Assessment of three noodle products based on measurements of total capsaicin content in chilli sauce

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To Danish Veterinary and Food Administration, Chemistry and Food Quality Division

On Assessment of three noodle products based on measurements of total capsaicin content in chilli sauce

From DTU National Food Institute

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Request

In an email of 14 June 2024, DTU National Food Institute received information from the Danish Veterinary and Food Administration, which has been provided with new information from a law firm about the composition of the three brands of 'hot and spicy' noodles which differs from what has previously been assessed in a memo dated 6 June 2024. In the memo from 6 June 2024, the calculations of the total capsaicin content were made based on an assumption that the chilli strength came from both noodles and chilli sauce in a pack of instant noodles. On 20 June 2024, the Danish Veterinary and Food Administration forwarded the company's analyses of the content of capsaicin in all three chilli sauces and, in one case, also of dihydrocapsaicin in the sauces to be mixed with the three noodle products. Here information is provided that chilli is only spicing the chilli sauce and not the noodles. The same information had also been received from the law firm.

The information received from the Danish Veterinary and Food Administration about the content of the sauces is shown in the table below.

Product	Capsaicin (mg/100 g)	Dihydrocapsaicin (mg/100 g)	Total Capsaicin (mg/kg)
3 X Extra Hot Spicy Chicken Flavor Ramen (sauce)	87.47	31.1218	1186
Extra Hot Spicy Chicken Flavor Ramen (sauce)	52.96	-	530
Stew Type Hot Chicken Flavor Ramen (sauce)	29.88	-	299

Furthermore, information has been received that the weights of a chilli sauce sachet are the same as those submitted by the law firm (the weights are shown below in Table 1).

The Danish Veterinary and Food Administration would like health assessment of the products based on this information. A quick response has been requested.

Conclusion

One pack (140 g) of both noodles and chilli sauce in the product '3 x Spicy & Hot Chicken' contains 37.5 mg total capsaicin (the sum total of capsaicin and dihydrocapsaicin) in the sauce. One pack (140 g) of '2 x Spicy & Hot Chicken' contains 16.9 mg capsaicin and a calculated total capsaicin content of 23.1 mg in the sauce. One pack (145 g) of 'Hot Chicken Stew' contains 11.1 mg capsaicin and a calculated total capsaicin content of 15.1 mg in the sauce.

Ingestion of large quantities of total capsaicin/capsaicinoids may cause acute poisoning. In recent years, cases of poisoning (gastrointestinal symptoms, respiratory problems, and circulatory disorders) have been reported in children and adolescents who ate a single extremely hot chip, where a content of 11.8-59.3 mg of total capsaicin per chip was measured. One chip was eaten as part of a challenge/competition on how well the participants tolerated the extremely hot product. The total capsaicin content in a pack of each of the three noodle products ("3 x Spicy & Hot Chicken", "2 x Spicy & Hot Chicken", and "Hot Chicken Stew") is in the range in which symptoms of poisoning were seen with the extremely hot chips.

Based on the available data, DTU National Food Institute assesses that the levels of total capsaicin which can be ingested with a single pack of the three types of noodles are so high that they may pose a risk of consumers developing acute poisoning.

Background

Capsaicin and other capsaicinoids in chilli and pepper

The pungent and spicy taste of chilli peppers (fruits from some varieties of *Capsicum annuum* L. (bell pepper or chilli pepper) and *Capsicum frutescens* L. (cayenne pepper)) comes from the content of the group of compounds known as capsaicinoids. This group of compounds includes capsaicin, dihydrocapsaicin, and nordihydrocapsaicin. Capsaicin typically constitutes the main part, about two-thirds, of the total capsaicinoid content. Analytically, the strength of chilli and products containing chilli is determined as the total capsaicin concentration, total capsaicin (the sum total of capsaicin, dihydrocapsaicin, and nordihydrocapsaicin). The pungency/'chilli strength' of chilli products can also be indicated using the so-called Scoville scale with 'Scoville Heat Units' (SHU). The conversion factor is 1 mg total capsaicin/kg = 16.1 Scoville = 16.1 SHU (BfR 2011).

