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Dangerously Sodium Overload or Mere Over-Claiming Health Issue? A Case of Malaysia's Tasty Snack Papadum

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Abstract

Papadum is one of the delicious and favourite snacks in Malaysia. In 2018, The Consumers Association of Penang (CAP) claim that it has high sodium content. Therefore, this research was performed to verify the claim. A total of six different papadum brandswere fried and analyse for sodium concentration and Total Dissolved Solids (TDS) value. Based on the results, The TDS also showed insignificant difference ($p > 0.05$) at both 0.02 g/mL and 0.01 g/mL for all brands with the range value of 1785.33 ± 15.20 to 1315.33 ± 15.60 ppm and 1232.33 ± 0.00 to 873.67 ± 0.00 ppm, respectively. The 0.1 g/mL papadum solution was considered undetectable due to analyser sensitivity limitation. Next, the sodium concentration for all brand ranged from 1120.83 - 1874.18 mg/100g (4 samples) which was within the daily intake limit of sodium at not more than 2,000 mg per day, as recommended by the World Health Organisation (WHO). However, its sodium content is considered quite high as most consumer might consume other type of food. Papadum 1 and papadum 3 were significantly difference ($p<0.05$) with other types of papadum. Based on the Pearson correlation test, different papadum brands exhibited irrelevant correlation ($r=0.033$) with sodium concentration and TDS. In contrast, there was a strong inverse correlation ($r=-0.926$) between sodium concentration with TDS as the concentration of the papadum solution increased. In conclusion, this study agreed that papadum contains a significant amount of sodium that could affect human health when taken in a large amount daily.

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Introduction

Papadum or poppadom is a popular snack from the Indian subcontinent. The word 'papadum' is derived from the Sanskrit word 'parpata', which means flattened disc. Indian restaurants often serve papadum as an appetiser or a sidedish with an array of chutney for dipping or even as a standalone snack. The disc-shaped, crispythin, and light as air papadum is usually made based on a seasoned dough from peeled black gram flour.[1] The most important ingredient in making papadum is flour (made with flour from legumes like lentils or chickpeas). Other ingredients, such as salt, baking soda, slaked lime, and peanut oil, are added to improve its texture and taste. When the flour is mixed with water to make the dough, the protein content in the flour is converted to gluten, which is an elastic substance that forms a continuous network throughout the dough and can retain gas, thus, causing the dough to expand when baked.[2] The dough is then spread into a thin round flat bread and left to dry. The raw papadum is then deep-fried and ready to eat.

The presence of high sodium, especially in processed food and during cooking, has exposed Malaysians to a relatively highsalt diet intake.[3,4,5] Given the increasing public awareness to uphold consumer rights and interests, particularly food products and healthcare, there is growing speculation that papadum is unhealthy due to the allegedly high sodium content. The Consumers Association of Penang (CAP) has issued a health warning that papadum is dangerously overloaded with sodium with more than 1000–2000 mg per 100 g of papadum.[6] A person that consumes more than five pieces of papadum per meal would roughly consume more than 2000 mg of sodium per day, which exceeds 2,000 mg daily intake limit of sodium set by the World Health Organisation (WHO).[7] Meanwhile, the Health Ministry recommends Malaysian adults to consume an average amount of 7.15 g of salt a day,[8] which is also above the WHO recommendation.

Sodium chloride or commonly known as table salt consists of the inorganic chloride and sodium compounds at 60 and 40% by weight, respectively.[9] It is a natural preservative, stabiliser, and colour enhancer that extend the shelf-life of food in the market by preventing the growth of bacteria and microorganisms.[10] In fact, sodium is an essential nutrient for human health. Besides functioning as an electrolyte in the extra cellular fluid and osmotic solute, sodium also aids in nerve impulse conduction, regulates muscle control, and facilitate nutrient absorption in the small intestine. It also maintains the acid-base balance by combining with an anion.[11]

