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SHORT COMMUNICATION

Contents of Boric Acid in Noodles and Processed Foods

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ABSTRACT

Boric acid is commonly used as pesticides, antifungal and antiseptics. It was also used as a food preservative to prolong the shelf life and enhance the food texture. In Malaysia, the addition of boric acid during food processing is prohibited due to its detrimental effect on health. In this study, noodles and fish-based processed food from different manufacturers were analysed for their boric acid concentrations by using the curcumin method. The results showed that there was high concentration of boric acid found in the noodles and fish-based processed food samples. The amount of boric acid detected in yellow noodles varied over the four weeks and amongst manufacturers. A similar pattern was also observed for ‘kuey teow’ (flat rice noodle) and ‘kolok’ noodle. The highest amount of boric acid concentrations was found in ‘kuey teow’ followed by yellow noodles and ‘kolok’ noodle. There was also inconsistency in the concentration of boric acid in fish cakes, fish balls and crab sticks. For fish-based products, crab stick contained the highest amount of boric acid followed by fish ball and fish cake. Even though the addition of boric acid to food is banned in Malaysia, the results of this study showed that boric acid is still being used as a food preservative in food manufacturing.

Keywords: Boric acid, noodles, preservative, processed foods

In Malaysia, processed food and noodles become the preferred foods in the country with statistic showing 59.27% and 58.01% locals consuming wheat noodles and rice-based noodles in a week, respectively (Norimah *et al*., 2008). In order to meet the demand by the population, fresh noodles and processed food are mass-produced by manufacturers throughout the country. However, these foods are easily perishable due to microbial load as they have high moisture content and rich with nutrient suitable for microbial growth (Wang *et al*., 2018). Hence, to extend the shelf-life of the food, food preservation is vital and one of the most commonly available preservatives used in the food industry is boric acid.

Boric acid possesses antifungal and antibacterial activities, hence a good preservative to prolong the food’s shelf life and give food a better texture (Seta *et al*., 2009). Boric acid can control starch gelatinisation and enhance colour, texture and food producers use it to hide the staleness and preserve the freshness of fish, prawn and meat. Low levels of boric acid ingestion result in minimal or no toxicity and does not require aggressive treatment in most patients (Litovitz *et al*., 1988). However, chronic ingestion of boric acid results in vomiting, nausea, diarrhoea, and abdominal pain ensued by headaches, fever, tremors, muscle twitching, a lack of energy and weakness (Boone *et al*., 2012). In severe cases, coma, seizures, liver and kidney dysfunction, a low red blood cell count and death can occur. For neonates, doses between 3-6 g total are possible to cause death while for adults, the potential lethal dose is 15-20 g total (Litovitz *et al*., 1988).

The utilization of boric acid as a preservative has been prohibited by the Malaysian government, just as in some different nations like Singapore, Thailand, China and United

Kingdom (Ang *et al*., 2010; MyHealth, 2012). A study showed manufacturers in Sarawak used boric acid as preservative in their noodles and fish-processed food products despite the ban from the government (Yiu *et al.*, 2008). Therefore, there is always a concern regarding usage of boric acid in food manufacturing and this warrants a revisit study.

Hence, this study aims to determine and compare the boric acid levels in the noodles and fish-based products produced by different manufacturers in Sarawak. In this study, three different brands of yellow noodles and 'kuey teow' noodle and two different brands of 'kolok' noodle were used. 'Kuey teow' noodle has a wide and flat appearance (with a diameter of 0.5 to 1.0 cm) while 'kolok' noodle is an egg noodle with springy looks (Figure 1). For processed food, four different brands of fish cake, fishball and crab stick were used. All the different brands came from different manufacturers.

The samples were purchased at the supermarkets around Kota Samarahan, Sarawak from March to May 2019. Dates of purchases for different batches of samples was a week apart. The samples were processed on the same day they were bought or refrigerated at 4 °C until the date of the experiment. The duration between the date of purchase and experiment did not exceed a week.

Boric acid concentration was determined using curcumin method according to Takakura *et al.* (2017) with minor modification where the samples were blended until smooth and mixed with nanopure water. The stock solution, with a concentration of 0.057 µg/ml was prepared by adding 5.7 µg of boric acid powder to 100 mL of 10% (v/v) 2-ethyl-1,3-hexanediol/chloroform and put on ice to completely dissolve the powder. Standard solution of 0, 50, 100, 150 and 200 µg/mL concentrations of boric acid were prepared from the stock solution. Then 0.5 mL of 0.3% curcumin/acetic acid solution and 0.05 mL of concentrated sulphuric acid were added to 0.05 mL of a standard solution of boric acid. The solution was mixed thoroughly using vortex and allowed to stand for 30 min at room temperature before measuring the absorbance at 550 nm using UV spectrophotometer (Perkin Elmer, USA).

