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Physicochemical Properties of Various Commercial Chilli Sauces in Malaysia

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In Malaysia, chilli sauce is extremely popular and widely consumed. Because it is used as a condiment in everyday life, it is a must-have in every home. At the present time, there is relatively little data available in scientific journals yet about the physicochemical properties of local commercial chilli sauce in Malaysia. This research was conducted out to learn more regarding the physicochemical properties of commercial chilli sauce. A variety of five chilli sauces (SK, SH, SM, SL, SJ) from popular options were purchased locally and the following parameters were determined by measuring: pH, total soluble solids (°Brix), water activity, syneresis, viscosity, salt content and colour. According to the result, it was discovered that all of the sauces tested were acidic (2.63-3.42). Furthermore, total soluble solids ranged from 33.93-51.86. Brix is a fluid indicator of total soluble solids, and it was found that in the chilli sauce samples are predominantly sugar. In addition, the result for water activity was in the range of (0.89-0.97). Furthermore, the colour of the sample was determined by using L*, a*, and b* values. The range of L*, a* and b* values was (27.41-34.11), (13.77-23.66) and (9.43-20.56), respectively. The a* value shown that most chilli sauce samples were bright red. None of the samples had any water syneresis. Every company used an appropriate stabiliser in the chilli sauce, resulting in acceptable flavour after stored at room temperature for extended periods of time after opening.

Keywords: Chilli sauce; salt content; pH; colour; syneresis

I. INTRODUCTION

Chilli (*Capsicum annuum*) was categorised as a spice-vegetable that is commercially important. It is grown primarily in Southeast Asia, such as India, China, and Mexico, and it is widely used in international cuisines (Ahmed *et al.*, 2000). Chilli pepper fruits can synthesise and produce a variety of important compounds, like capsaicinoids (responsible for chillies' distinctive "heat"), pigments like anthocyanins and carotenoids, and vitamins A, B, and C (Martnez-lópez *et al.*, 2014). Chilli is gaining popularity in the global market due to its value-added products, which include chilli sauce, chilli powder, chilli oils, and many others. Chilli sauce is a well-known condiment made from chilli peppers. Definition of chilli sauce in "Codex Alimentarius", is a product made from the edible portion of raw ingredients produced by heat for culinary use as a seasoning and condiment (García-casal *et al.*, 2016). According to Malaysian Food Regulation 1985, chilli sauce is a sauce made from fresh, ripe chillies or chilli powder, with salt, sugar, vinegar, and other ingredients. In chilli sauce need to have 5% w/w of chillies.

Currently, chilli sauce is a well-known condiment product and has been used extensively in Malaysia (Low *et al.*, 2009). Adabi, Life, Cap Tamin, Lingam's, Masterfoods, Kimball, Heinz, Koki Kampung Koh, Enaq, MH Foods, and many more are the examples of chilli sauce's brands that exist in Malaysian markets. To meet market demands, each brand offers a number of varieties such as garlic-infused, spicy-hot, tangy-sweet, or even exotic blends inspired by global cuisines (Low *et al.*, 2009). Mostly, the production of chilli sauce will start with cleaning the fresh chillies and boiling over medium heat until tender. The chilli paste will then be ground until smooth before being cooked with several ingredients like

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sugar, water, vinegar, starch, and additives and slowly brought to a simmer. Once finished, the chilli sauce is flowed into a processing tank for bottling (Liong *et al*., 2020). When unpacked and unlabelled, the chilli sauces appear similar like other brands, but their way of preparation and quantity of ingredients in the particular recipe can be different. According to Smith and Emmanuel (2018), these variations can affect not only the quality aspects of the product, such as appearance, odour, consistency, and taste, but also the nutritional value. Mostly, chilli sauce in Malaysia has different levels of sweetness as well as heat intensities. They have also been developed with differing levels of heat, ranging from mild to extremely hot. Chilli sauce products are frequently consumed with a variety of foods to enhance the flavour as well as the looks and texture characteristics for instance, it is consumed as garnishes for seasoned red meat, poultry, fish, egg dishes, and other foods (Ikhu-omoregbe & Bushi, 2008). As a result, these characteristics or parameters will undoubtedly influence consumer preferences and marketing values.

