the boiling water with a low-speed stirring effect for 10 min as stated by Gao *et al.* (2019). The cooked fish gel was removed from the boiling water pot and cooled for 15 min. Cooked fish gel was weighed, and recorded as  $W_2$ . The cooking yield was determined by using Equation 3:

$$\text{Cooking yield (\%)} = \frac{W_2}{W_1} \times 100 \quad (3)$$

## 2.7 Statistical Analysis

A one-way analysis of variance (ANOVA) was used in analysing the statistical analysis. One factor was studied, which was the different concentrations of iodized salt added to the samples. All the factors were compared using Tukey's test method with a confidence level of 95%. Statistical analysis was carried out using Minitab Software version 19 (Minitab Inc., State College, PA, USA). All analyses were conducted in triplicates.

## 3. Results and Discussions

### 3.1. Physicochemical Analysis

#### 3.1.1. Chemical composition

The moisture content of the control surimi sample in this study was 78.52% which was relatively higher than the result of 75%–76% stated by the USDA for surimi fish paste (USDA, 2012). Parvathy *et al.* (2018) reported that the moisture content of fresh *E. affinis* surimi was 74.54%. Based on the moisture content result of 78.52%, it may be possible that a meat-water ratio used during washing significantly affects surimi moisture content. The meat ratio (W/M), the washing cycle, and the washing time are the three washing variables that will affect the moisture content of the washed minced meat (Lin & Park, 2008). Thus, the high amount of moisture content in this result may be due to the difference of (W/M) used, 3:1 (W/M) compared to the study done by Parvathy *et al.* (2018) which was 2:1 (W/M). As the iodized salt concentration increased, the moisture content of the surimi in the (Table 2) decreased. The moisture content significantly ( $p < 0.05$ ) decreased when 0.5% (w/w) iodized salt concentration was added (Table 2). The moisture content of fish surimi started to decrease when salt was added (Greiff *et al.*, 2015). A similar result of decreased moisture content from 81.9% to 72.9% was obtained due to the addition of salt to the fresh feseikh fish species (Ahmed *et al.*, 2018). The moisture content of the fish surimi was reduced due to water being drawn out of the fish tissues causing slight dehydration when coarse salt was added for salting treatment (Mostafa & Salem, 2015).

Parvathy *et al.* (2018) reported that the protein composition of unwashed *E. affinis* was 26.34%. The result of protein composition for 0% salt (w/w) obtained in this study, was 16.08%. The difference in protein composition might be due to the washing effect during the preparation of the fish mince. The washing process will cause losses of soluble protein, however, it improves the gelation of the fibrillar fraction (Muraleedharan *et al.*, 2018). Based on the protein analysis reported, a significant difference ( $p < 0.05$ ) between samples with different concentrations of salt was obtained. The protein compositions were found to

decrease significantly ( $p < 0.05$ ) from 16.08% to 13.94 % when 1.0 % (w/w) salt was added. Due to the large salt uptake by the muscle, some protein would be dissolved in the brine as water is drawn out because of the competition with muscle protein for water molecules, thus, resulting in denaturation and aggregation of these proteins through the salting-out process (Ahmed *et al.*, 2018; Mostafa & Salem, 2015). However, the quantity of protein loss from the surimi depends on the condition of the fish, the amount of salt added and, the salting duration.

Ash is about inorganic residue remaining after removing organic matter by heating application which is also known as a measure of total mineral content in the food. The ash content of the surimi displayed a significant difference ( $p < 0.05$ ) when the concentration of iodized salt added increased to 1.5% (w/w). The relatively high ash content could be due to the salt penetration into the fish flesh thus causing the fish juice to ooze during the salting process (Ahmed *et al.*, 2018). A high concentration of salts also contributes to the increasing mineral content, such as Ca, K, or Na, causing high ash content in the surimi due to osmosis (Mercuria *et al.*, 2018).