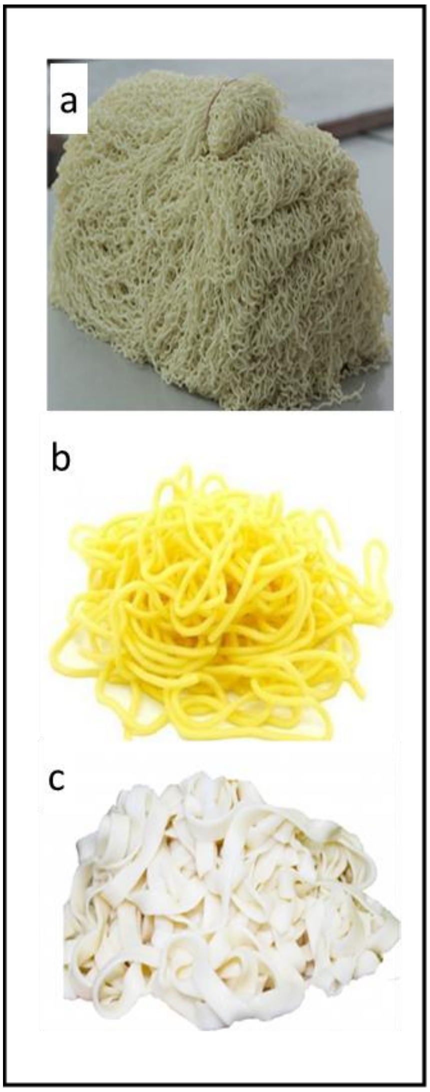

Figure 1. The types of local noodles: (a) 'kolok' noodle, (b) yellow noodles (c) 'kuey teow' noodle

The measurement of sample's boric acid concentration was done by firstly, blending 50 g of sample with 100 mL of nanopure water. Then, 0.2 mL of 50% sulphuric acid and 4 mL of 10% 2-ethyl-1,3-hexanediol/chloroform solution was added to 1 mL of the sample solution. The mixture was shaken for 5 min using a vortex mixer followed by centrifugation at 3000 rpm for 10 min. The top organic layer was collected as an extract. Then, 0.5 mL of curcumin reagent (0.3% curcumin/acetic acid) and 0.05 ml concentrated sulphuric acid were added to 0.05 ml of the extract. The mixture was mixed thoroughly using vortex mixer and allowed to stand for 30 min at room temperature. After 30 min, the absorbance of the mixture was read at wavelength 550 nm using UV-spectrophotometer against a blank test solution. Finally, boric acid concentration was determined using the standard.

The data from this study was analysed by one-way analysis of variance (ANOVA) coupled with Tukey's post-hoc test using Statistical Package for the Social Sciences (SPSS version 22). A p value < 0.05 was considered as statistically significant.

The results showed that the concentrations of boric acid in yellow noodles from manufacturer A from week one to week four were 379.2 ± 8.3, 135.2 ± 13.8, 127.2 ± 4.6 and 187.2 ± 4.0 µg/g, respectively (Figure 2). The highest concentration of boric acid for manufacturer A was recorded in week one. There was a significant difference in concentration of boric acid in week one compared to week two, week three and week four but there was no significant difference in concentration of boric acid between weeks two and week three. The concentrations of boric acid in yellow noodles from manufacturer B from week one to week four were 755.2 ± 16.6, 423.2 ± 24.1, 123.2 ± 27.7 and 183.2 ± 2.3 µg/g, respectively (Figure 2). Similar to manufacturer A, the highest concentration of boric acid was recorded in week one. There was also a significant difference in concentration of boric acid in week one compared to week two, week three and week four. There was also a significant difference in boric acid concentration between weeks two, week three and week four. For manufacturer C, the concentrations of boric acid from week one to week four were 1791.2 ± 18.0, 271.2 ± 18.0, 131.2 ± 10.1 and 143.2 ± 18.0 µg/g, respectively with the highest concentration of boric acid was also recorded on week one (Figure 2).

There was a significant difference in concentration of boric acid in week one compared to week two, week three and week four. However, there was no significant difference in concentrations of boric acid between weeks three and four. The ANOVA analysis of concentrations of boric acid among different manufacturers of yellow noodles showed no significant difference in boric acid concentrations among the three different manufacturers.