Sodium is readily absorbed from the intestine and carried to the kidneys, where it is filtered and returned to the blood vessel to maintain at an appropriate level. The amount of sodium absorption in the body is directly proportional to the total sodium intake of an individual. Approximately 90 - 95% of sodium is lost through urine while the rest is lost through faeces and sweat. Aldosterone is used to regulate the sodium balance. When sodium level in the blood rises, thirst receptors in the hypothalamus, which is located in the brain, stimulate the thirst sensation. Ingestion of fluids would return the sodium level to normal. However, when the sodium level decreases, the sodium excreted through urine also decreases.[11,12]

However, the over consumption of sodium has been associated with negative health effects, such as high blood pressure, accounted for 49% of coronary heart disease and 62% of strokes in specific control studies.[13,14,15] Recently, it was reported that 30.3% of Malaysian adults aged 18 years and above were diagnosed with hypertension (due to high sodium intake), which is the major risk factor for cardio vascular disease and the leading cause of death worldwide.[14,16,17,18,19,20]

Various methods have been introduced to measure the amount of sodium in liquid-based materials and solutions. One of the common methods is the Total Dissolved Solids (TDS), which is the term used to describe the inorganic salts and small amounts of organic matter present in a solution. The principal constituents are usually sodium, potassium, nitrate, calcium, magnesium, carbonate, sulphate, chloride, and hydrogencarbonate. A high TDS represents higher turbidity and low solution clarity.[21] There are two principal methods of measuring TDS: gravimetric and conductivity. The gravimetric method is considered the standard and most accurate approach but istime-consuming due to the slow evaporation of samples to obtain constant dryness.[22] On the other hand, the Electrical Conductivity (EC) measurement using the TDS meter is a quick method

to estimate the TDS value. In addition, the TDS value of water is directly related to the conductivity of dissolved ionised solids in the water. Ions from the dissolved solids support the ability for water to conduct an electrical current that represents conductivity.[23]

Furthermore, the Inductively Coupled Plasma Mass Spectrometry (ICP-MS) is an advanced elemental analysis technology capable of detecting most of the elements in the periodic table. The instrument possesses such a high sensitivity to detect elements from mg/L to ng/L concentrations and can determine the isotope composition of a sample using less cumbersome pre-treatment procedures compared to other MS techniques. The sensitivity of advanced ICP-MS instruments is from around 10 - 1000 Mcps/(mg/L) depending on the natural abundance and ionisation in the plasma.[24] Previously, the ICP-MS was successfully used to analyse the sodium (Na) metals concentration present in salt.[25] Given the growing concern on the potential health hazard from the consumption of papadum, this research was carried out to investigate the concentration of sodium in papadum using ICP-MS and TDS techniques and determine the relationship between the sodium concentration and TDS value in papadum. Intake of nutritious and healthy food in appropriate amount is very important in maintaining a healthy lifestyle. The aim of this research is to study the concentration of sodium in papadum to verify the claim that papadum poses a health risk to consumers.

Material and Methods

Materials

A total of six different brands of papadum used in this research were purchased from a fresh Indian market in Selangor, Malaysia with a prince ranging from MYR2.50 to MYR4.50/pack (Figure 1).

Fig. 1: Pictorial of six different brands of commercially available papadum purchased in a local Indian market in Malaysia. The number(top left) representsthe sampling number of the respective brand.

Methods

Sample Preparation

Each purchased papadum was first deep-fried usingthe same cooking oil brand at 180 °C until they turned golden brown. It was then cooled down to room temperature. 50 g of fried papadum was then dried blend and stored in airtight container for further analysis.

Total Dissolved Solids (TDS) Analysis

The TDS analysis was measured using the IC Controls 210-C (TDS) analyser.[23] Prior to the analysis, the analyser was calibrated using the standard TDS for sodium chloride in ppm or mg/L with NIST SRM traceable materials. About 1.0 g of fried papadum was weighed and added with different volumes of Deionised Water (DIW) comprising 10, 50 and 90 mL to achieve three papadum solutions with different concentrations (0.1, 0.02 and 0.01 g/mL). These concentrations were choose based on pre-liminary study that shows a significant difference of pH value between sample.The mixture was then vortexed and filtered using a mesh cloth. Finally, the mixture was subjected to instant measurement of TDS analysis. Approximately, 50 mL of sample was poured into a beaker for the analysis. The electrical current of ions was measured as sodium chloride in ppm or mg/L or conductivity in µS/cm.

