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Effects of Deep Frying on Proximate Composition and Micronutrient of Indian Mackerel (*Rastrelliger kanagurta*), Eel (*Monopterus albus*) and Cockle (*Anadara granosa*)

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Abstract: This study was conducted to determine the proximate composition and four micronutrients (Cd, Cu, Mn and Zn) of Indian Mackerel (*Rastrelliger kanagurta*), Eel (*Monopterus albus*) and Cockle (*Anadara granosa*). All fish and shellfish were purchased from local fish market in Kuantan city. All samples of each species were mixed and divided into two groups based on random selection. Each group were again divided into 3 sub-groups which were considered as replications. The first group were kept uncooked. The second group were fried in a beaker of 400 mL palm cooking oil capacity at a temperature approximately of 180°C for a 15 min period. Both raw and fried samples were analysed following standard methods to determine protein, lipid, ash, moisture, carbohydrate, Cd, Cu, Mn and Zn contents. Results showed that protein content was higher in Indian mackerel and eel than cockle while overall Cd, Cu, Mn and Zn contents were higher in cockle than Indian mackerel and eel. Therefore, fish is better than shellfish in the nutritional point of view. Fried fish and shellfish had very high fat content. Therefore, frying cannot be recommended to prepare a healthy diet. More research is needed including all cooking methods of fish to know the nutritional changes by each cooking method. Fish contains many important fatty acids and amino acids which might be lost during frying. Therefore, future study should include the effects of different cooking methods on amino acids and fatty acids compositions of fish and shellfish.

Key words: *Rastrelliger kanagurta*, *Monopterus albus*, *Anadara granosa*, proximate composition, heavy metal

INTRODUCTION

Malaysia is one of the highest fish producing country in Asia. This is because it has a vast water area. Fish is one of the main sources of protein to Malaysian (MFD, 2008; Kumolu-Johnson and Ndimele, 2011). Fish contain high quality of protein with a complete range of the essential amino acids and fat with polyunsaturated fatty acids that provide a lot of health benefits including keeping our heart and brain healthy (Agusa *et al.*, 2007). In 2002, the per capita consumption of fish in Malaysia was 53 kg, while in 2010 was 56 kg. In 2010, the total consumption of fish in Malaysia was more than 1.58 billion kg.

Among various types of fishes, one of the popular fish in Malaysia is Indian mackerel (*Rastrelliger kanagurta*). This is because it has a good taste and it is available in all areas in Malaysia. Malaysia's Department of Statistics has reported the total

consumption of Indian mackerel has been increasing simultaneously since 2005 until today. Apart from Indian mackerels, now-a-days, many Malaysians consume a shellfish, cockles (*Anadara granosa*) as a source protein. Now-a-days, a few Malaysian also consume freshwater eel (*Monopterus albus*) because of taste and soft texture. Generally, Malaysians do not consider nutritive value during selection of fish for consumption. The selection of fish is normally based on the availability, cost and taste. In this study, an attempt was made to provide information on important nutrients composition in Indian mackerel, freshwater eel and cockles. This information would be very useful for consumer to conceptually increase their knowledge regarding the nutrients contents in Indian mackerel, freshwater eel and cockles.

Frying and boiling (curry) are two popular methods generally used to cook fish in Malaysia. However, frying is more popular than boiling to cook fish in Malaysia because it is one of the fastest and simplest methods of

fish cooking. Since frying involves with a very high temperature (usually 170-180°C) it degrades nutrients through hydrolysis and oxidation of the fatty acids (Rossel, 2001). The breakdown products can give rise to good flavor and taste. However, cooking methods are very important parameter for nutritive value of fish. The food nutritive value can be affected by deep-frying (Gokoglu *et al.*, 2004). Similarly, nutritive value of fish can be changed by deep-frying. There are some published studies (Ersoy and Ozeren, 2009; Erkan *et al.*, 2010) which discuss the effect of different cooking methods on nutritive value of different fishes. However, information about the effects of deep-frying on the changes of nutritive value of Indian mackerel, freshwater eel and cockles is still lacking. Such information can improve our understanding on the preparation of healthy diet with cockles, Indian mackerels and eels. This study helps to understand the effect of deep-frying on proximate composition of cockles, Indian mackerel and eel. The main objectives of this study were to determine proximate composition and selected the mineral content of fresh cockle, Indian mackerel and eel and to compare the proximate composition and selected mineral content between fresh and fried cockle, Indian mackerel and eel.