The concentrations of boric acid of ‘kuey teow’ noodle from manufacturer D from week one to week four were 1691.2 ± 12.9, 479.2 ± 6.9, 139.2 ± 12.9 and 343.2 ± 28.0 µg/g, respectively (Figure 3). The highest concentration of boric acid was recorded in week one. There was a significant difference in concentration of boric acid in week one compared to week two, week three and week four. The concentrations of boric acid in ‘kuey teow’ noodle for manufacturer E from week one to week four were 91.2 ± 8.0, 1687.2 ± 32.0, 91.2 ± 4.6 and 351.2 ± 6.1 µg/g, respectively (Figure 3). On the contrary to manufacturer D, the highest concentration of boric acid was recorded in week two. There was also significant difference in concentration of boric acid in week two compared to week one, week three and week four. However, there was no significant difference in concentration of boric acid between weeks one and three.

For manufacture F, the concentrations of boric acid from week one to week four were 579.2 ± 35.5, 1075.2 ± 65.5, 715.2 ± 23.3 and 315.2 ± 8.0 µg/g, respectively with the highest concentration of boric acid was recorded on week two. There was a significant difference in concentration of boric acid in week two compared to week one, week three and week four. However, manufacturer F showed no significant difference in concentration of boric acid between weeks one and week three. The ANOVA analysis of concentrations of boric acid among different manufacturers of ‘kuey teow’ noodle showed no significant difference in boric acid concentrations among the three different manufacturers.

The concentrations of boric acid in ‘kolok’ noodle from manufacturer G from week one to week four were 727.2 ± 18.5, 547.2 ± 23.1, 367.2 ± 12.2 and 259.2 ±4.0 µg/g, respectively (Figure 4). The highest concentration of boric acid was recorded in week one and there was a steady decreased in concentration from week one to four. There were significant differences in concentrations of boric acid in week one compared to week two, week three and week four.

For manufacturer H, the concentrations of boric acid were 167.2 ± 10.6, 499.2 ± 4.6, 303.2 ± 16.6 and 395.2 ± 8.3 µg/g, respectively with the highest concentration of boric acid recorded in week two. There was a significant difference in concentration of boric acid in week two compare to week one, week three and four. The independent T-test analysis of concentrations of boric acid among different manufacturers of ‘kolok’ noodle showed significant differences in boric acid concentration among the two different