Sodium (Na) Analyte Concentration using the ICP-MS

The papadum sample was first digested using an SK-10 high-pressure rotor microwave.[26] Prior to digestion, about 1.0g of fried papadum was weighed in a TFM vessel (a vessel made up from a copolymer of tetrafluoroethylene and a small amount of the perfluoro (propylvinyl ether)) and added with 5mL of 65% nitric acid, 5 mL of deionised water (DIW) and 1.0 mL of 30% hydrogen peroxide. The solution was then gently swirled to homogenise the sample. A blank digest (without papadum) was prepared using the same way. The vessel was then closed and introduced into the rotor segment. Once tightened using a torque wrench, the segment was inserted into the microwave cavity and the temperature sensor was connected. The sample was heated up to 180ºC and maintained for 10 mins, followed by cooling down to 100ºC for 15 mins ata pressure sensor (P) of 45 bar and a maximum power of 1500W. The digested sample was then diluted with 0.05 L of DIW, filtered and analysed using an ELAN900 ICP-MS (Perkin Elmer, Saiex, Germany).[27] The condition of the analysis was set at 2.5 L/mins acetylene flow, 10 L/mins airflow, and 45˚ burner head rotation. The Na concentration was then measured at 589 nm. The auto-diluted calibration standardof Perkin Elmer Pure plus was used for the sodium element concentration calibration at 10, 20, 50, and 100 mg/L, respectively. The concentration of sodium was calculated in ppm. Once the sodium concentration in the papadum sample was measured, the daily consumption estimation was calculated, as follows:

$$\text{Daily consumption estimation} = \text{NaPs} \times \text{DPs} \times \text{WPs} \times \text{Ai}$$

Where Na Ps refers to the sodium concentration in papadum sample, DPs is the dilution of papadum sample (0.05 L), WPs is the approximate weight of a piece of papadum sample (13 g), and Ai is the average number of papadum intake (4 pieces/person/meal). The result is expressed in mg of Na/person.

Statistical Analysis

A Minitab version 17 (Minitab Inc., Sydney, Australia) was employed to analyse the results via the one-way Analysis of variance (ANOVA) and Fisher test to determine the significant difference at 95% confidence level between all papadum brand samples ($p<0.05$). The results were expressed as the mean ± standard deviation (n = 3). The linear correlation between the two variables (sodium concentration and TDS) was also evaluated between three papadum concentrations using the Pearson correlation test to study the strength of the relationship between each variable.

Results and Discussion

Total Dissolved Solid (TDS) Analysis

Table 1 below shows the TDS for six different papadum brandsat different concentrations of 0.1 0.02 and 0.01 g/mL.Generally, insignificant differences in terms of TDS($p > 0.05$) were observed between different brands of papadum. All the TDS readings for the papadum solution at 0.1 g/mL concentration were spiked and peaked at 3999.00 ppm. In this test, the prepared concentration was considered too high for the device. The 210-C conductivity analyser is an auto-ranging analyser with aninput circuit consisting

of four detection ranges that switch automatically during the measurement. For example, the 0 - 10000 µS/cm range is determined by the gain used by the analyser plus the cell constant of the sensor. Since the cell constant of the analyser used in this research is 5.0cm, the detectable design range was 0 - 5000 µS/cm or equal to 0 - 3205.13ppm.[28]

Meanwhile, for papadum solution at 0.02 g/mL concentration, the lowest TDS content was recorded by papadum 3 at 1315.33 ± 15.60 ppm, followed by papadum 5, papadum 1, papadum 6, papadum 4, and papadum 2. However, all samples showed no significant difference ($p>0.05$), indicating that all papadum samples have approximately the same concentration of inorganic salts and organic matter content.