In the absence of a comprehensive framework for assessing and characterising Malaysian chilli sauces, the development of standardised quality control measures, product formulation improvements, and consumer satisfaction is hampered. Furthermore, a lack of knowledge about the specific characteristics of commercial chilli sauce makes it difficult to differentiate between brands and identify factors that influence consumer preference. To bridge these gaps, this research aims to identify the parameters that best describe and characterise Malaysian chilli sauces as well as to identify the key characteristics of commercial chilli sauce in terms of pH, total soluble solids (°Brix), water activity, syneresis, viscosity, salt content, and colour for selected brands.

II. MATERIALS AND METHOD

Five different commercially available chilli sauce brands were chosen and sampled from local supermarkets in Gong Badak, Kuala Terengganu, Malaysia. All chilli sauces were produced locally. The composition of these sauces, as shown on the packaging labels, are summarised in Table 1.

Table 1. Composition of the commercial chilli sauces.

Samples	Ingredients
SK	Sugar, chilli, tomato paste, salt, garlic, extract stevia, spices, contain modified starch and acid regulators as permitted food conditioners.
SH	Chilli, sugar, tomato paste, garlic, food conditioner (Xanthan gum), original flavouring, salt, acetic acid, preservative (sodium benzoate), tartrazine and ponceau 4R (origin of chemicals).
SM	Sugar/Brown sugar, chilli, chilli paste, vinegar, salt, tomato paste, contains thickeners and acid regulators as permitted food conditioners. Contains permitted flavours. Food additives are from plant or synthetic sources.
SL	Sugar, chilli, vinegar, salt, tomato paste, contain modified cornstarch, acid regulators and thickeners as permitted food conditioners.
SJ	Water, sugar, dried chilli, modified starch, salt, garlic, acetic acid, flavour enhancer, edible gum, preservative, spices and colours.

Determination of pH: The pH of five samples was evaluated using a pH meter (Mettler Toledo, Switzerland). The pH instrument was calibrated prior to analysis with buffers of pH 4.0 and 7.0 (Yin & Chin, 2022).

Total Soluble Solids: The total soluble solid content of sauces was measured with a digital refractometer (Smart-1, Atago, Japan) with automatic temperature compensation at 25°C (AOAC, 2005), and the outcomes were presented in °Brix (Berutto *et al.*, 2021). The amount of 0.5 ml samples was used to thoroughly coat the prism surface.

Water activity: This analysis used a water activity metre (Series 4, Aqualab, USA). The sample's temperature is not more than 4°C. The 7.5 ml samples were poured into the disposable cup. Finally, once equilibrium water vapour was reached at 25°C, water activity measurements were taken. Results are expresseed as mean with standard deviation (Mohd Khairi *et al*., 2014).

Syneresis analysis: The syneresis test was performed using a centrifuge machine (Thermo Scientific, Sorvaii Biofuge Prime R). A 20.00 ± 0.01g sample was then centrifuged at 3000 g for 30 min, and the percentage was calculated using equation (1) (Hamid *et al.*, 2020).

$$\text{Syneresis } (\%) = \frac{a}{b} \times 100 \quad (1)$$

Where,

a = weight of water separated from the sample (g),

b = total weight of the sample prior to centrifugation (g)

Viscosity analysis: The sauces viscosity was measured using Brookfield DV1 Digital Viscometer (Middleboro, MA) together with spindle type RV 4 at 10 rpm for 1 min. The outcomes were stated in mPa.S (Mahmood *et al.*, 2019).