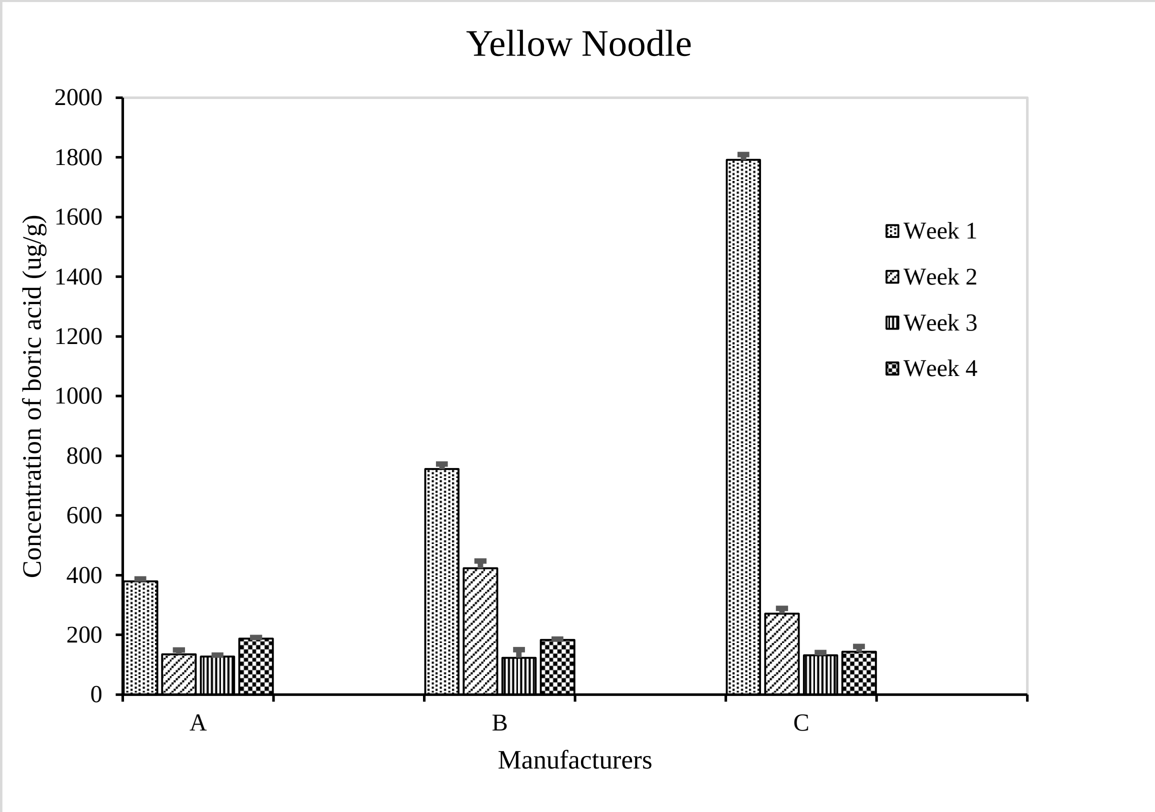

Figure 2. Concentrations of boric acid of yellow noodles from three different manufacturers (A, B and C) over four weeks

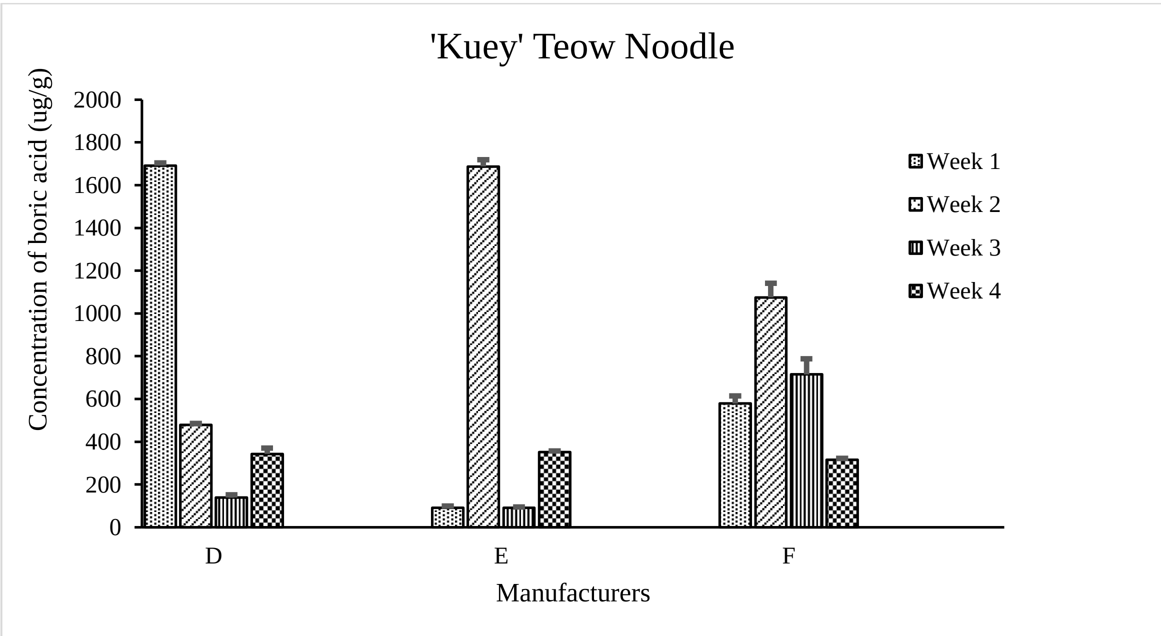

Figure 3. Concentrations of boric acid of 'kuey teow' noodle from three different manufacturers (D, E and F) over four weeks

manufacturers G and H.

The results for fish cake show that the concentrations of boric acid for manufacturer I from week one to week four were 119.2 ± 28.8, 959.2 ± 24.3, 47.2 ± 0.1 and 531.2 ± 8.3 µg/g, with week two having the highest concentration of boric acid (Figure 5). There was a significant difference in concentration of boric acid between the four weeks. For manufacturer J, the concentrations of boric acid from week one to week four were 63.2 ± 10.1, 379.2 ± 9.2, 903.2 ± 19.7 and 311.2 ± 27.7 µg/g, respectively. The highest concentration of boric acid was recorded in week three. There was a significant difference in boric acid concentration between the four weeks. The concentrations of boric acid for manufacturer K were 123.2 ± 4, 139.2 ± 26.6, 599.2 ± 10.1 and 79.2 ± 2.3 µg/g from week one to week four.

