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Research Article

Iodine Content of Malaysian Foods

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ABSTRACT

Background: Iodine is an essential mineral that is important for human nutrition. Iodine content was determined in 138 Malaysian food samples using inductively coupled plasma-mass spectrometry.

Method: The samples include 31 cereal products, 9 starchy root and tuber products, 4 legume products, 11 nut and seed products, 4 vegetables, 5 fruits, 22 sugar and syrup products, 3 meat products, 3 eggs, 7 fishes, 14 milk products, 11 oil and fat products, 1 beverage and 13 other food products. Up to six different brands were sampled from local supermarkets in the Klang Valley, Malaysia.

Results: The results showed that the concentration of iodine in the Malaysian food samples varied according to food groups. The iodine values were found to be in range of 3.71-100.64 µg/100 g for cereal products, 8.78-53.50 µg/100 g for starchy root and tuber products, 6.72-30.19 µg/100 g for legume products, 8.16-35.98 µg/100 g for nut and seed products, 1.57-2.44 µg/100 g for vegetables, 1.56-2.20 µg/100 g for fruits, 0.06-23.90 µg/100 g for sugar and syrups products, 5.79-24.36 µg/100 g for meat products, 16.88-158.70 µg/100 g for eggs, 25.21-53.27 µg/100 g for fish, 8.57-61.63 µg/100 g for milk products, 3.58-160.00 µg/100 g for oil and fat products and 2.84-56.72 µg/100 g for other food products.

Conclusion: In conclusion, Malaysian foods showed large variation in iodine content with main iodine food source from the marine environment, iodized salt and fortified animal feeds.

Keywords: Iodine; ICP-MS; Malaysian; Foods

INTRODUCTION

Iodine is classified as one of the essential trace elements that need to be taken daily in an adequate amount to facilitate the synthesis of thyroid hormones, triiodothyronine (T3) and thyroxine (T4) by the thyroid gland. Insufficient thyroid hormone secretion in our body will lead to hypothyroidism while hyperthyroidism will occur due to excessive amount of thyroid hormone in our blood [1,2]. According to World Health Organization (WHO), consumption of iodine for school children is recommended at 120 µg/day. While for adolescents and adults are recommended at 150 µg/day. On the other hand, slightly higher level of iodine intake at 250 µg/day is recommended for pregnant and lactating women. Iodine deficiency occurs when iodine intake falls below recommended levels and it can cause a wide range of illnesses, including goiter and mental retardation [3,4].

The highest and richest iodine content can be found in most natural food sources such as marine fish including shrimps, cod, salmon and mackerel [3]. However, in some meat products as well as green vegetables, beverages and fruits such as cabbage leaf, green beans, coconut water, pineapple, banana, mango, papaya and watermelon, they generally contain low level of iodine [5]. The iodine content in food varies according to the iodine present in the environment. Therefore, the same food item might contain different levels of iodine depending on the locality where it was produced. This is applicable to plant foods as well where the iodine concentration varies by species. Plants grown on iodine-rich soil will contain substantial amount of iodine same as the fish, where the iodine in fish reflects the content in the water they inhabit [3].

Food fortification of iodine as well as iodized salt used in our daily consumption will improve the intake of iodine as recommended.

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The amount of iodine in foods varies depending on fortification, cooking or manufacturing process. The analysis of individual foods can provide information on variation of iodine content in our daily diet intake. Therefore, a database of iodine contents in each food products is very important and necessary as a reference sources to improve the daily dietary intake of individuals [3,6].

Determination of iodine content in food has always been a challenging analytical problem due to the low concentrations, difficult sample preparation and its volatility [7]. Therefore, an accurate determination requires a sensitive analytical method which in this analysis, ELAN 6000 inductively coupled plasma mass spectrometry (ICP-MS) was used. The main objective of the current study was to determine the iodine content in Malaysian foods.