Salt content analysis: Titration using the modified Volhard method was used to determine salt as sodium chloride (Mueda, 2015). Back titration with potassium thiocyanate is used in this method to determine the concentration of chloride ions in the solution. The sauce also should digest in order to free the salt and obtain the chloride ion. The sauce was determined via titration with 0.1 mol/L potassium thiocyanate after reacting with nitric acid and potassium permanganate. The first occurrence of a dark red colour signifies the endpoint. The percentage was calculated using equation (2).

$$NaCl\ \% = \frac{(V_2 - V_1) \times N \times 5.844}{W} \quad (2)$$

Where,

V_1 = Titer volume of sample

V_2 = Titer volume of blank

N = Normality KScN

W = Weight sample

Colour analysis: A Chroma metre was used to measure the colour of all samples (Konica Minolta, model CR400). In the CIELAB system, L* denotes the degree of lightness or darkness (L* = 0 denotes perfect black and L* = 100 denotes perfect white), while a* denotes the degree of redness or greenness and b* denotes the yellowness or blueness, respectively according to the methods of Ritthiruangdej *et al.* (2011).

Statistical analysis: The data was analysed using one-way ANOVA on IBM SPSS statistic 23. (SPSS Inc., Chicago, IL, USA). The Posthoc of Tukey test was employed to see whether there were significant differences in means across all comparisons ($p < 0.05$). All analysis were performed in triplicate.

III. RESULT AND DISCUSSION

The pH values shown in Table 2 were in the range of 2.62-3.44, with a significant difference ($p < 0.05$) between all samples. Sauce SL (2.63 ± 0.02) was discovered to be the most acidic sauce opposed to the others owing to consist the highest quantity of vinegar. Sauce SJ (3.42 ± 0.02) was found to be the least acidic. This result met the required standard, which was not to exceed 4.5 (Thai Agricultural Standard, 2008). The pH value is slightly lower to various studies of sauces, such as in chilli sauce with garlic which is in the range of 3.56-3.96 (Mahmood *et al.*, 2019) and spicy sweet chilli sauce in the range of 3.42-3.66 (Yin & Chin, 2022). In general, the acidic properties of chilli sauce were almost certainly caused by some vinegar in the recipe, as shown in Table 1. The higher amount of acetic acid in the sauce can produce a lower pH value and it was agreed by Chaethong and Pongsawatmanit (2015). Moreover, a lower pH value can shows longer shelf life as pH can sustain the balance of microorganisms in the sauce.

Besides, total soluble solids (TSS) obtained for this study were in the ranged from 33.90 to 52.20. Sample SM and SL have the highest value of TSS, which were 49.67 ± 0.61 and 51.86 ± 1.53, respectively. However, sample SJ has the lowest °Brix, which is 33.93 ± 0.25. Sugar is a main ingredient that always detected in the total soluble solids of chilli sauce, and °Brix is an indicator of the total of soluble solids in a liquid used in the food industry to determine the quantity of sugars in the juice, liquors, carbonated beverages, and the sugar manufacturing industry (Kleinhenz & Bumgarner, 2012). °Brix obtained for all samples were in the range from 33.90-52.20, similar to what was discovered by Thi *et al.* (2020) in black cherry tomato sauce and Hamid *et al.* (2020) in pineapple-chilli sauce. All samples met the Malaysian Food Act (1983) and Food Regulation (1985) minimum TSS requirement of not less than 25% TSS in chilli sauce. TSS levels above a certain threshold are associated with an

increase in chilli sauce viscosity. Past research by Gamonpilas *et al.* (2011) revealed that the sauce with the lowest TSS had the lowest consistency, closely related to viscosity.

In terms of water activity, there was a significant difference between the samples, ranging from 0.89 to 0.97 (Table 2), that was similar towards what Diantom *et al.* (2017) reported in tomato sauce and Berutto *et al.* (2021) recently discovered in strawberry-enriched ketchup sauces. There were significant differences ($p < 0.05$) in water activity (a_w) among the chilli sauces. However, the SL had a significantly lower a_w (0.89) than all the other chilli sauces. Water activity (a_w) is a vital parameter because it can influence chemical degradation reactions as well as microbiological growth in food products. Almost all the samples could develop and grow bacteria due to the high water activity of the chilli sauce. Fortunately, their low pH had already been recognised as a significant barrier.

