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Sodium and potassium contents in selected salts and sauces

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Abstract

The study was undertaken to determine and compare the sodium and potassium contents in selected salts (table salt, coarse salt, French sea salt, Himalayan pink salt and bamboo salt) and sauces (light soy sauce, sweet soy sauce, chili sauce, tomato sauce and mayonnaise). Findings of the present study showed that the sodium content of salts was highest in table salt (35870.0 mg/100 g) and lowest in French sea salt (31235.0 mg/100 g), whereas the potassium content was highest in bamboo salt (399.4 mg/100 g) and lowest in table salt (43.7 mg/100 g). There was no significant difference between sodium amounts of the salts. Bamboo salt was significantly higher in potassium than other salts. The ranking of sodium and potassium in sauces was similar, where light soy sauce contained the highest amount (4402.0 and 395.4 mg/100 g) and mayonnaise contained the least (231.3 and 63.6 mg/100 g). Both sodium and potassium contents of light soy sauce were significantly higher than other sauces. Bamboo salt is a better choice instead of other salts in terms of the potassium level. Among sauces, although light soy sauce is high in potassium; however, its high sodium has offset the beneficial effect of potassium.

Introduction

Salt is an important seasoning ingredient added during cooking to increase the flavour of dishes. Also, salt is commonly added in processed foods as a preservative, stabiliser, texture enhancer, colour enhancer, and more. About 90% of salt is largely added in food processing, in restaurant foods, in sauces and cooking (Choong *et al*., 2012). Sauces are liquid or semi-liquid seasonings that provide flavour, moisture and visual appeal to dishes. They are rarely consumed by themselves, but served as an accompaniment to food or an ingredient in cooking foods (Codex Alimentarius, 1995).

Salt is high in sodium, which contains about 2000 mg or 88 mM sodium in one teaspoon (5 g) of salt as declared by the Malaysian Dietary Guideline (MDG) (NCCFN, 2010). Sauce is also known as one of the foods that high in sodium. Since 1980, some flavouring agents, such as soy sauce, Worcestershire sauce, catsup, pickles, olives, and garlic, onion, and celery salts, were claimed to be high in sodium (Marsh *et al.*, 1980).

Salt is classified into organic and inorganic salts. Organic salt is defined as salt that containing organic ion. The name "organic salt" has been given for commercial purpose. Organic salt is referring to all salts obtained from natural sources, including table salt. However, we categorized table salt as inorganic salt because some of the table salts are synthesized by the factory, especially in the form of sodium chloride. Sodium is a naturally occurring mineral in most foods with a small amount. It is necessary for humans to maintain the balance of physical fluid system and is also required for nerve and muscle functioning. However, too much sodium can damage human's kidneys and increase the chances of high blood pressure (Munteanu and Iliuţã, 2011). In contrast, an adequate intake of potassium can compensate the adverse effects of sodium on blood pressure, lower blood pressure and decrease the risk of hypertension (Bussemaker *et al.*, 2010).

The topics of excessive sodium and insufficient potassium intake were being concerned in these few years as both are leading to some adverse effects on human health. In Malaysia, a recent Ministry of Health survey reported the mean population salt intake had achieved 8.7 g a day, which is equivalent to 3419 mg

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of sodium. The sodium intake of Malaysians is much higher now, contributed up to 1.7 times, than the limit set by the WHO (NCD-MOH, 2012). In contrast to the current trend of excessive sodium intake, a study in 2010 revealed that many countries do not meet the daily recommended potassium intake. A study that collected data from 21 countries spread across North America, Europe, Asia and Oceania reported that the average potassium intakes of these countries ranged from 1.7 g (in China) to 3.7 g per day (in Finland, the Netherlands and Poland) (Van Mierlo *et al*., 2010).

In Malaysia, sodium and potassium contents are not included in the mandatory nutrition labelling on packaged foods (Hawkes, 2004). Thus, there is lack of sodium and potassium information labelled on salts and sauces products that sold in Malaysia. Besides, Market Watch (2012) reported the increased in sales volume (2.98%) than the production volume for sauces, dressing and condiments (2.84%) from year 2009 to 2010. This shows the increasing trend for sodium intake among Malaysian. In addition, there is no publication in this country reporting on the amount of sodium and potassium in imported salts, such as Himalayan pink salt and bamboo salt. Therefore, there is a need to determine and compare sodium and potassium contents in selected salts and sauces that available in Malaysia market.