There was a significant difference in concentration of boric acid in week three compared to week one, two and four. However, there was no significant difference in boric acid concentration between week one and week two. From week one to week four, the recorded concentrations of boric acid for manufacturer L were 267.2 ± 6.9, 603.2 ± 14.4, 487.2 ± 8.3 and 227.2 ± 4 µg/g, respectively. The highest concentration of boric acid was in week two. There was a significant difference in concentration of boric acid in week two compared to week one, was a significant difference in concentration of boric acid in week two compared to week one, week three and week four. The ANOVA analysis of concentrations of boric acid among different manufacturers of fish cake shows that there were no significant differences in concentration of boric acid among different manufacturers.

The concentrations of boric acid for fishball from manufacturer M over four different weeks were 279.2 ± 30.3, 1827.2 ± 25.4, 715.2 ± 24.4 and 183.2 ± 10.1 µg/g, respectively with the highest concentration of boric acid recorded in week two (Figure 6). There was a significant difference in boric acid concentration when comparing between week two with week one, week three and week four and also between week one, week three and week four. The concentrations of boric acid from week one to week four for manufacturer N were 3.2 ± 2.3, 1403.2 ± 50.7, 1723.2 ± 46.1 and 75.2 ± 2.3 µg/g, respectively. Week three shows the highest concentration of boric acid. There was a significant difference in concentration of boric acid between weeks one, two and three. However, there was no significant difference in boric acid concentration between week three and four. For manufacturer O, the concentrations of boric acid in week one to week four were 1279.2 ± 26.3, 79.2 ± 0.1, 35.2 ± 2.3 and 51.2 ± 2.3 µg/g, respectively with week one having the highest concentration of boric acid.

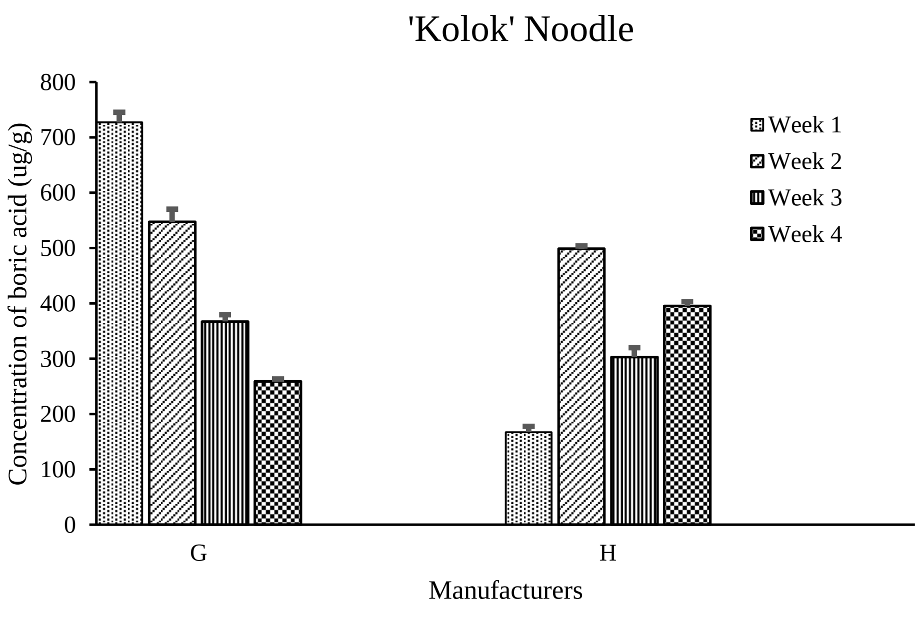

Figure 4. Concentrations of boric acid of 'kolok' noodle from different manufacturers (G and H) over four different weeks