MATERIALS AND METHODS

Sampling

A stratified sampling plan based on the Protocol for Sampling and Methods of Analysis for Malaysian Food Composition [8] was used for food sampling. Food products were sampled from retail outlets in the Klang Valley (Malaysia) from 2011-2017. Up to six brands of each product type were purchased. The food products included commonly consumed food such as cereal products, starchy root and tuber products, legume products, nut and seed products, vegetables, fruits, sugar and syrup products, meat products, fish, milk products, oil and fat products, beverage and other food products. These foods were chosen based on the commonly consumed food from Malaysian Adult Nutrition Survey Study [9].

Sample preparation

Cereal products, starchy root and tuber products, legume products and nut and seed products were grounded into fine powder using a food grinder (7011HS, Waring, USA). The bones, viscera, head and fins of fish products were removed before homogenization. While for vegetables and fruits, the samples were washed with tap water and non-edible parts such as skin and seed were removed prior to homogenization. Samples were stored in air tight containers and kept at 4°C.

Reagents

Reagents used were obtained from Fluka (iodide), Perkin Elmer (indium), Merck (suprapure nitric acid) and Sigma® [tetramethylammonium hydroxide (TMAH)]. Water used was purified and deionized (18.2 MΩ) using the PURELAB® flex elga pure water purification system (Lane End, High Wycombe, United Kingdom).

Iodine analysis

The analysis for iodine content was carried out using Inductively Coupled Plasma-Mass Spectrometry (ELAN 6000 II ICP-MS, Perkin Elmer, USA) method previously described by Khalid and Fabien [10]. About 0.25-0.5 g of samples was weighed into Perfluoroalkoxy (PFA) tubes and added with 4.5 mL deionized water and 1 mL TMAH (25%). Then, the tubes were placed in a drying oven at 90°C for 3 hours. After cooling, deionized water was added to a final volume of 10 mL. These solutions were then centrifuged at 3000 rpm for 15 minutes. If any visible particulates remained after centrifuging, the samples were filtered. The resulting solutions can then be analysed directly or with an extra dilution if high matrix concentrations are present. Calibration standard solutions ranging from 5 to 100 µg/L were prepared and analysed prior to samples analysis. Indium was used as an internal standard. Internal quality control and National Institute of Standards & Technology (NIST) standard reference material (SRM) 1549 non-fat milk powder were used as a control and analysed simultaneously after calibration of the standards. Iodine results will be accepted if they were within the control limits of the quality control material.

Statistical analysis

The descriptive statistics were calculated using Statistical Packages for Social Science (SPSS) version 18.0. The results were reported as mean and standard deviation.

RESULTS AND DISCUSSION

Iodine content for selected food products are shown in Table 1. The iodine content in the foods vary between samples and within samples in the food groups. High iodine concentrations were found in eggs, fish and milk products, whereas the lowest iodine concentration was found in vegetables.

Eggs contained the highest amounts of iodine with the concentration ranging from 16.88-158.70 µg/100 g. These results are in good agreement with previously reported study by Haldimann et al. [3] (21.9-162.5 µg/100 g). The high iodine concentration in chicken eggs is likely due to iodine supplementation of laying hens feed. Study done by Kaufmann et al. [11] showed that iodine supplementation of feed enriched iodine in eggs.

Fish products also contained relatively high amounts of iodine in the range of 25.21-53.27 µg/100 g. Iodine content in fish reflects the habitat they live which showed that seawater and its mineral composition influences its concentration [3]. Similarly, marine fish was also reported to be the richest natural food source of iodine in the study conducted by Leufroy et al. [5] (2.22-51.90 µg/100g) and Haldimann et al. [3] (38.70-692.60 µg/100 g). Besides fish, cod liver oil also contained high amounts of iodine and it was contributed by the source of the ingredient which was from liver of cod fish.