New product information submitted to the Danish Veterinary and Food Administration and forwarded to DTU National Food Institute

According to the information received from the law firm and based on the new analyses received on June 20, the chilli strength (measured in Scoville Heat Units or measured as the content of capsaicin and dihydrocapsaicin) is only found in the chilli sauce that is poured over the noodles and not in the overall noodle product.

Table 1 shows the conversions of Scoville Heat Units to total capsaicin calculated by DTU National Food Institute, information about grams of chilli sauce in a pack (received from the law firm), and calculations of the content of total capsaicin in the chilli sauce done by the law firm and by DTU Food, respectively. The

total content of total capsaicin in the overall pack (noodles + sauce) is identical to the content in the chilli sauce, according to the law firm's information. In addition, DTU Food has calculated the total content of total capsaicin (in the chilli sauce and the noodles) in one kg of each of the three noodle products.

Table 1

Product name	Weight per pack	Strength (Scoville Heat Units)	Total capsaicin	Weight per sachet of chilli sauce containing capsaicin	Total capsaicin per chilli sauce pack (according to law firm)	Total capsaicin per chilli sauce pack (calculation – DTU National Food Institute)	Total capsaicin per kg of product (noodles + sauce)
3 x Spicy & Hot Chicken	140 g	> 13,000	> 807.4 mg/kg	31.8 g	> 25.7 mg	> 25.7 mg	> 183.4 mg/kg
2 X Spicy & Hot Chicken	140 g	> 8,000	> 496.9 mg/kg	31.8 g	> 15.8 mg	> 15.8 mg	> 112.9 mg/kg
Hot Chicken Stew	145 g*	4,705	> 292.2 mg/kg	37 g	10.5 mg	10.8 mg	74.6 mg/kg

*The law firm wrote 140 g for pack size, but it says 145 g on the pack

Table 2 shows the measured content of capsaicin and in one product also of dihydrocapsaicin in the chilli-containing sauces that are added to each of the three noodle products. It should be noted that the name of one of the noodle products is "Extra Hot Spicy Chicken Flavor Ramen". As this is the product for which analyses have been submitted, it is assumed that this product is the same as "2 x Spicy Hot Chicken". For "2 X Spicy & Hot Chicken" and "Hot Chicken Stew", there is only information about measurements of the capsaicin content. In measurements of chilli sauces/spice powders added to portions of noodles in Korea, the content of both capsaicin and dihydrocapsaicin was measured in all 24 samples of sauces/spice powder. According to the Federal Institute for Risk Assessment (BfR) (2011), the distribution between the different capsaicinoids is approximately 63-77% capsaicin, 20-32% dihydrocapsaicin, and 1-8% nordihydrocapsaicin. If it is assumed that the distribution of capsaicin and dihydrocapsaicin for the other two products is the same as in the chilli sauce for "3 x Spicy & Hot Chicken", dihydrocapsaicin constitutes 26% of the measured total capsaicin. The calculations of the dihydrocapsaicin content are based on the assumption that the measured content of capsaicin corresponds to 70% of the total capsaicinoid content, while dihydrocapsaicin constitutes 26%.
The table therefore shows the content based on the measurements as well as further calculations of the total capsaicin content for the two noodle products where information has only been received about measurements of the capsaicin content.

Table 2

Product name	Weight per pack	Weight per sachet of chilli sauce containing capsaicin	Capsaicin (mg/100 g sauce)	Dihydrocapsaicin (mg/100 g sauce)	Total capsaicin or capsaicin (mg/100 g sauce)	Capsaicin and/or total capsaicin per chilli sauce pack	Capsaicin and total capsaicin per kg of product (noodles + sauce)
3 x Spicy & Hot Chicken	140 g	31.8 g	87.47	31.1218	118.6 total capsaicin	37.7 mg total capsaicin	269.3 mg/kg total capsaicin
2 X Spicy & Hot Chicken*	140 g	31.8 g	52.96	No data received	53 capsaicin	16.9 mg capsaicin, 23.1 mg total capsaicin (calculated)	120.4 mg/kg capsaicin, 165.1 mg/kg total capsaicin (calculated)
Hot Chicken Stew	145 g**	37 g	29.88	No data received	29.9 capsaicin	11.1 mg capsaicin, 15.1 mg total capsaicin (calculated)	76.3 mg/kg capsaicin, 104.6 mg/kg total capsaicin (calculated)