Materials and Methods

Sample

A total of ten samples was selected to be analysed in this study, included five types of salts (refined table salt, Himalayan pink salt, kosher salt, bamboo salt, French sea salt) and five types of sauces which can directly add to foods (tomato ketchup, chili sauce, mayonnaise, sweet soy sauce and light soy sauce). A convenience sampling method was used to collect these samples. The samples were purchased in two supermarkets from Kuala Lumpur and Selangor, Malaysia. The brand of each sample was randomly selected from variety brands that available in the markets.

Preparation of samples

There were three types of forms presented among the samples, which were liquid form (light soy sauce), viscous form (tomato sauce, chili sauce, mayonnaise and sweet soy sauce) and solid form (refined table salt, Himalayan pink salt, Kosher salt, bamboo salt, French sea salt). The methods of preparation of samples before ashing were different according to their forms. The liquid sample was homogenised by inverted the sample container for several times to make sure that all components in the sample was thoroughly mixed well. The preparation of plain viscous samples was simple as well by mixed each sample in a beaker with a spatula until homogeneous. The solid samples were prepared by grinding the sample with pastel and mortar into a fine powder. After that, the fine powder was mixed well in order to get a homogeneous sample.

Preparation of ash solution

There were some cleaning processes on the apparatus needed to be carried out before started to dry ash the samples. In order to prevent the presence of minerals that capable to contaminate the samples and affect the results, all the apparatus must be cleaned thoroughly by rinsing 3-4 times using distilled water. The dry ashing method was preceded by weighing 0.001 g (for determination of sodium) and 0.005 g (for determination of potassium) of homogenised sample in a crucible with an electronic balance. The particular sample weights were required based on the analytical working range and detection limits of flame atomic absorption spectrometry (AAS) (Perkin Elmer, 2011). Later, the crucible with sample was placed on a hotplate in fume hood and heated until it became charred. Sample must be dried before ashing. Otherwise, bursting sound can be heard inside the furnace during the ashing. Therefore, the sample was allowed to dry in an oven at 130°C for one day. After that, the sample was placed in a muffle furnace at 550°C overnight. The completely ashed sample should be free of black carbon particles and turned into white or grey in colour (AOAC, 2000).

After ashing, the preparation of ash solution was begun by adding 5 ml of concentrated HCl to the ash and evaporated it to dryness on the steam bath. Additional 2 ml of concentrated HCl was added to dissolve the residue and support the mineralisation. The crucible was swirled with care so that all ash comes into contact with acid. Then, the crucible was covered with a watch glass and heated on the hot plate until the solution started to boil. The watch glass was rinsed down with 20 ml of distilled water and the solution was filtered using the Whatman No 41. filter paper into a 100 ml of volumetric flask. At the same time, the crucible and residue were also washed and filtered with 10 ml of boiling water through the filter into the same volumetric flask. The washing steps were repeated for at least three times to ensure that all the residues were filtered without leftover. At last, the solution was cooled and made up to a volume of 100 ml with distilled water (AOAC, 2000).

Table 1. Operating parameters for flame AAS

Element	Flame type	Lamp current (mA)	Wavelength (nm)	Slith width (nm)
K	Air-acetylene	4.0	766.5	0.8
Na	Air-acetylene	3.0	589.0	0.8

Table 2. Sodium and potassium contents of selected salts

Salt	Sodium (mg/100 g)	Potassium (g/100 g)
French sea salt	31235.0 ± 5013.4^{a}	$284.3 \pm 3.6^{a,b}$
Kosher salt	34610.0 ± 975.8^{a}	$182.7 \pm 63.8^{a,c}$
Bamboo salt	35055.0 ± 1534.4^{a}	399.4 ± 7.9^{b}
Table salt	35870.0 ± 28.3^{a}	43.7 ± 30.7^{c}
Himalayan pink salt	34805.0 ± 2948.6^{a}	246.6 ± 32.2^{a}

Different superscript lowercase letters (a– c) denote significant difference between the samples

Determination of sodium and potassium in salts and sauces

The ash solutions were prepared for the analysis of sodium and potassium contents in the selected salts and sauces by flame AAS. Before the measurements were started, the instrument was set up according to the operating parameters (Table 1). A series of potassium (0.0 to 1.5 ppm) or sodium calibration solution (0.0 to 0.8 ppm) were prepared from potassium standard solution or sodium standard solution (1000 ppm) using dilution method. The standard curves of absorbance versus concentration of sodium or potassium were plotted by measuring the absorbance of several calibration solutions with known concentrations through flame AAS. The ideal standard curve was stated by Beer-Lambert law that the absorbance of an absorbing analyte is directly proportional to its concentration for the existing set of conditions. The equations of the standard curves for sodium and potassium were $y = 0.515x + 0.044$ ($R^2 = 0.999$) and $y = 0.307x + 0.021$ ($R^2 = 0.998$), respectively.