Similarly, the papadum solution at 0.01 g/mL concentration for all papadum brands showed an insignificant difference ($p > 0.05$). Papadum 2 has the lowest TDS content of873.67 ± 0.00, followed by papadum 6, papadum 4, papadum 3, papadum 5, and papadum 1 in descending order. Thus, all samples at 0.01 g/mLconcentration were assumed to contain the same concentration of inorganic salts and organic matter content. The insignificant difference ($p>0.05$) of TDS between all sample brand at each concentration might be due to the approximately similar formulation of flour and seasoning used in the manufacturing process of all the papadum brands.[2]

Besides, a higher dilution sample contains significant lower TDS value for papadum 2, papadum 3, papadum 4 and papadum 6. Physically, the higher volume of water makes the solution clearer and less turbid when observed.[21] The addition of water or dilution will affect the concentration of dissolved component in a solution. A Slightly saline solution has TDS reading between 1000 - 3000 ppm.[29,30] Since the papadum solution in this research has range between 873.67 ± 0.00 -1785.33 ± 15.20,it shows that high papadum and some low papadum solution was categorised in slightly saline water category, this result shows that papadum solution might contains sodium chloride. The main constituent of sodium present in the solution was confirmed through further analysis using the ICP-MS.[25]

Table 1: Total Dissolved Solid (TDS) for different papadum brands at varying concentrations.

Papadum sample	TDS (ppm) for different papadum concentrations		
	0.1 g/mL	**0.02 g/mL**	**0.01 g/mL**
1	3999.00 ± 0.000^{a}	1513.00 ± 23.20^{Aa}	1232.33 ± 0.00^{Aa}
2	3999.00 ± 0.000^{a}	1785.33 ± 15.20^{Aa}	873.67 ± 0.00^{Ba}
3	3999.00 ± 0.000^{a}	1315.33 ± 15.60^{Aa}	992.33 ± 0.00^{Ba}
4	3999.00 ± 0.000^{a}	1688.33 ± 13.2^{2Aa}	962.67 ± 0.00^{Ba}
5	3999.00 ± 0.000^{a}	1375.67 ± 30.33^{Aa}	1149.67 ± 0.00^{Aa}
6	3999.00 ± 0.000^{a}	1567.00 ± 24.67^{Aa}	900.33 ± 0.00^{Ba}

[A]Mean with the same alphabet shows an insignificant difference between papadum solution concentration ($p > 0.05$).

[a]Mean with the same alphabet shows an insignificant difference between papadum samples ($p > 0.05$).

Sodium Concentration in Papadum

Based on Table 2, it was observed that there is significant difference ($p<0.05$) between papadum 1 and papadum 3 with other types of papadum. The papadum 6 recorded the lowest sodium concentration, followed by papadum 5, papadum 4, papadum 2, papadum 1 and papadum 3. All papadum contained quite similar range of sodium concentrations that heavily depends on the specific formulation of each brand.

In addition, the result of this research supports the claim that the daily overconsumption of sodium intake is an alarming health issue.[6] However, the

results of sodium content in papadum obtained in this research was below than the previous laboratory test claim,[31] in which the papadum sodium content was ranged from 431.09 ± 94.34 to 720.84 ± 300.65 mg/100g with four samples containing 1120.83 - 1874.18 mg/100g depending on the papadum brands. This shows that 4 pieces of papadum does not exceeds the daily sodium intake limit recommended by WHO (2012), which is 2000 mg/day. However, the result of this research supports sodium content result recorded in The George Institute for Global Health report which is 1219 mg/100g.[32] By assuming that an individual only consumes papadum for their meal in a day, the amount of papadum should not be more than 4 pieces to follow the WHO sodium intake limit, as the amount of 5 and above papadum pieces will surely results in more than 2000mg/100g sodium content. However, an individual would probably consume other food than papadum in a day depending on their preference and food varieties available in the market. Thus, a lower amount of papadum is recommended to prevent an excessive daily intake of sodium.