MATERIALS AND METHODS

Sample collection and preparation: A total of 6 Indian mackerels (weight 50-100 g), 6 eels (100-160 g) and of 6 cockles (10-20 g) were purchased from local fish market in Kuantan city and transported immediately to the laboratory with an ice-box. On arrival in the laboratory, all samples were smoothly washed by tap water to remove blood and slime. The Indian mackerels and eels were eviscerated, de-headed, filleted. The cockle flesh was removed from shell. The bones of the Indian mackerels and eels were separated from the flesh. All the samples were then cut into pieces and washed with tap water several times to remove blood.

All pieces of samples of each species were mixed and divided into two groups based on random selection. Each group were again divided into 3 sub-groups which were considered as replications in this study. The first group was kept uncooked. The second group was fried in a beaker of 400 mL palm cooking oil capacity at a temperature approximately of 180°C for a 15 min period. All fresh and fried samples were hand de-boned (if necessary) and ground in a mortar to ensure homogeneity and representative samples taken for analysis. Samples were put in a sterile container and kept under frozen conditions (-20°C) until analysis.

Proximate composition analysis: Moisture content of the samples were determined according to AOAC (1993) with slight modifications by Tee *et al.* (1996). One gram of the sample was weight out in a sterile, flat, aluminum dish and dry up to constant weight at 100°C in an oven. The percentage of moisture content was calculated according to equation below:

$$\text{Moisture content (\%)} = \frac{\text{Weight of fresh sample (g)} - \text{Weight of dry sample (g)}}{\text{Weight of fresh sample (g)}} \times 100$$

Ash content was also determined according to AOAC (1993) with slight modifications by Tee *et al.* (1996). One gram of the sample was weighed and put into a dry, tarred porcelain dish and then placed in a muffle furnace at 500°C for 22 h. Then, the samples were cooled in desiccators and weighed. The percentage of ash content was calculated using the following equation:

$$\text{Ash content (\%)} = \frac{\text{Weight of Ash (g)}}{\text{Weight of sample (g)}} \times 100$$

Crude protein contents were determined according to Kjeldahl method described by AOAC (1993). For this, 1 g of sample was weighed into digestion tubes. Two Kjeltabs Cu 3.5 (catalyst salts) were added into each tube. About 15 mL of concentrated acid sulphuric (H₂SO₄) was carefully added into the tube and then shaken gently. Digestion procedure was performed using pre-heated (420°C) digestion block of Kjeltec 2200 (Foss Analytical, Hoganas, Sweden) for 60 min until clear blue/green solution was obtained. Digested samples were cooled for 10-20 min. Distillation procedure was then performed using distillation unit of Kjeltec 2200. Distillate was titrated with 0.1 N hydrochloric acid (HCl) until blue end point achieved. Volume of acid required in the titration was recorded. Blank was prepared with the exclusion of sample. The percentage of crude protein content was calculated according to the following equation:

$$\text{Protein (\%)} = \text{Nitrogen (\%)} \times 6.25$$

where, 6.25 is the conversion factor for nitrogen to protein:

$$\text{Nitrogen (\%)} = \frac{(T - B) \times N \times 14.007}{\text{Weight of sample (g)}} \times 100$$

where, T is the titration volume for sample (mL), B is the titration volume for blank (mL), N is the normality of acid to 4 decimal places.