For the fat content analysis, the sample without iodized salt recorded 0.63% fat while the sample added with 0.5% (w/w), 1.0% (w/w) and 1.5% (w/w) iodized salt were 1.0%, 1.06% and 1.28%, respectively. The fat level content for 0%(w/w) surimi is lower than the result reported previously by Parvathy *et al.* (2018) who found that the total fat content of fresh *E. affinis* meat was 1.10%. This might be due to the effect of storage time on the lipid oxidation of the surimi. Lipid oxidation is one of the main processes that cause lipid deterioration and causes the low shelf life of fatty fish. However, results showed a significant increase ( $p < 0.05$ ) in the total fat content with the addition of salt concentration from 1.0% up to 1.5% (w/w). During the salting process, mass transfer occurs on the fish muscle between water and salt, subsequently increasing the lipid concentration due to the loss of water from the fish muscle (Hassan & Fatma, 2015). The presence of salt concentration may also reduce the water activity of the fish mince, hence reducing lipid deterioration. Previous studies reported that the presence of salt concentration might serve on less effective lipid oxidation during storage of hot smoked tuna (*Thunnus albacores*) and tilapia at 4°C (Nejib *et al.*, 2011; Yanar *et al.*, 2006).

**Table 2.** Chemical composition of surimi added with different iodized salt concentrations

Salt concentration (%)	Chemical composition			
	Moisture (%)	Protein (%)	Ash (%)	Fat (%)
0	78.52 ± 0.48 <sup>a</sup>	16.08 ± 0.12 <sup>a</sup>	0.07 ± 0.02 <sup>b</sup>	0.63 ± 0.01 <sup>c</sup>
0.5	77.74 ± 0.29 <sup>b</sup>	16.23 ± 0.36 <sup>a</sup>	0.08 ± 0.05 <sup>b</sup>	0.56 ± 0.01 <sup>d</sup>
1.0	75.84 ± 0.02 <sup>c</sup>	13.94 ± 0.19 <sup>b</sup>	0.12 ± 0.02 <sup>ab</sup>	1.11 ± 0.03 <sup>b</sup>
1.5	75.18 ± 0.11 <sup>c</sup>	15.14 ± 0.53 <sup>c</sup>	0.19 ± 0.01 <sup>a</sup>	1.58 ± 0.01 <sup>a</sup>

\*Means within each row with different superscript letters indicate significant differences ( $P < 0.05$ ) as measured in Tukey's Multiple Comparison Test

### 3.1.2. pH analysis

pH is one of the vital factors that can affect the final quality of surimi in the real world of surimi processing. Table 3 depicts the pH of the sample without the addition of iodized salt (control) was slightly acidic, which was 5.44. Based on the previous study, unwashed *E. affinis* tuna fish species were reported to have a 6.7 pH value. The lower pH value in this study might be due to the removal of all the water-soluble components or oxidation of the fish protein and fat content in the presence of oxygen during the washing process, thus leaving concentrated acidic elements such as amino acids, lactic acid, and free fatty acid (Lanier *et al.*, 2005). Results in Table 3 also showed that the pH means value reduced significantly ( $p < 0.05$ ) from 5.44 to 5.41 after adding 0.5% (w/w) iodized salt concentration to the sample. This may be explained by an increase in the ionic strength and interactions between the salt ions and proteins inside the cells (Greiff *et al.*, 2015). However, when the salt concentration increases to 1.5%, the pH value was found to increase significantly ( $p < 0.05$ ) to 5.48. This is due to the neutral pH properties of table salt that might be shifting the pH value of the surimi in high concentrations (Mostafa & Salem, 2015).

**Table 3.** pH of surimi added with different iodized salt concentration

Salt concentration (%)	pH (%)
0	5.44 ± 0.01 <sup>b</sup>
0.5	5.41 ± 0.00 <sup>c</sup>
1.0	5.43 ± 0.01 <sup>b</sup>
1.5	5.48 ± 0.00 <sup>a</sup>

Data given were mean values ± standard deviation of triplicates ( $n=3$ ). Different letters indicate the differences ( $p < 0.05$ ) between mean values within the concentration of iodized salt.