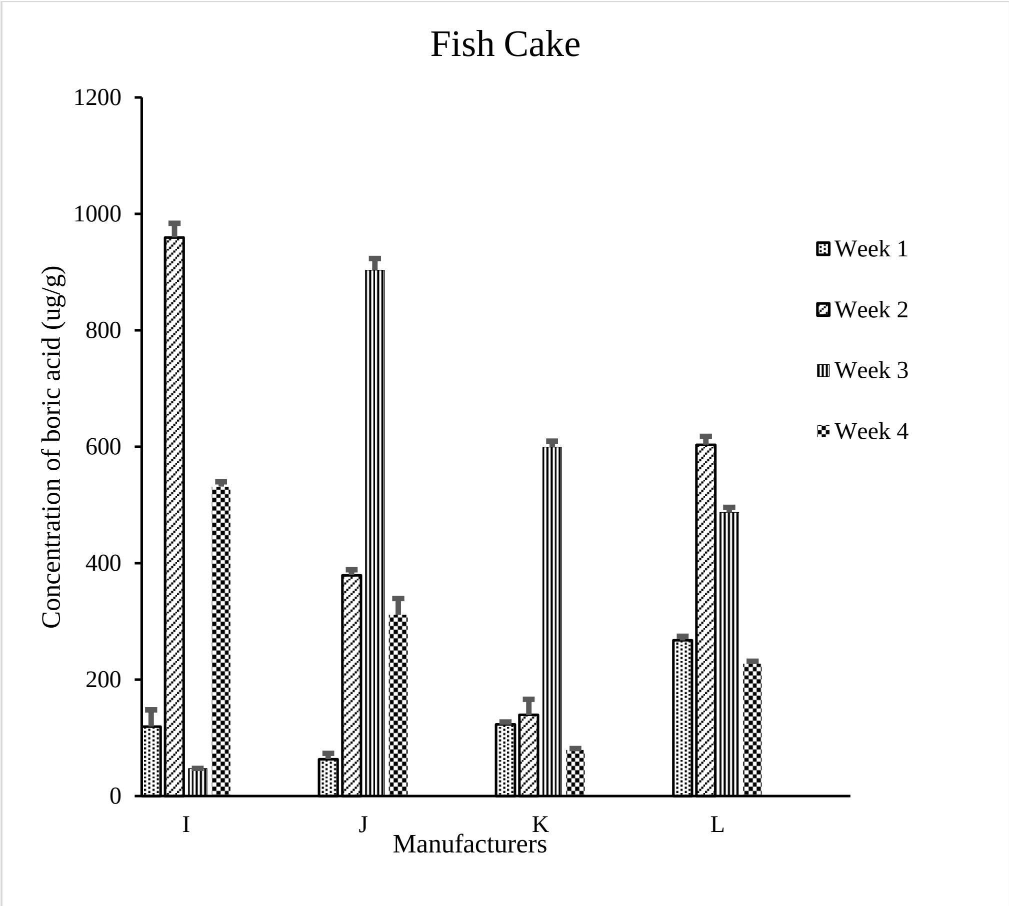

Figure 5. Concentrations of boric acid of fish cake from different manufacturers (I, J, K and L) over four different weeks

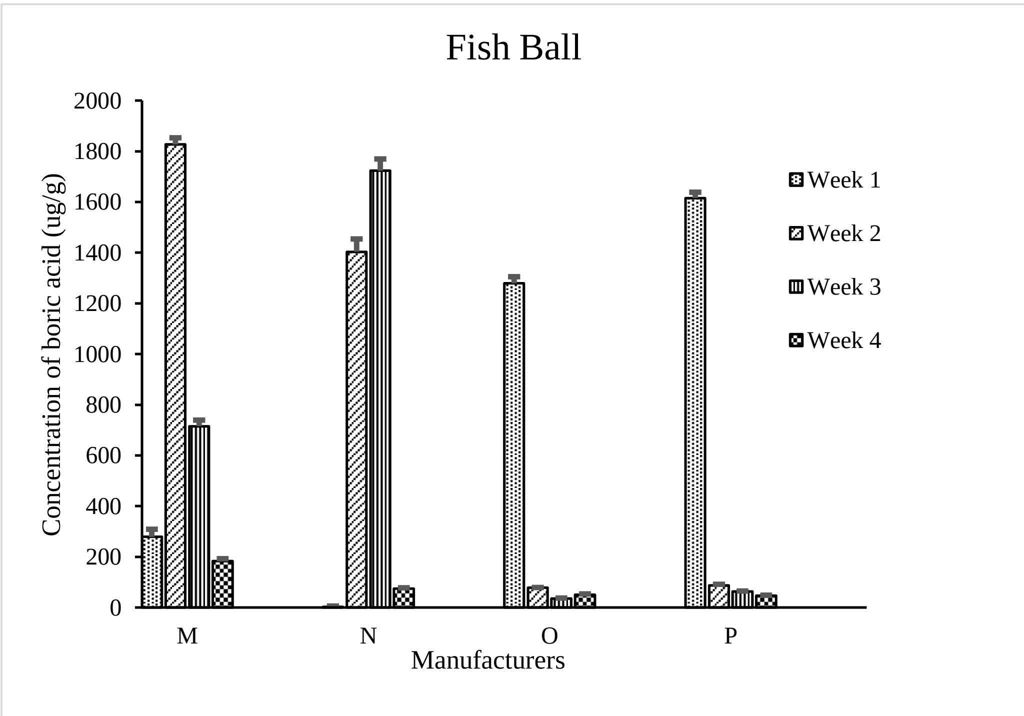

Figure 6. Concentrations of boric acid of fishball from different manufacturers (M, N, O and P) over four different weeks