*"Extra Hot Spicy Chicken Flavor Ramen" in certificate of analysis

***The law firm wrote 140 g for pack size, but it says 145 g on the pack

A single article (Cho & Kwon 2020) has measured the content of total capsaicinoids (the sum total of capsaicin and dihydrocapsaicin, in the following referred to as total capsaicin) in foods, including noodles, on the Korean market, on which, according to the article, there is an increasing demand for spicy foods. In three brands of 'instant' noodles that were marketed as extremely hot, a total capsaicin content of 3.31-7.18 mg was measured in the chilli sauce/spice powder added to a serving of noodles. In seven brands of noodles designated as hot, there was a total capsaicin content of 1.00-2.10 mg in the portion of spice added to one serving of the noodles, while six brands of mildly spicy noodles had a total capsaicin content that varied from 0.57-0.82 mg in the quantity of spice mixture added to a serving of noodles. Noodles from the company SamYang were included in all three strength categories. There is no information about when the products in the study were sampled.

In order to compare the content of total capsaicin in the noodles with other chilli-containing foods, a table has been inserted (Table 3) showing total capsaicin content in different foods.

Table 3. Total capsaicin content (sum total of capsaicin, dihydrocapsaicin, and nordihydrocapsaicin) in different foods (BfR 2011).

Example	Total capsaicin (mg/kg)
Sweet bell pepper powder	< 1
Paprika powder (piquant)	5-30
Tabasco sauce	100-300
Green jalapeno chillies, fresh	Up to 500
Sambal oelek	Up to 800
Chilli powder	1,000-3,000

DTU National Food Institute has previously assessed the content of total capsaicin in an extremely hot chilli chip, where a single chip was ingested as a challenge on the ability to tolerate the product. Measurements of 26 samples of this chip showed a variable total capsaicin content (3946 ± 296 mg/kg to 19752 ± 1481 mg/kg). This corresponded to an ingestion of between 11.8-59.3 mg of total capsaicin after intake of a single chip (3 g).

Cases of illness described

The extremely hot chilli chip resulted in cases of illness in Germany, where the cases reported included two girls aged 13 and 14 years old who developed stomach symptoms and respiratory problems. These cases were investigated by the police and the food safety authority, which stated that they were caused by ingestion of the product. The girls did not suffer from have any kinds of allergy. According to a parent of one of the girls, the attending physician had stated that the symptoms were caused by damage to the gastric mucosa (RASSF Alert 2023).

The German Federal Institute for Risk Assessment (Bundesinstitut für Risikobewertung (BfR)) collected (BfR 2023a) information about the number of cases of poisoning reported to German poison control centres (counterparts of the Danish Poison Control Hotline (Giftlinjen)) after ingestion of capsaicin-containing products in the period 2021-2023. There were reports of 77 persons, of whom 37 were linked to ingestion of the extremely hot chilli chip. Five of them had moderate symptoms, while the others were asymptomatic or only had mild symptoms at the time at which they contacted the poison control centres. All five persons with moderate symptoms had gastrointestinal symptoms (not further described). In addition to these symptoms, two also had circulatory problems (not further described). Except for reports about four adults, all other reports concerned children or adolescents, which applied to the reports from 2023. DTU National Food Institute assumes that information about symptoms at the time at which the poison control centres are contacted is used to assess whether the persons should be examined in an emergency room. Therefore, the report cannot be used to assess the total number of poisoned persons and the severity of their symptoms. The symptoms appear quickly after ingestion and, in a number of enquiries, symptoms may therefore have subsided by the time of contact. In none of the reported cases of poisoning was it possible to link the ingestion to a specific quantity of total capsaicin. Measurements of 26 chip samples collected during the same period showed that a single chip (3 g) resulted in the ingestion of between 11.8-59.3 mg of total capsaicinoids.