### 3.1.3. Colour measurement

Myofibrillar protein is the main component used mainly as a functional ingredient in a product of fish-based surimi. Generally, the quality attributes of the surimi fish-based



product is determined through its colour. Washing deboned fish mince is one of the methods concerned in the processing of surimi to remove myoglobin, fat, and other impurities, thus resulting in increasing lightness ( $L^*$ ), decreasing redness ( $a^*$ ) and also yellowness ( $b^*$ ) by using water. Table 4 shows the *E. affinis* surimi tristimulus colour values ( $L^*$ ,  $a^*$ ,  $b^*$ ) when different concentrations of iodized salts were added. From the results obtained, the lightness reduced significantly ( $p < 0.05$ ) when the iodized salt concentration added increased. A previous study reported that potassium iodate ( $KIO_3$ ) iodized salt would change the pickles' colour to a darker colour when preparing pickling brine (Jessica *et al.*, 2018).  $KIO_3$  iodized salt also showed an effect on the colour of high-fat sausage (Jessica *et al.*, 2018). As a result, the lightness value of the *E. affinis* surimi was reduced when an increased iodized salt concentration was added. However, the lightness increased on the 1.5% (w/w) surimi due to fish muscle's loss of blood (Hassan & Fatma, 2015). The sample added with a 1.0% (w/w) concentration had a significantly higher ( $p < 0.05$ ) positive  $a^*$  value indicating a more intense reddish colour compared to the control sample. This result partially agrees with the reports by Sang-Keun *et al.* (2011) and Baxter and Skonberg (2008) about the increase of surimi chicken and Jonah crab mincemeat redness value when salt concentration increased due to reduction of moisture content drawn out from the fish tissue and hence, increased the redness value due to the increasing of surimi myoglobin content (Sang-Keun *et al.*, 2011). However, in a very high concentration of salt, which is 1.5% (w/w), the redness tone reduces to 7.19, due to the removal of blood from the muscle (Hassan & Fatma, 2015). For the  $b^*$  value, surimi added with 1.5% (w/w) salt showed the significantly ( $p < 0.05$ ) highest mean values, indicating the highest yellow colour. These could be explained due to the reaction between free radicals and oxygen in the presence of iodized salt thus leading to lipid oxidation and resulting in metmyoglobin formation and discolouration of fish meat (Hassan & Fatma, 2015). However, overall, the iodized salt concentrations showed no significant difference ( $p > 0.05$ ) towards the surimi whiteness value.

**Table 4.** Tristimulus colour and whiteness values of different surimi formulations

Salt concentration (%)	Tristimulus colour and whiteness			
	$L^*$	$a^*$	$b^*$	Whiteness
0	44.71 ± 0.43 <sup>a</sup>	7.30 ± 0.10 <sup>c</sup>	10.82 ± 0.28 <sup>b</sup>	43.19 ± 0.46 <sup>a</sup>
0.5	42.06 ± 0.30 <sup>b</sup>	7.64 ± 0.01 <sup>b</sup>	11.00 ± 0.08 <sup>b</sup>	40.53 ± 0.27 <sup>a</sup>
1.0	44.17 ± 0.14 <sup>a</sup>	7.96 ± 0.02 <sup>a</sup>	11.68 ± 0.01 <sup>a</sup>	42.41 ± 0.13 <sup>a</sup>
1.5	42.66 ± 0.11 <sup>b</sup>	7.19 ± 0.00 <sup>c</sup>	12.03 ± 0.03 <sup>a</sup>	40.98 ± 0.10 <sup>a</sup>

Data given were mean values ± standard deviation of triplicates ( $n=3$ ). Different letters indicate difference ( $p < 0.05$ ) between mean values within concentration of iodized salt.

### 3.2. Water Activity, Water Holding Capacity, Cooking Yield Measurement

The analysis of water activity is essential to understand the stability of food characterisation by measuring the effect of free water on microbial growth, and the physical and chemical properties of food, including enzyme activities. The measurement of the water activity is vital in many cases in the food industry such as in determining the critical control point for Hazard Analysis and Critical Control Points (HACCP) programs to ensure the values are within the range of the Food Safety and Quality. Based on the analysis results in Table 5, the addition of salt was significantly ( $p < 0.05$ ) affecting the water activity of the surimi. Salt penetrates the food, lowering the water activity in the deepest part of the flesh and the occurrence of impurities interferes with salt penetration which leads to low-quality products (Ahmed *et al.*, 2018). Salt concentration also could reduce the water activity by binding water molecules, increasing the effective content of flavour molecules, and their volatility thus resulting in flavour enhancement of surimi (Pedro and Nunes, 2007).