There was a significant difference in concentration of boric acid between weeks one, two, three and four. However, there was no significant difference in concentration of boric acid between weeks two and four and between weeks three and four. The concentrations of boric acid for manufacturer P from week one to week four were 1615.2 ± 22.7, 87.2 ± 4.6, 63.2 ± 2.3 and 47.2 ± 2.3 µg/g, respectively. The highest concentration of boric acid was recorded on week one and it shows significant difference in concentration of boric acid when compare with week two, week three and week four. However, there was no significant difference in concentration of boric acid between week three and week four. ANOVA analysis of concentrations of boric acid among different manufacturers of fishball shows no significant difference in concentration of boric acid between manufacturers M, N, O and P as $p \geq 0.05$.

The concentrations of boric acid of crab stick for manufacturer Q from week one to week four were 12.8 ± 0.1, 1611.2 ± 20.1, 647.2 ± 16 and 287.2 ± 16 µg/g, respectively (Figure 7). The highest concentration of boric acid was recorded in week two. There was a significant difference in concentration of boric acid between all the four weeks. For manufacturer R, the concentrations of boric acid for the four weeks were 135.2 ± 15.1, 1003.2 ± 46.1, 1879.2 ± 24.4 and 1295.2 ± 4.6 µg/g, respectively with week four having the highest concentration of boric acid. There was a significant difference in concentration of boric acid when comparing all four weeks. The concentrations of boric acid for manufacturer S were 675.2 ± 16.2, 79.2 ± 2.3, 143.2 ± 12.2 and 119.2 ± 10.1 µg/g from week one to week four, respectively.

Week one recorded the highest concentration of boric acid with significant difference in concentration of boric acid when compared with week two, week three and week four. There was no significant difference in concentration of boric acid between weeks three and week four. The concentrations of boric acid for manufacturer T from week one to week four were 1251.2 ± 35.6, 315.2 ± 24.3, 267.2 ± 22.3 and 199.2 ± 4 µg/g, respectively. The highest concentration of boric acid recorded was on week two. There was a significant difference in concentration of boric acid when comparing all the four weeks. Based on ANOVA analysis of the boric acid concentrations among different crab stick manufactures, there is a significant difference when comparing manufacturer R with manufacturers Q, S and T but there is no significant difference between manufacturers Q, S and T.

In summary, the results showed that the amount of boric acid detected in yellow noodles varied over the four weeks and amongst manufacturers. Similar pattern was also observed for ‘kuey teow’ and ‘kolok’ noodle. Unlike yellow noodles where the concentration of boric acid was recorded high in the first week, the ‘kuey teow’ and ‘kolok’ noodle did not display the same pattern. There was also a comparable pattern of inconsistency for the concentration of boric acid in the fish cakes, fish balls and crab sticks over the four weeks.

The concentrations of boric acid obtained in this study were comparatively high compared to studies by Mizura *et al*. (1990) and Yiu *et al*. (2008). Yiu *et al*. (2008) reported the concentration of boric acid of less than 4.5 ug/g in yellow noodles, ‘wantan’ and ‘kuey teow’ noodle at the supermarkets in Bintulu, Sarawak. On the other hand, there was slightly high concentration of boric acid in selected food from Peninsular Malaysia. For example, 918 ug/g in agar-agar strips, 819 ug/g in pickled mango, 532 ug/g in wet noodles and 347 ug/g in fresh prawns (Mizura *et al*., 1990).

The variation of concentration of boric acid in the noodles and fish-based food products over the four weeks and amongst manufacturers could be due the inconsistency in the measurement of boric acid added to the foods by some small-scale producers (Yiu *et al*., 2008). There was a possibility that at different production period, the addition of boric acid could be handled by different workers. Besides that, the amount of boric acid added by some individual manufacturer was based on approximation rather than exact measurement. Moreover, varied concentration of boric acid could also be the result of non-uniform or poor mixing of boric acid with the flour and other ingredients during the production process (Ang, 2010).