A case of presumed capsaicin intoxication involving a 27-year-old man has also been described. Based on assumptions about the capsaicin content of the chilli products eaten, the authors estimated that the person consumed at least 600 mg of capsaicin from hot chilli peppers and hot chilli sauce over a period of 90 minutes. The man participated in a competition in spicy food tolerance. The chilli products were eaten together with bread. He developed severe abdominal pain about 2-3 hours after ingestion, which led to

hospital admission. Treatment with analgesics resulted in complete regression of the abdominal pain within 30 hours (Koprdova *et al.* 2020).

In a Thai study, 20 subjects (aged 17-77 years, five women and 15 men) were given an aqueous solution of dried, powdered *Capsicum* (Prik Pon) via an intragastric tube. The history of the amount of capsicum consumption was thoroughly questioned and the subjects were classified as non consumers, mild or moderate consumers and heavy consumers according to their consumption patterns. The solution was prepared with 3 g of the spice in 30 ml of water, the mixture was filtered and, according to the article, a 3% solution was administered. Effects on the gastric mucosa were studied by gastric endoscopy with a minimum time of observation of 15 minutes after installation. Any symptoms of abdominal discomfort or of burning sensation of pain were also noted. Seven people had reactions to the dosage. Of these, three had mild changes in the gastric mucosa (oedema and/or hyperaemia, three had moderate changes (multiple haemorrhagic spots) and, in one case, a severe reaction with progressive and massive haemorrhagic areas followed by vomiting of dark reddish blood. This one person (a 20-year-old) had a moderate consumption of spicy food, had a medical history of repeated hematemsis and melena, where previous repeated examinations (X-ray and gastroscopies) had not established the cause. In 13 persons, no mucosal changes were seen. Two of the subjects experienced a burning sensation from the abdominal region, but did not have any changes in the gastric mucosa (Viranuvatti *et al.* 1972). According to an internet search, Prik Pon is the name of a hot chilli. No measurements of the capsaicin content were made in the study, and it is unclear how much chilli was administered per person. DTU Food has included the study because it shows considerable variation in sensitivity to the harmful effects of chilli/total capsaicin in a standardized trial design.

Risk assessments

The European Food Safety Authority (EFSA) has not performed a risk assessment of total capsaicin/capsaicinoids. In 2011, the German Federal Institute for Risk Assessment (Bundesinstitut für Risikobewertung (BfR)) assessed the health risk posed by chilli or chilli products. New memos have subsequently been issued by the Federal Institute for Risk Assessment (BfR) on this topic (BfR 2023 a,b).

The Federal Institute for Risk Assessment (BfR 2023b) describes that the NOAEL ('No Observed Adverse Effect Level') for adults, which the Federal Institute for Risk assessment (BfR 2011) established, was based on a study by Myers *et al.* (1987) conducted in a few adult subjects administered three doses of red pepper/chilli pepper. No measurements were made of the capsaicin/total capsaicin content in the spice, nor was other information provided about the strength, for example according to the Scoville scale. According to the Federal Institute for Risk Assessment (BfR 2023b), BfR (2011) assumed that the capsaicin content in the spice was 1% or less, while the authors of the article (Myers *et al.* 1987) assumed that the capsaicin content of the spice was 0.14%. There is considerable variation in the content of capsaicin and other capsaicinoids in fruits from *Capsicum annuum* and *C. frutescens*, depending on a number of factors such as variety, cultivation conditions and the age of the fruit. According to Evans (2009), the content of capsaicin may be as high as 1.5%. In addition, capsaicin is not evenly distributed in the fruit. For example, it is mentioned that there is a capsaicin content of 0.49% in the whole fruit, 0.1% in the fruit wall (pericarp), 1.79% in the partitions inside the fruit (dissepiment), and 0.07% in the seeds (Evans 2009).

DTU Food finds that the assessment made by the Federal Institute for Risk Assessment (BfR 2011) cannot be used to establish a safe level of capsaicin or total capsaicin, because of the high variability of

the capsaicin content in chilli and that it is therefore highly uncertain whether there was actually 1% capsaicin in the spice that Myers *et al.* (1987) used in their study.