Statistical analysis

All data are presented as mean ± standard deviation of three replicates. The statistical significant differences of the samples were analysed using SPSS for Windows, version 21. The mean differences among the samples were analysed using ANOVA with post-hoc Tukey HSD test. The significant difference was set at $p<0.05$.

Results and Discussion

The sodium contents of various salts were almost similar, which in the range of 31235.0-35870.0 mg/100 g. As shown in Table 2, the concentration of sodium in these salts was in the order of table salt (35870.0 mg/100 g), bamboo salt (35055.0 mg/100 g), Himalayan pink salt (34805.0 mg/100 g), kosher salt (34610.0 mg/100 g) and French sea salt (31235.0 mg/100 g).

The present study found that there were no significant differences between the sodium amounts (mg/100 g) in all the five selected salts, included both organic and inorganic salts. It has been declared that there is usually little difference between table salt and most sea salt on their sodium content that contain about 40% sodium by weight (Brown, 2013). As kosher salt and some sea salts may have larger crystal sizes than the table salt, which results in these salts have less sodium by volume, such as by teaspoon or tablespoon, but not by weight (Marcus, 2013). The amount of sodium in studied table salt was slightly lower than salt in USDA database (38758 mg/100 g) (United State Department of Agriculture [USDA], 2016).

Based on Table 2, it was clearly showed that the potassium content in salts was considered small as compared to sodium content. The potassium content of different salts was in the order of bamboo salt (399.4 mg/100 g), French sea salt (284.3 mg/100 g), Himalayan pink salt (246.6 mg/100 g), Kosher salt (182.7 mg/100 g) and table salt (43.7 mg/100 g). The potassium level of table salt was found to be significantly lower than other types of the selected salts, which were French sea salt, bamboo salt and Himalayan pink salt. However, no significant difference was found between table salt and kosher salt in terms of potassium content. The results obtained from this finding were similar to the data provided by the manufacturer. Usually all minerals, other than sodium, were stripped from table salt during the refining process which reasonably explain why this salt contains little amount of potassium compared to others (Zeratsky, 2010). Potassium content of studied table salt was 8 times higher than the reported value in USDA Nutrient database (USDA, 2016).

Table 3. Sodium and potassium contents of selected sauces

Sauce	Sodium (mg/100 g)	Potassium (g/100 g)
Light soy sauce	4402.0 ± 1127.1[a]	395.4 ± 60.3[a]
Sweet soy sauce	3106.0±261.6[a]	308.8± 0.9[a,b]
Chili sauce	553.1±252.7[b]	200.0±31.9[b]
Tomato ketchup	703.5±68.6[b]	289.5±32.4[a,b]
Mayonnaise	231.3±181.0[b]	63.6±5.2[c]

Different superscript lowercase letters (a– c) denote significant difference between the samples.

Meanwhile, the present study also found that bamboo salt contained a significantly higher amount of potassium compared to Kosher salt and Himalayan pink salt. The special manufacturing method of bamboo salt is the key reason in its high potassium content. Bamboo was known to be high in minerals, such as calcium, phosphorus and potassium (Bhatt *et al*., 2005). The steps of stuffing salt inside bamboo and baked them brought the nutrients of bamboo fully integrated into the salt (Kim *et al*., 2012). However, the source of potassium in other salts was completely related to the place of origin without any additional supply. Therefore, compared to other salts, the potassium contained in bamboo salt was significantly higher.

The sodium content of varieties sauces is shown in Table 3. In contrast to salts, the range of sodium in the selected sauces was broad, which was in range from 231.3 to 4402.0 mg/100 g. Light soy sauce contained the highest amount of sodium (4402.0 mg/100 g), followed by sweet soy sauce (3106.0 mg/100 g), tomato ketchup (703.5 mg/100 g), chili sauce (553.1 mg/100 g) and mayonnaise (231.3 mg/100 g). Generally, the sodium content of soy sauce in the study was lower than the reported values of soy sauce varieties (exception for low sodium and reduced sodium) of USDA database (5493-6820 mg/100g). While ordinary catsup was reported to contain lower sodium of 907 mg/100g (USDA, 2016).