Crude lipid assay was carried out by a Soxtec extraction procedure with a Soxtec 2050 automated extraction system (Foss). Approximately 1 g of sample was weighed into tarred cellulose thimbles. A defatted cotton plug was placed on top of each sample to keep the material immersed during the boiling step and to prevent any sample loss from the top of the thimble. Samples were extracted with petroleum ether (boiling range 40-60°C) solvent. The extraction thimble was set into the weighed aluminum cup (Foss) and approximately 70 mL of petroleum ether (40-60) was added to each cup. Crude fat was extracted by immersing the sample in the boiling solvent under reflux for 30 min. The sample thimble was raised and rinsed with condensed solvent for an additional 45 min. The reflux rate was adjusted to approximately 3-5 drops during the extraction and rinse steps. Then, the extraction Petroleum ether (40-60) was removed by a final evaporation step (10 min). The sample cups were lifted about 1 cm during the evaporation cycle to avoid excessive sample heating and then pre drying 1-2 min. After completion of the extraction process, sample cups were dried at 105°C for at least 30 min and transferred to a desiccator and cooled to ambient temperature. Weight of the crude fat extracted was determined dry-matter basis (DMB) using following equation:

$$\text{Crudfat (\% of DMB)} = \frac{\text{Weight of lipid (g)}}{\text{Weight of sample (g)}} \times 100$$

Carbohydrate was calculated using indirect method. The following standard equation was used for carbohydrate content estimation:

$$\text{Carbohydrate content (\%)} = 100\% - (\% \text{ moisture} + \% \text{ ash} + \% \text{ protein} + \% \text{ lipid})$$

Cd, Mn, Cu and Zn content analysis: All samples were digested before analysing Cd, Mn, Cu and Zn content using Atomic Absorption Spectrometry (AAS). For digestion, a representative sample of up to 0.3 g was extracted and dissolved in 6 mL concentrated nitric acid and 1 mL of hydrogen peroxide for 45 min using microwave heating unit named multiwave 3000. The sample and acids were placed in a quartz microwave vessel or vessel liner. The vessel was sealed and heated in the microwave unit. After cooling, the vessel contents were filtered, centrifuged and allowed to settle and then diluted to 15 mL in falcon tubes. The tubes were sealed and kept under room temperature prior using Atomic Absorption Spectrometry (AAS).

All the digested samples were then analysed three times for several minerals like Cd, Mn, Cu and Zn using SIMAA 6100 Perkin Elmer Atomic Absorption Spectrometry (AAS). This machine detected the presence of the selected minerals using graphite furnaces atomic absorption spectrometry (GFAAS).

Statistical analysis: All data were analyzed using SPSS version 16.0. All data were checked for normality before analysis. Only the percent data had to be arcsine-transformed before analysis. Nutrients contents of Indian mackerel, eel and cockle were compared through one way ANOVA. If an ANOVA was significant, differences between the means were analyzed by Tukey test for unplanned multiple comparisons of means ($p < 0.05$). The t-test was used to compare the nutrients content between raw and fried samples.

RESULTS

Nutrients content of fresh Indian mackerel, eel and cockle: Indian Mackerel, cockle and eel were significantly different ($p < 0.05$) in term of moisture, protein, lipid, carbohydrate, ash, Cd, Mn, Cu and Zn contents (Table 1). Moisture content was highest in cockle, followed by eel and Indian mackerel. Protein content of Indian mackerel and eel were significantly higher ($p < 0.05$) than the protein content in cockle. There was no significant difference ($p > 0.05$) between the protein content of Indian mackerel and eel. Lipid content was highest in Indian mackerel, followed by cockle and eel. Carbohydrate content was higher in the Indian Mackerel than in the eel. Indian mackerel had higher ash content than eel and cockle ($p < 0.05$). There was no significant difference between ash content of eel and cockle ($p > 0.05$).

Cockle had higher Cd, Mn and Zn contents than Indian mackerel and eel ($p < 0.05$). However, Indian mackerel and eel are statistically similar on Cd, Mn and Zn contents. Cu content was comparatively highest in Indian mackerel, followed by cockle and eel.