A high daily intake of papadum could cause high blood pressure or hypertension that results in other cardio vascular diseases, such as coronary heart disease and strokes to the consumer, and ultimately leads to death.[14,16,17,18,19,20] In view of this, various prominent national and international health organisations, along with many governments around the world, have expressed the importance of reducing the daily consumption of dietary salt. Consumers are advised to drink more water to eliminate dietary salts in the body through urination. Besides, a healthy lifestyle and regular exercise are necessary to stay fit and healthy.[11] Thus, Malaysians should be more aware when consuming papadum by taking appropriate serving and drinking more water since the salt in papadum is literally a silent killer and very harmful.

Table 2: The sodium (Na) analyte concentration of six different brands of papadum and the estimated sodium (Na) intake/person/meal.

Papadum sample	Sodium concentration in papadum (mg/100g)	Sodium (Na)/person intake (mg/100g)
1	625.02 ± 163.91^{b}	1625.05^{b}
2	443.87 ± 93.18^{a}	1154.06^{a}
3	720.84 ± 300.65^{c}	1874.18^{c}
4	443.33 ± 91.626^{a}	1152.66^{a}
5	434.96 ± 91.94^{a}	1130.90^{a}
6	431.09 ± 94.34^{a}	1120.83^{a}

$^{a-f}$Mean with a different alphabet shows a significant difference between papadum samples ($p < 0.05$).

Correlation between the Sodium Concentration and TDS in Papadum and the Correlation between Different Brands of Papadum

The Pearson correlation (r) describes the degree of relationship between two variables that range from -1 to +1. A negative correlation value indicates that one variable increases as the other variable decreases. In contrast, a positive correlation value signifies the simultaneous increase of both variables.[33] Furthermore, a value closer to 0 represents a weak relationship between the variables. Based on the results, Pearson's correlation analysis demonstrated a strong negative correlation (r = -0.926) between the sodium concentration and the TDS value as the concentration of the papadum solution increased from 0.1 to 0.02 and 0.01 g/mL sample concentration. When the concentration of sodium content increased, theTDS decreased since the amount of the solvent increased. The correlation test shows that the salt can be easily dissolved by drinking enough water after consuming papadum.

Meanwhile, in terms of the correlation between different papadum brand samples and TDS value, it was observed that the Pearson's correlation

coefficient was nearly 0 (r = -0.033), indicating that the different brands of papadum have a very weak negative correlation and almost no significant relationship with the TDS value.This may be due to the almost similar ingredients used in all the papadum brands. Papadumis primarily made of flour and water, followed by the addition of salt, baking soda, slaked lime, and peanut oil to improve its texture and taste. The dough is then flattened into a thin, round flat bread and left to dry before ready for deep-fried or packaged to be sold in the market.[2]

Conclusion

This research showed that the sodium content in papadum was relatively high at a range from 431.09 ± 94.34 to 720.84 ± 300.65 mg/100g with four samples containing 1120.83 - 1874.18 mg/100g depending on the papadum brands. Papadum 1 and 3 has significantly higher sodium content than the other papadum brands tested. Besides, there is no significant difference in term of TDS content between all papadum sample at 0.1,0.02 and 0.01 g/mL papadum solution concentration. But, the TDS is significantly difference for papadum solution with different concentration. The lower dilution factor and water content, thus, becoming more concentrated. Additionally, the statistical analysis showed that different brands of papadum do not affect sodium concentration and TDS. However, a strong negative correlation between the sodium concentrations and TDS value was detected as the concentration of the papadum solution increased. In short, this study agreed the claim that papadum contains a significant amount of sodium, which might exceed the recommended daily salt intake by WHO, and could affect the health of consumers. Given that the correlation test showed the salt in papadum can be easily dissolved in water, consumers are advised to drink more water after consuming papadum to eliminate excess salt in the body through urination.

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Conflicts of Interest

No data were used else where to support this study and it was entirely a new set of data.