Boric acid is not listed as permitted food preservative nor additives in Malaysian Food Act 1983 and Food Regulations 1985 (MyHealth, 2012). Despite of legislation and stated punishment towards those found guilty, boric acid is still used as preservative in noodles and fish-based food products, as revealed from this

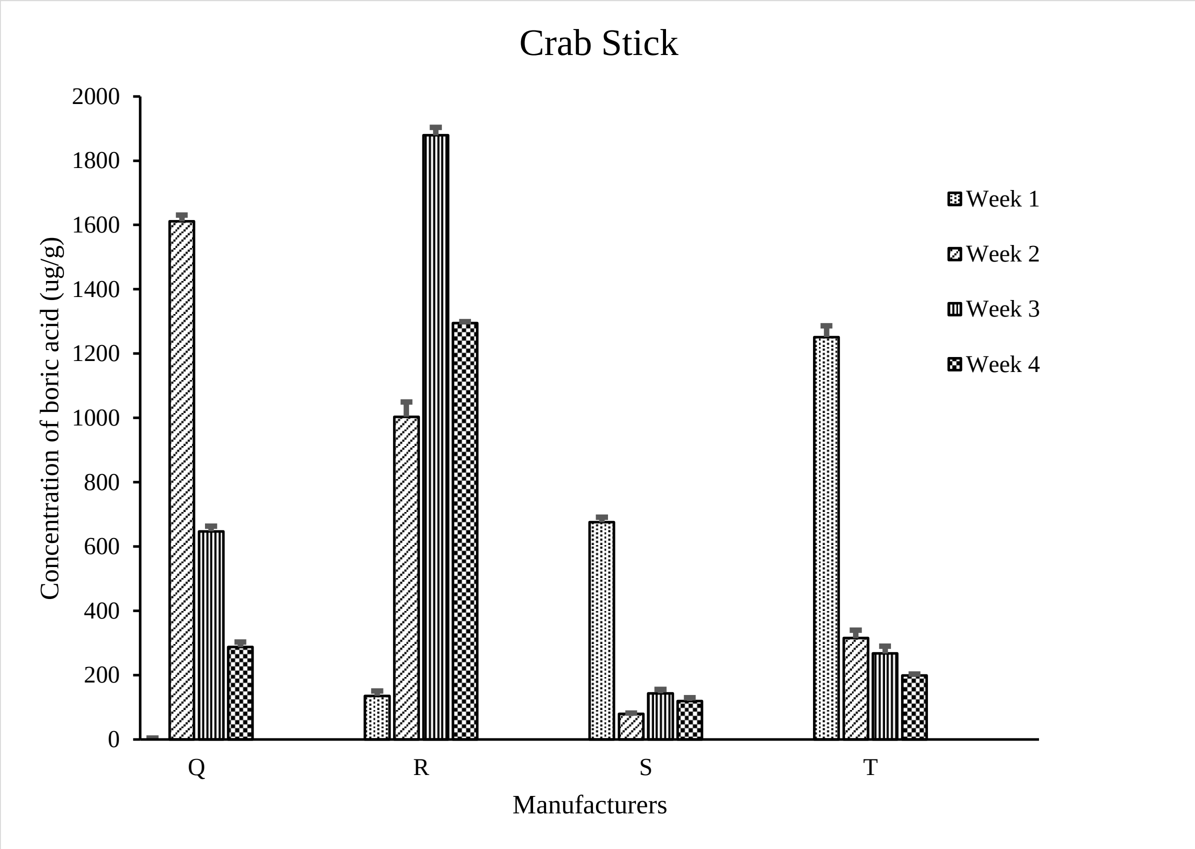

Figure 7. Concentrations of boric acid of crab stick from different manufacturers (Q, R, S and T) over four different weeks

research. The most possible reason for certain food products was added with some amount of boric acid was to extend the shelf-life of the food product in order to accommodate the higher market demand. Boric acid as a food preservative can enhance the food texture, control starch gelatinisation, enhance colour, texture and flavour of food products (Yiu *et al*., 2008). Therefore, adding this chemical into food products can improve food quality and makes them appealing to the consumers.

Besides that, boric acid also acts against yeasts effectively, with moulds and bacteria to a lesser extent (Ma, 2009). This explains the wide use of this chemical to preserve yellow noodles, 'kuey teow' and 'kolok' noodle which are not dried noodles. Some complicated physicochemical and biochemical changes can occur in fresh noodles during storage contributing to a shorter shelf-life. In order to keep these noodles fresh and extend their shelf-life, boric acid is a suitable preservative as it can prevent profit loss to the manufacturers due to easy spoilage of food products. The other reasons of manufacturers adding boric acid into food products despite law enforcement and possible health effects could be the price of boric acid and consumers' attitude towards this issue (Tho, 2006). Boric acid is cheaper than other legal preservatives while indeed improve texture of food products. In conclusion, albeit efforts implemented by government banning the use of boric acid in food processing, the substance can still be found in food products specifically in supermarkets around Kota Samarahan, Sarawak.

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