Nutrients contents of fried cockle, Indian mackerel and eel: Average nutrients content of fried Indian mackerel, cockle and eel were significantly different ($p < 0.05$) (Table 2). Highest moisture was observed in fried Indian mackerel, followed by fried eel and fried cockle. However, opposite results of moisture content were observed in case of lipid and Mn contents. Protein content was higher in fried eel than fried mackerel, while lowest quantity of protein was observed in fried cockle. Fried cockles had

Table 1: Macronutrient and micronutrient contents in raw Indian mackerel, eel and cockle

Parameter	Significance (p-value)	Indian mackerel	Eel	Cockle
Moisture (%)	***	76.64±0.48 ^a	78.19±0.62 ^b	87.30±0.64 ^a
Protein (%)	**	16.88±0.56 ^a	19.10±0.81 ^a	13.04±2.60 ^b
Lipid (%)	***	3.89±0.24 ^a	1.33±0.18 ^c	2.00±0.10 ^b
Carbohydrate (%)	***	1.15±0.08 ^a	0.29±0.17 ^b	0.00±0.00 ^c
Ash (%)	**	1.44±0.07 ^a	1.05±0.21 ^b	0.88±0.02 ^b
Cd (mg kg ⁻¹)	**	2.00±0.41 ^b	2.36±0.08 ^b	3.40±0.26 ^a
Mn (mg kg ⁻¹)	***	3.12±0.32 ^b	4.24±0.94 ^b	22.68±1.94 ^a
Cu (mg kg ⁻¹)	**	5.60±1.36 ^a	1.58±0.97 ^b	3.29±0.70 ^{ab}
Zn (mg kg ⁻¹)	**	54.11±15.16 ^b	61.15±7.25 ^b	96.17±9.93 ^a

Values (Mean±95% CI) in the same row with no superscript in common differ significantly at p<0.05, if the effects are significant, ANOVA was followed by Tukey test, **p<0.01, ***p<0.001

Table 2: Macronutrients and micronutrients of fried Indian mackerel, Eel and Cockle

Parameter	Significance (p-value)	Indian mackerel	Eel	Cockle
Moisture (%)	***	20.39±5.31 ^a	16.92±7.02 ^b	0.27±0.28 ^c
Protein (%)	**	40.54±4.45 ^b	50.93±2.26 ^a	28.05±0.44 ^c
Lipid (%)	***	20.18±0.38 ^a	23.96±2.71 ^b	41.38±1.17 ^c
Carbohydrate (%)	***	1.61±0.47 ^a	4.22±3.17 ^a	0.36±0.58 ^b
Ash (%)	**	17.27±0.85 ^b	3.97±0.52 ^c	30.30±1.40 ^a
Cd (mg kg ⁻¹)	**	3.10±0.07 ^b	2.99±0.15 ^b	4.32±0.16 ^a
Mn (mg kg ⁻¹)	***	2.36±0.70 ^a	4.30±0.10 ^b	7.38±0.90 ^a
Cu (mg kg ⁻¹)	**	1.47±0.46 ^a	0.00±0.00 ^b	0.37±0.23 ^b
Zn (mg kg ⁻¹)	**	28.39±2.61 ^b	40.89±10.50 ^a	23.68±1.76 ^c

Values (Mean±95% CI) in the same row with no superscript in common differ significantly at p<0.05, if the effects are significant, ANOVA was followed by Tukey test, **p<0.01, ***p<0.001