The amounts of sodium found in light soy sauce and sweet soy sauce were significantly higher than the other selected sauces. However, no significant difference in sodium content was found between these two sauces. Soy sauce is commonly known as a high sodium sauce. In 2013, researches in Colorado State University classified the food items according to sodium content and gave out the same result as in the present study. The study grouped tomato ketchup and mayonnaise into food item with elevated sodium while soy sauce in the group of high sodium (Bellows and Moore, 2013).

The higher sodium content of light soy sauce and sweet soy sauce compared to other studied samples was coming from the addition of salt during the manufacturing process. A large amount of salt was required in suppressing putrefactive bacteria and other destructive organisms, to leave the valuable microorganisms, koji mold, lactic acid bacteria, and yeast, free to work (Thaker and Barton, 2012). Besides that, salt as a main raw material was important in providing the base of the salty taste and contributing to the unique appearance, colour, flavour and fragrance of soy sauce. However, in the production of chili sauce, tomato ketchup and mayonnaise, salt was just a secondary ingredient and its effect was less important besides just giving the taste. There was only 2 to 3% of tomato ketchup and chili sauce, and 1.5% of mayonnaise constituted by salt (Hui, 2006; Brown, 2013). Therefore, sodium levels in these three sauces were not as high as light soy sauce and sweet soy sauce.

According to Table 3, light soy sauce had the highest level of potassium (395.4 mg/100 g) among all the selected sauces whereas mayonnaise contained the lowest (63.6 mg/100 g). At the same time, the amount of potassium found in sweet soy sauce, tomato ketchup and chili sauce were 308.8, 289.5 and 200.0 ± 31.9 mg/100 g respectively. When compared to USDA database, the level of potassium in soy sauce varieties was generally in a broader range of 212 to 3098 mg/100 g especially in the soy sauce from hydrolysed vegetable protein with reduced sodium. While regular mayonnaise in the database was reported to contain only 20mg/100 of potassium (USDA, 2016).

From Table 3, it is clear that potassium content of mayonnaise was significantly less than the other sauces. There was an obvious difference between the principle ingredients of mayonnaise and other sauces. Mayonnaise was mainly made from egg yolk, vegetable oil and vinegar whereas the other sauces were containing soybean, chili and tomato (Hui, 2006; Shurtleff and Aoyagi, 2012; Brown, 2013). Generally, potassium is largely obtained in fruits, vegetables, nuts and whole grains.

Apart from that, potassium level in light soy sauce was significantly higher than chili sauce. The amount of potassium was largely affected by the main ingredients used in processing the sauce. Light soy

sauce is produced from soybean while peeled tomato is the basic ingredient of chili sauce. According to USDA Nutrient Database, the potassium content of soybean is higher than that in tomato (U.S. Department of Agriculture, 2014). Besides that, the tomato peeling process during manufacturing of chili sauce further reduces its potassium content. Based on Elbadrawy and Sello (2011), tomato peel contains high level of potassium. At the same time, another study by Navarro-González *et al.* (2011) also reported that potassium is one of the major elements in tomato peel. Thus, there was no doubt that light soy sauce contained significantly higher potassium content than chili sauce. Sweet soy sauce was also mainly produced from soybean; however, the process of adding caramel and re-fermentation caused the potassium level became less cumulated (Hui *et al.*, 2003). Therefore, no significant difference was found between the potassium content of sweet soy sauce and chilli sauce.

Conclusions

Sodium contents of the selected salts were not significantly different. In contrast, potassium content was significantly higher in organic salt, especially the bamboo salt. Therefore, organic salt is a better choice of salt for consumers instead of table salt related to potassium content. Yet, the consumers are encouraged to control their daily sodium intake in order to maintain health, particularly for hypertensive patients. As expected, light soy sauce and sweet soy sauce were significantly higher in sodium content than other sauces. At the same time, light soy sauce contained the highest amount of potassium. Although its potassium content was relatively higher compared to others, it may not compensate the potential risk of adverse health outcomes resulting from its high sodium content.

Health problem related to excessive sodium intake is a high concerned in many countries nowadays. Therefore, the consumers are encouraged to reduce the intake of sauces with higher sodium content, such as soy sauce. Further exploration about the nutritional contents of salts and sauces is required in order to provide consumers an opportunity to know the nutritional value of salts and sauces, followed by making the proper decision in choosing and using these salts and sauces.

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