References

1. Anon. What is Papadum? Easy Recipe and Tips for Making Perfect Indian Crackers. https://www.masterclass.com/articles/what-is-papadum-easy-recipe-and-tips-for making perfect- indian-crackers#what-is-papadum-served-with. 2020. Accessed 24th July 2021.
2. Augustyn, A., Zeidan, A., Zelazko, A., Eldridge, A., McKenna, A., Tikkanen, A., Gadzikowski, A., Schreiber, B.A., Duignan, B., Lozada, C., Levin, C., Mahajan, D., Promeet, D., Goldstein, E., Rodriguez, E., Gregersen, E., Munez, E., Shukla, G., Liesangthem, G., Lotha, G., Young, G., Bolzon, H., Luebering, J.E., Wallenfeldt, J., Hibler, J., Rafferty, J. P., Gupta, K., Rogers, K., Chmielewski, K., Manchanda, K., Heintz, K., Chaveriat, L., Dixon, L., Matthias, M., Petruzzello, M., Ray, M., Metych, M., Bauer, P., Riley, P., Bhathya, P., Vasich, S., Hollar, S., Singh, S., Gupta, S., Seddon, S., Setia, v. and Jang, W. Flour. Encyclopedia Britannica. https://www.britannica.com/topic/flour. 2020. Accessed 24th July 2021.
3. Noor, M.I., Koon, P. B., Siong, T. E., Lin, K. G. and Ley, S. H. Recommended Nutrient Intakes for Malaysian (RNI) Technical report. National Coordinating Committee of Food and Nutrition (NCCFN). Ministry of Health Malaysia. 2007.
4. Webster J.L., DunfordE.K. and Neal, B.C. A Systematic Survey of The Sodium Contents of Processed Foods. *Am.J. Clin. Nut*. 2010;91:413–420.
5. Haron, H., Hiew, I., Shahar, S., Michael, V. and Ambak, R. A Survey on Salt Content Labeling of The Processed Food Available in

Malaysia. *Int. J. of Env. Res. and Pub. Health.* 2020;17:1-8.

6. Dermawan, A. Papadum Dangerously Overloaded with Sodium. *New Straits Times*, 9 October 2018. https://www.nst.com.my/news/nation/2018/10/419462/papadumdangerously overloaded sodium. 2018. Accessed25 July 2021.
7. World Health Organisation. Guideline: Sodium Intake for Adults and Children. Geneva, World Health Organization https://www.who.int/elena/titles/guidance_summaries/ sodium_intake/. 2012. Accessed25th July 2021.
8. Health Ministry. Recommended Nutrient Intakes for Malaysia, Ministry of Health Malaysia (MOH), Putrajaya. 2015.
9. National Coordinating Committee on Food and Nutrition. Malaysian Dietary Guidelines. Ministry of Health Malaysia. 2010.
10. Rosma, A., Afiza, T.S., Nadiah, W.A., Liong, M.T. and Gulam, R.R.A. Microbiological, Histamine and 3-MCPD Contents of Malaysian Unprocessed "Budu". *Int. Food Res*. J.2009;16:589–594.
11. Stratzullo, S. Sodium. *Adv. Nut.* 2014;5(2):188–190.
12. Grimes, C. A., Riddell, L. J. and Nowson, C. A. Consumer Knowledge and Attitudes To Salt Intake And Labelled Salt Information. *Cent. for Phy. Activity and Nut. Res.* 2010;53(2):189-194
13. He, F.J. and MacGregor, G.A. A Comprehensive Review on Salt and Health and Current Experience Of Worldwide Salt Reduction Programmes. *J. Hum. Hypertens*. 2008;23(6):363-384.
14. Strazzullo, P., D'Elia, L., Kandala, N.B. and Cappuccio F.P. Salt Intake, Stroke, and Cardiovascular Disease: Meta-Analysis of Prospective Studies. *Brit. Med. J.* 2009;339:1-9.
15. He, F.J. and Mac Gregor, G.A. Reducing Population Salt Intake Worldwide: From Evidence to Implementation. *Prog. in Cardio vascular Disease.* 2010; 525(5):363-382.
16. Chobanian, A.V., Bakris, G.L., Black, H.R., Cushman, W.C., Green, L.A., Izzo Jr, J.L., Jones, D.W., Materson, B.J., Oparil, S., Wright Jr., J.T. and Roccella E.J. The Seventh Report of The Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: JNC 7 report. *JAMA*. 2003;289 (19):2560-2572.
17. Yang, Q.H., Zhang, Z.F., Elena, V.K., Fang, J., Carma, A., Hong, Y.L., Fleetwood, L., Dai, S.F., Janelle, P.G., Tian, N., Mary, E.C. and Robert, M. Sodium Intake and Blood Pressure Among Us Children and Adolescents. *J. of Am. Acad. of Paediatr.* https://pediatrics.aa ppublications. org/content/130/4/611. 2012.
18. Mente, A., O'Donnell, M. J. and Rangarajan, S. Association of Urinary Sodium and Potassium Excretion with Blood Pressure. *The New Eng. J. of Med.* 2014;371 (7):601–611.
19. Institute for Public Health. National Health and Morbidity Survey 2015. http://www.iku.gov. my/images/IKU/Document/REPORT/nhmsreport2015vol2.pdf. 2015. Accessed 26th June 2017.
20. William, B. F., David, G. E., Claudine, T. J. and William, S. W. Dietary Sodium and Health: More than Just Blood Pressure. *US Nat. Lib. of Med. Nat. Ins. of Health.* 2016;65(10): 1042-1050.
21. Sheffer. M. Guidelines for Drinking-Water Quality- Total Dissolved Solids In Drinking-Water. World Health Organization, Switzerland. 2nd ed. https://www.who.int/water_ sanitationhealth/dwq/chemicals/ tds.pdf. 2003. Accessed 30th July 2021.
22. Robert, L. and Bradley, J. Moisture and Total Solids Analysis. USA: Springer.2010;87-102.
23. Anon. Total Dissolved Solids Measurement. https://iccontrols.com/wp-content/uploads/art-v1400001_total_dissolved_solids_measurement.pdf. 2014. Accessed 21st January 2021.
24. Elliott, S., Knowles, M. and Kalinitchenko, I. A New Direction in ICP-MS. *American Laboratory.* 2004;24–29.
25. Cubadda, F. Chapter 19: Inductively Coupled Plasma Mass Spectrometry. Food Toxicants Analysis Techniques, Strategies and Developments. Edition no 1. United Kingdom: Elsevier. 2007;697-751.
26. Anon. Milestone Srl - Helping Chemists: Application Note HPR-FO-40. 198. https://subitam.sinop.edu.tr/wp-content/uploads/sites/93/2019/12/Mikrodalga.pdf. 2005.