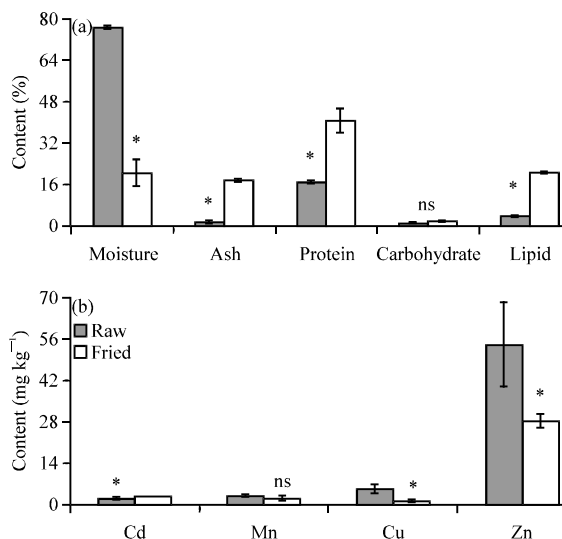


Fig. 1(a-b): Effects of frying on (a) Macro-nutrients and (b) Micronutrients contents in Indian mackerel based on t-test, *Significant difference between treatment (raw and fried), ns: No significant difference

highest ash content, followed by Indian mackerel and eel. Mn of fried cockle was higher than the Mn content of Indian mackerel and eel (p<0.05). In case of Mn content, fried Indian mackerel and fried eel are statistically same (p>0.05). Cu content of fried mackerel was higher than the Cu content of fried eel and cockle (p<0.05). Eel had highest Zn content, followed by Indian mackerel and cockle.

Effects of deep-frying on nutrients content of cockle, eel and Indian mackerel:

All macronutrients content were statistically different between raw and fried Indian mackerel except carbohydrate content (Fig. 1a). Frying reduced moisture content of Indian mackerel, whereas an opposite result was observed in case of ash, protein and lipid contents of Indian mackerel. Eel and cockle showed similar trend of Indian mackerel when compare with macronutrients content between fresh and fried samples (Fig. 2a, 3a). Frying reduced Cu and Zn content of Indian mackerel, whereas an opposite result was observed in case of Cd content in Indian mackerel (Fig. 1b). Eel and cockle showed similar trend of Indian mackerel when comparing Cd, Cu and Zn contents between fresh and fried samples (Fig. 2b, 3b). Frying reduced Mn content in cockles whereas there is no significant effect of frying on Mn content of Indian mackerel and eel.

DISCUSSION

In this study, some selected nutrients contents of fresh and deep-fried Indian mackerel, eel and cockle were studied. Among many nutrients, protein content is one of most important criteria to evaluate food quality. It is an important constituent of foods for a number of different reasons such as growth, replacement of metabolic losses and damaged tissue as well as general well-being. Proteins are the major source of energy, as well as containing essential amino acids which are needed to human health. In the present study, when compared among raw fish (Indian mackerel and eel) and shellfish (cockle); fish has

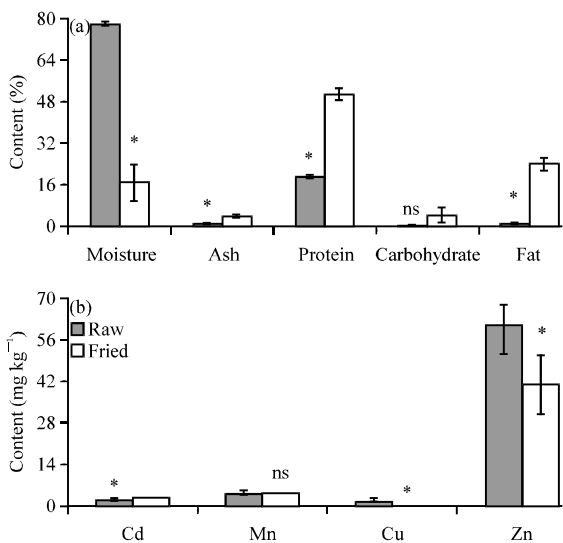


Fig. 2(a-b): Effects of frying on (a) Macro-nutrients and (b) Micronutrients contents in eel based on t-test, *Significant difference between treatment (raw and fried), ns: No significant difference