Furthermore, as seen in Table 2, the chilli sauce sample did not present any water syneresis at all. Syneresis, also recognised as serum separation, is indeed a major consideration in sauce viscosity stability during storage. Yet when starch is not used as a thickening agent, water leakage out of a gel is typical in chilli sauce (Rengsutthi & Charoenrein, 2011). In Malaysia, most chilli sauces do not have any separation. This is probably because the addition of the appropriate type and amount of starch that present in sauce which reduces the degree of syneresis (Sahin & Ozdemir, 2004). Thus, the gel strength will increase and make it denser and more compact, which allows it to create a firm network and withstand weight per width area. In other sauces, such as chilli sauce with 1% purple water yam starch also not produced any syneresis (Astrini *et al.*, 2019). Hence, it is demonstrated that good thickeners and stabilisers were used in all samples of chilli sauce.

The viscosity of this sauce product ranged between 1207.01 mPa.S and 2386.72 mPa.S (Table 2). Sample SK has the highest viscosity compared to the other samples. There were statistically significant differences ($p < 0.05$) between samples SJ (2188.31 ± 56.00 mPa.S), SL (1819.34 ± 61.30 mPa.S) and SH (1207.01 ± 30.40 mPa.S), but no significant differences ($p > 0.05$) between SK (2386.72 ± 85.70 mPa.S) and SM (2348.03 ± 54.70 mPa.S). The viscosity of a product is dictated by the intermolecular forces that exist among a molecule and water solutes such as sugars and acids. This interaction is caused by hydrogen bond strength and intermolecular spacing, which are highly reliant on concentration and temperature (Kaur *et al.*, 2021). Ketchup is one of the most common foods in which hydrocolloid thickeners are used to control viscosity. The viscosity of Malaysian chilli sauce is mostly good due to the incorporation of starch and xanthan mixture in sauces that enhanced their elastic properties, and the viscosity of sauce varies according to the processing method, type and amount of starch, and food additives applied (Yin & Chin, 2022). The viscosity of the sauce rises as the concentration of starch or xanthan gum increases.

In addition to serving as a preservative, salt is used in processed foods as a stabiliser and colour enhancer. The majority of staple food in Malaysia contained a substantial level of sodium. Muneer *et al.* (2020) stated that gravy and sauce had the highest salt levels (3.97/100 g). According to Table 2, the salt content over all samples did not vary significantly, and the values were within the range of (3.64 ± 0.58%) - (3.92 ± 0.01%) NaCl. Chilli sauce is one of Malaysia's top ten sodium sources, causing excessive salt consumption (Shahar *et al.*, 2019). Other sauces, such as doenjang sauce, had a NaCl concentration ranging from 10.80% to 17.10%. Doenjang is a popular fermented soybean food made by combining and fermenting brine with mouldy cooked soybeans (Nam *et al.*, 2012). Thus, doenjang has a higher value of NaCl concentration rather than Malaysian chilli sauce. Although sodium chloride (NaCl) plays an important role in physiological processes, excessive sodium consumption leads to health problems such as heart disease, cardiovascular disease, and high blood pressure (Shahar *et al.*, 2019).

Chilli sauce colour values were determined using L*, a*, and b* values, which represent lightness to darkness, greenness to redness, and yellowness to blueness, respectively. Table 3 presents the intensity of colour properties in chilli sauce. The L*, a* and b* values of all samples varied from the range 27.45 to 34.11, 13.77 to 23.66 and 9.43 to 20.56, respectively. The brightness of the chilli sauce produced did not differ significantly between samples SL, SM, and SK, but it did differ significantly between samples SH and SJ (Table 3). The L* value for sample SH was slightly higher compared to the

samples SJ, SL, SM and SK. L* value for sample SH was (34.11 ± 0.99) compared to the L* value in sample SM (27.45 ± 1.02). This could be attributable to the whitish colour of garlic contributed during the sauce's processing. As described by Mahmood *et al.* (2019), when the quantity of garlic was increased, the lightness of the sauce increased significantly.