The Federal Institute for Risk Assessment (BfR 2011) mentions that serious health impairments have been observed with an excessively high consumption of chillies or chilli preparations. The harmful effects include: Irritation of mucous membranes, nausea, vomiting, and hypertension and even hypertensive crisis which can be life-threatening under certain circumstances. The dosage of capsaicinoids ingested by affected persons is unknown. Children may react sensitively to chilli products. Severe cases of poisoning (even fatal) of small children who have ingested chilli preparations has been described in the international literature (BfR 2001), for example a death of an 8-month-old boy (Snyman *et al.* 2001). In these cases, symptoms such as shock, acidosis, central cramps, acute kidney failure, septicemia, enlargement of the liver, unconsciousness, and respiratory restrictions have been seen. As described by Viranuvatti *et al.* (1972), there is also considerable individual sensitivity to chilli, where some subjects (aged 17-77) were unaffected, others experienced burning pain in the abdominal region without observed changes in the gastric mucosa, while yet others had varying degrees of changes in the gastric mucosa.

The Federal Institute for Risk Assessment (BfR 2011) mentions several cases of poisoning after competitions involving consumption of hot chilli products. Reference is, for example, made to coverage in the German press in 2010 of a case where 13-14-year-old school children had competed on drinking a very hot chilli sauce. Ten of the pupils complained about extreme nausea and were taken to an emergency room. Eight of them were hospitalized for further treatment and observation.

Furthermore, the Federal Institute for Risk Assessment (BfR 2011) warns against competitions where the purpose is to eat extremely hot chilli/foods containing chilli, as these intakes may, for example, cause very serious cases of sudden hypertension ('hypertensive crisis'), which, in a worst-case scenario, is life-threatening. A case is described where a man who had participated in a competition on who could eat the most chilli fruits in a specified time developed hypertensive crisis followed by acute cardiac infarction.

Allergic reactions
Allergic reactions have been described after oral ingestion of cayenne pepper, but they are rare. Symptoms such as urticaria, generalized eczema, and respiratory complaints have been reported, which can be life-threatening under certain circumstances (BfR 2011).

Reflections on use of chilli products in cooking compared with competitions on the ability to tolerate extremely hot chili products
The ingestion of chilli products with a high content of total capsaicin must be assumed to be self-limited due to the strong burning sensation in the oral cavity or stomach or other discomfort when eating chilli products as a food. Viranuvatti *et al.* (1972) saw varying sensitivity to adverse effects of total capsaicin/chilli in humans.

It must be assumed to be different in competitions, where the objective is to tolerate the intake of extremely hot chilli products, and where the competition participants therefore ignore the discomfort caused by the ingestion. This could be the reason why there are primarily descriptions of cases of acute poisoning symptoms in people who have eaten chilli products in competitions that involve eating hot chilli products. This was seen in the recent case of children and adolescents who ate a single extremely hot chilli chip. The Federal Institute for Risk Assessment (BfR 2011) mentions 13-14-year-olds who were

brought to a hospital after competing on who could drink an extremely hot chilli sauce, and there have also been cases of poisoning in persons who have participated in competitions on eating, for example, hot chilli fruits (BfR 2011, Koprdova *et al.* 2020). In the assessment of the Federal Institute for Risk Assessment (BfR 2011), it warns consumers against competitions (referred to as "Fiery Foods Competitions") where the aim is to eat extremely hot chilli fruits or chilli products, as these intakes may cause, for example, severe health impairments such as hypertensive crisis, which, in a worst-case scenario, can be life-threatening.

Summary

The information based on measurements of capsaicin content and in one product also of dihydrocapsaicin content (Table 2) is more accurate than the information about content calculated on the basis of information about Scoville data, where, for two products, there was even only information that these were greater than a given Scoville unit (Table 1).