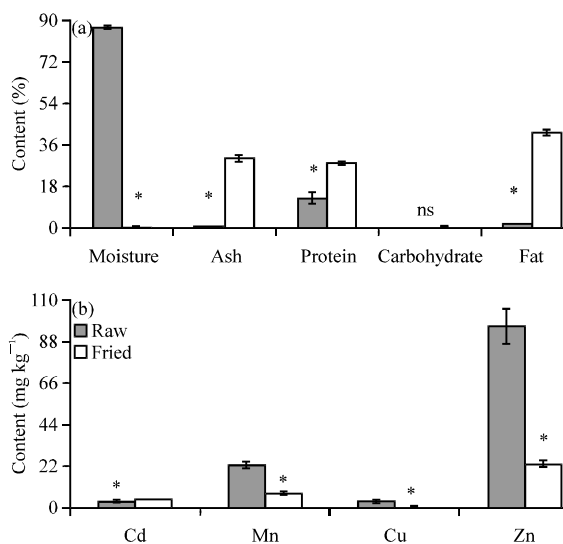


Fig. 3(a-b): Effects of frying on (a) Macro-nutrients and (b) Micronutrients contents in cockle based on t-test, *Significant difference between treatment (raw and fried) ns: No significant difference

higher protein content than shellfish. However, overall heavy metals content were higher in shellfish than finfish. Almost similar results were observed by Nurnadia *et al.* (2011). In case of moisture and lipid content, no definite

trend was observed when compare uncooked finfish and shellfish. However, an inverse relationship between the lipid and moisture content was observed in uncooked fish and shellfish. The fat content of Indian Mackerel was slightly higher than the value obtained by Nurnadia *et al.* (2011). However, the differences in proximate composition in fresh fish could be due to many factors, such as age, size, habitat, species, etc.

In this study, a comparison between raw and fried Indian mackerel, eel and cockle was made and found significant difference between them. Fried samples had higher fat, protein and ash content compare to raw samples. There is no previous study which compared the effects of frying on nutrient content of eel and cockles. However, Arias *et al.* (2003) and Erkan *et al.* (2010) observed similar effects of frying on nutrients content in fish samples. The increase in fat content was most obvious in fried fillets mainly due to the absorption of oil and leaching out of the water by the fish during deep-frying. According to Saguy and Dana (2003), cooking oil penetrates into the fillets during frying. This ultimately increases fat content in fried fish. The results of this study is similar to the results observed by Rosa *et al.* (2007), Gokoglu *et al.* (2004) and Gall *et al.* (1983) who reported significantly higher lipid content in fried fish than raw fish. The plausible reason of higher protein and ash content in fried samples might be the decreased in moisture content which subsequently increased all other nutrients. Steiner-Asiedua *et al.* (1991), Unlusayin *et al.* (2001) and Erkan *et al.* (2010) reported similar findings.

In micronutrient, there were significant different between raw and fried Indian mackerel, eel and cockle. Similar finding was observed by Bandarra *et al.* (2009). In this study, micronutrients were mostly heavy metal. The result showed that shellfish had overall higher heavy metal than fish. However, macronutrients in cockle are slightly lower compared to eel and Indian mackerel. The similar result was also observed in fried sample. These indicate that freshwater fish and marine fish are better than shellfish in the nutritional point of view.

CONCLUSION

Protein content was higher in fish than cockle (shellfish) while overall heavy metal contents were higher in cockle than Indian mackerel and eel. Therefore, fish is better than shellfish in the nutritional point of view. However, more research is needed to analyze a complete nutritional profile of these fish and shellfish. Fried fish and shellfish had very high fat content due to absorption of fat during frying, although they had higher protein, fat and ash. Therefore, frying cannot be recommended to

prepare a healthy diet. More research is needed including all cooking methods of fish to know the nutritional changes by each cooking method. This would be very helpful to select a healthy diet. Age, size and location are very important factor for nutritional value of fish. Therefore, these factors should be considered in the future study. Fish contains many important fatty acids and amino acids which might be lost during frying. This was not considered in this study. Therefore, future study should also include the analysis of the composition of amino acids and fatty acids.

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