Furthermore, there is no significant different ($p > 0.05$) was attained in a* value. Basically, the redness value is caused by the combination of carotenoid pigments such as capsanthin and capsorubin from chilli (Arimboor & Natarajan, 2015). Sample SH has the highest redness value. Meanwhile, the b* value was measured to determine the yellowness component in chilli sauce. The total result for the b* value for all samples was reduced from samples SH, SJ, SL, SM and SK. It was found that sample SH has significantly different than other samples. Sample SH contains the highest b* value (20.56 ± 2.59) compared to sample SK (9.43 ± 0.42), the lowest b* value. However, no significant differences were found between samples SJ and SL. Similarly, no statistically significant differences were found between samples SM and SK. This could be thought to be due to the addition of synthetic food dyes in sauce, such as tartrazine and ponceau 4R. As mentioned by Gómez *et al.* (2012), tartrazine is commonly found in many food products to improve the colour and visual aesthetic appeal of certain foods.

Table 2. Analysis pH, total soluble solid, water activity, viscosity and salt content of commercial chilli sauce (n=3).

Sample	SK	SH	SM	SL	SJ
pH	2.84 ± 0.02^{c}	3.16 ± 0.01^{b}	2.80 ± 0.02^{c}	2.63 ± 0.02^{d}	3.42 ± 0.02^{a}
TSS (°Brix)	41.57 ± 0.75^{b}	40.03 ± 0.95^{b}	49.67 ± 0.61^{a}	51.86 ± 1.53^{a}	33.93 ± 0.25^{c}
Water activity	0.94 ± 0.01^{bc}	0.97 ± 0.01^{a}	0.91 ± 0.01^{cd}	0.89 ± 0.01^{d}	0.96 ± 0.01^{ab}
Syneresis (%)	0.00	0.00	0.00	0.00	0.00
Viscosity (mPa.S)	2386.72 ± 85.70^{a}	1207.01 ± 30.40^{d}	2348.03 ± 54.70^{ab}	1819.34 ± 61.30^{c}	2188.31 ± 56.00^{b}
Salt as NaCl (%)	3.87 ± 0.06^{a}	3.97 ± 0.06^{a}	3.92 ± 0.01^{a}	3.64 ± 0.58^{a}	3.68 ± 0.06^{a}

Values are expressed in mean ± standard deviation. The value with different superscript ($^{a-c}$) letter in the same row is significantly different ($p < 0.05$).

Table 3. Colour profile of commercial chilli sauce (n=3).

Sample	SK	SH	SM	SL	SJ
L*	27.92 ± 0.29^{c}	34.11 ± 0.99^{a}	27.45 ± 1.02^{c}	29.06 ± 0.57^{c}	31.21 ± 0.09^{b}
a*	13.77 ± 0.69^{a}	23.66 ± 0.49^{a}	17.29 ± 2.52^{a}	14.07 ± 10.46^{a}	21.33 ± 0.49^{a}
b*	9.43 ± 0.42^{c}	20.56 ± 2.59^{a}	10.28 ± 1.78^{c}	14.47 ± 0.49^{b}	16.29 ± 0.33^{b}

Values are expressed in mean ± standard deviation. The value with different superscript ($^{a-c}$) letter in the same row is significantly different ($p < 0.05$).

IV. CONCLUSION

In conclusion, the current study showed that mostly physicochemical properties of chilli sauce in Malaysia have a significant difference ($p < 0.05$), such as in pH values which in the range of 2.62 - 3.44, the water activity of all samples was found in the range of 0.89 - 0.97, total soluble solids (TSS) were in the range from 33.90 - 52.20 and viscosity obtained for this sauce product were in between 1207.01 mPa.S and 2386.72 mPa.S. Sample SH also has the highest salt content 3.97 ± 0.06% than other sample and mostly all chilli sauce studied have no syneresis at all. Moreover, for colour analysis, sample SH has the highest value for L*, a* and b* values 34.11 ± 0.99, 23.66 ± 0.49 and 20.56 ± 2.59, respectively compared to the other sample. Understanding these properties allows us to evaluate quality, safety, and stability while also addressing current sauce issues such as spoilage, contamination, or inadequate formulation. Furthermore, comparing the obtained values for all parameters to the Malaysian Food Act and the Codex Alimentarius helps us ensure adherence to regulatory standards, strengthening consumer protection, and maintaining the food industry's integrity.

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