Accessed28th January 2021.

27. Spivey, N. Analysis of Micronutrients in Fortified Breakfast Cereal by Flame Atomic Absorption Using Microwave Digestion and Fast Flame Sample Automation. https://resources.perkinelmer.com/lab-solutions/resources/docs/app_fast-flame-pinaa cle-900-cereal-micronutrients-012240_01.pdf. 2015. Accessed 28th January 2021.
28. Anon. User Manual Model 210-C Industrial Conductivity Analyzer UM-210-C-1.01. https://iccontrols.com/wp-content/uploads/um-210-c.pdf. 2020. Accessed 30thJuly 2021.
29. Lehr, J. H., Pettyjohn, Wayne, E., Gass, Tyler, E. Domestic Water Treatment. New York: Mc Graw-Hill. 1980.
30. Anon. Get Informed | Total Dissolved Solids (TDS). https://www.knowyourh2o.com/indoor-6/total-dissolved-solids. 2015. Accessed 2nd May 2022.
31. Mohamed Idris, S.M. Beware of Papadum Danger. The Consumers Association of Penang (CAP). Malaysia Kini.https://www.malaysiakini.com/letters/446570. 2018. Accessed 30th July 2021.
32. Julia, T. Salt content of processed foods in India. The George Institute for Global Health. https://www.georgeinstitute.org/sites/default/files/salt-content-of-processed-foods-in-india-june-16.pdf. 2016. Accessed 2nd May 2022.
33. Ching, T. L. Correlation and Regression With R. https://sphweb.bumc.bu.edu/otlt/ MPH Modules/BS/R/R5_Correlation-Regression/R5_Correlation-Regression_print.Html. 2018. Accessed 17thFeb 2021.