**Table 5.** Water activity, WHC, and cooking yield (%) of fish mince added with different concentrations of iodized salt

Salt concentration (%)	Water activity ( $a_w$ )	WHC (%)	Cooking Yield (%)
0	$0.98 \pm 0.00^a$	$20.05 \pm 0.01^{ab}$	$61.51 \pm 0.32^d$
0.5	$0.97 \pm 0.00^b$	$19.93 \pm 0.07^b$	$69.86 \pm 0.32^c$
1.0	$0.97 \pm 0.00^b$	$20.11 \pm 0.21^{ab}$	$71.40 \pm 0.32^b$
1.5	$0.96 \pm 0.00^c$	$20.14 \pm 0.03^a$	$76.78 \pm 0.20^a$

Data given were mean values  $\pm$  standard deviation of triplicates ( $n=3$ ). Different letters indicate the differences ( $p < 0.05$ ) between mean values within the concentration of iodized salt.

Another important physical analysis that has been done was water holding capacity (WHC) to determine the gelling property related to the network gel strength as well as the quality of frozen surimi. In a more reliable and dense protein network structure, more water could be retained (An *et al.*, 2018). Generally, the loss of water-holding capacity (WHC) is caused by the diminution of myofibrillar proteins from the combination of myosin and actomyosin due to the denaturation of protein during storage. Based on the results obtained, water holding capacity (WHC) showed no significant ( $p > 0.05$ ) changes when salt was added up to 1.0% (w/w). However, significance ( $p < 0.05$ ) was detected for the sample added with 1.5% (w/w) iodized salt and showed the highest percentage of WHC compared to 0.5% (w/w) salt concentration. The presence of salts in the sample increases the ionic strength between proteins due to the presence of cation, I from the iodized salt. The cation charge will encourage to development of a salt bridge between peptide chains and ionic strength, thus increasing the WHC of surimi (Greiff *et al.*, 2015). Moreover, it might also be due to the

interaction between unfolding proteins in the system with the anionic groups of water molecules leading to the increase of WHC.

Cooking yield can be defined as properties of protein food that are related to the texture properties and the network characteristics of the semi-solid food which is well known as a gel characteristic (Youling, 1993). Cooking yield resulted from the structural changes that happened due to the different protein denatures at several temperatures during the cooking process (Honikel, 2015). Based on the results obtained in Table 5, cooking yield showed a positively significant increase ( $p < 0.05$ ) with increased salt concentration. Purnomo and Rahardiyana (2008) have reported that high cooking yield is obtained because of the high-fat retention in the meat-based product. Therefore, this is in agreement as reported above, which the highest fat content has been observed in the surimi formulation with the highest percentage of salts. The presence of iodized salt could increase the ionic strength between the salt ion and the fish protein thus stimulating the high cooking yield in the fish surimi paste (Greiff *et al.* 2015).

#### 4. Conclusions

A study on the physicochemical properties of red meat fish species, *E. affinis* added with different concentrations of iodized salt has been conducted to identify the best additive formulation for *E. affinis* surimi processing that's suited to consumer acceptance. Several significant influences have been identified including proximate composition, pH, colour, water activity, water holding capacity and cooking yield. Based on the results obtained, iodized salt decreased the moisture content and increased the fat content of the *E. affinis* surimi paste. Increased iodized salt concentrations also help in controlling microbial growth and enzyme activities by reducing the water activity, thus helping in producing a longer shelf-life of fish-based products. Iodized salt also could enhance the *E. affinis* surimi paste flavour molecules and their volatilities. This study also revealed that the utilisation of iodized salt could reduce the lightness ( $L^*$ ) of *E. affinis* fish surimi instead of increasing their redness ( $a^*$ ) and yellowness ( $b^*$ ) value, however, it does not affect the whiteness value. It can be concluded that the preferred concentration of iodized salt for the production of *E. affinis* surimi was found to be 1.5% (w/w) salts. Overall, all these data obtained can help the surimi industry produce a much healthier surimi product with optimal food additives, economical and environmentally friendly in terms of the raw fish supply chain.

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