The capsaicin content in the chilli sauce has been measured for two of the noodle products, while, in a third product, both the capsaicin content and the dihydrocapsaicin content have been measured. In a Korean study of 24 samples of chilli sauces, all the samples contained both capsaicin and dihydrocapsaicin. DTU The National Food Institute has therefore calculated the content of total capsaicin based on the measurement of both capsaicinoids in one product and has given the capsaicin content and the calculated total capsaicin content in the two products where only capsaicin was measured (Table 2).

As there is only chilli in the chilli sauce and not in the noodles, the content of capsaicin and/or total capsaicin (capsaicin and dihydrocapsaicin) is the same in a serving of sauce and in a pack of noodle product (sauce + noodles). This means that one pack of noodle product (sauce + noodles) of '3 x Spicy & Hot Chicken' contains 37.7 mg total capsaicin (pack size 140 g). There is a capsaicin content of 16.9 mg and a calculated total capsaicin content of 23.1 mg in a pack (140 g) of '2 x Spicy & Hot Chicken' and a content of 11.1 mg capsaicin and a calculated content of 15.1 mg total capsaicin (145 g) in 'Hot Chicken Stew'.

If the total capsaicin content is converted into per kg of product (noodles + sauce), the content of '3 x Spicy & Hot Chicken' is 269.3 mg/kg total capsaicin. In '2 x Spicy & Hot Chicken', a content of 120.4 mg/kg capsaicin is measured, and a content of 165.1 mg/kg total capsaicin is calculated. This means that the level in both products is on a par with what is found in tabasco sauce (100-300 mg/kg). The comparison with the content in 140 g of tabasco sauce is not completely ideal, as additional water is added to the finished noodle product, but it does give an indication of the chilli strength. The capsaicin content of 76.3 mg/kg product (noodles + sauce) in 'Hot Chicken Stew' is in the range between the 5-30 mg/kg found in strong paprika powder and what is found in tabasco sauce.

A single study has measured the total capsaicin content of various 'instant' noodle products on the Korean market. In three brands of 'instant' noodles marketed as extremely hot, a total capsaicin content of 3.31-7.18 mg was measured in the chilli sauce/spice powder added to a serving of noodles. As the noodles do not contain chilli, the content of the sachets corresponds to what is contained in a pack (serving). This means that the three brands of noodles assessed in this memo are all stronger than the noodles referred to as extremely hot in the study of noodles on the market in Korea in around 2020.

The harmful effects of ingesting chilli/cayenne and products made from them with a high content of capsaicin and other capsaicinoids include: Irritation of mucous membranes, nausea, burning sensation in the abdominal area, severe abdominal pain, vomiting, and hypertension, which, in a worst-case scenario, may be life-threatening. Studies have also shown changes in the gastric mucosa in a number of subjects, which showed that there is individual sensitivity to the harmful effects of capsaicin and other capsaicinoids. It is known that very small children are highly sensitive to capsaicin. No studies have been found on whether there is a difference in sensitivity between adults and older children/adolescents.

In the literature, cases of acute poisoning have been described in adults, but especially children and adolescents, who have participated in competitions/challenges, where the objective was to eat extremely products heavily spiced with chilli. In most cases, there is no information about the quantity of ingested capsaicin or total capsaicin. However, there are data on the ingestion of a single chip (3 g) with a content of between 11.8 and 59.3 mg total capsaicin, which caused cases of illness primarily in children and adolescents who ate the chip.

The total capsaicin content per pack (140 or 145 g) for the noodle products: '3 x Spicy & Hot Chicken' (37.7 mg total capsaicin), '2 x Spicy & Hot Chicken' (16.9 mg capsaicin, calculated total capsaicin content of 23.1 mg), and for 'Hot Chicken Stew' (11.1 mg capsaicin and calculated content of 15.1 mg total capsaicin) are all within the range of 11.8-59.3 mg total capsaicin, which has previously given rise to acute poisoning in children and adolescents who ate a hot chillispiced chip.

Based on the available information, DTU National Food Institute therefore assesses that there may be a risk of developing acute poisoning due to the high levels of capsaicin and total capsaicin in the three noodle products '3 x Spicy & Hot Chicken', '2 x Spicy & Hot Chicken', and 'Hot Chicken Stew'.

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