The iodine content in milk products ranged from 8.57-61.63 µg/100 g. The results found in milk products are in good accordance with those reported by Longvah et al. [12] (5.60-60.40 µg/100 g). Milk contained proportionately high amounts of iodine contributed from the enrichment of milk with iodine as stated in the ingredients label. Besides that, increases in iodine content of milks are due to upsurge use of iodine-fortified feed and teat-cleaning iodophors [3,13]. Iodophors have been used extensively in many countries for control of micro-organism in dairy processing sites [14]. While for cheese, the iodine content is mainly contributed by the addition of iodized salt in cheese manufacturing [15]. According to Sieber [16], the cheese content does not reflect the iodine level of the milk from which it was produced.

Plants foods also contain iodine and it was varied from species to species. The iodine content in cereal products ranged from 3.71 to 100.64 µg/ 100 g. These results are in good agreement with previous study by Haldimann et al. [3] (0.4-103.2 µg/100 g). However, baked

Table 1: Iodine in food.

Food Group	n	Iodine contents in fresh weight samples (µg/100 g as eaten) Mean ± SD
Cereal products		
Rice, Boil in Bag Rice	6	11.7 ± 5.78
Rice, Siam	6	20.76 ± 26.19
Rice, Basmathi	6	8.2 ± 1.00
Rice, Fragrant	6	9.64 ± 5.22
Biscuit, Chocolate Chip	6	12.76 ± 6.27
Wafer, Chocolate, Full Coated	6	14.33 ± 5.01
Biscuit, Corn	6	12.27 ± 6.84
Biscuit, Cracker With Sugar	6	8.6 ± 4.64
Biscuit, Crackers, Vegetable Flavour	6	8.54 ± 7.76
Biscuit, Cream Filled	6	14.07 ± 9.75
Biscuit, Oatmeal	6	11.52 ± 5.00
Biscuit, Shortbread	6	15.71 ± 2.11
Biscuit, Wholemeal Crackers	5	73.21 ± 21.04
Corn Flakes	6	43.92 ± 48.23
Muesli	6	9.91 ± 1.94
Biscuit, Milk	6	6.95 ± 5.70
Biscuit, Raisin	4	12.51 ± 4.19
Cookies, Butter	6	67.55 ± 36.15
Oatmeal Cereal, Dry	6	27.62 ± 19.32
Barley Flour	2	10.34 ± 0.61
Egg Noodles	6	58.15 ± 54.62
Flour, Rye	4	17.91 ± 17.14
Nestum Cereal, Dry	1	100.64 ± 21.04
Premix Flour	6	31 ± 27.03
Spaghetti, Dry	6	18.4 ± 18.15
Flour, Wheat, Self-Raising	6	4.24 ± 0.97
Bun, Chocolate	4	5.39 ± 1.19
Bun, Coconut	6	4.28 ± 0.63
Bun, Kaya	3	4.92 ± 0.41
Bun, Potato	6	9.39 ± 1.91
Bun, Red Beans	3	3.71 ± 0.50
Starchy root and tuber products		
Breadfruits Chips	4	12.04 ± 0.29
Potato Chips, Spicy	5	21.04 ± 4.00
Tapioca Chips, Spicy	6	38.02 ± 14.63
Sweet Potato, Red, Chips	4	53.5 ± 25.04
Tapioca Chips, Barbeque	5	8.78 ± 3.91
Food Group	n	Iodine contents in fresh weight samples (µg/100 g as eaten) Mean ± SD
Starchy root and tuber products		
Tapioca Chips, Black Pepper	3	25.1 ± 14.94
Tapioca Chips, Plain, Salted	3	27.31 ± 9.73
Tapioca Chips, Plain, Unsalted	6	9.81 ± 2.71
Flour, Sago	6	16.31 ± 15.95
Legume products		
Black Eye Bean	6	30.19 ± 21.76
Carob Flour	6	6.72 ± 4.09
Soya Flour	5	29.49 ± 15.51
Soya Sauces, Sweet	6	23.49 ± 6.93

	Nut and seed products	
Broad Bean	6	27.62 ± 5.12
Coconut, Shredded	3	35.98 ± 9.92
Flaxseed	6	27.2 ± 2.29
Ginkgo Nuts	6	8.45 ± 2.54
Hazel Nut	3	8.16 ± 4.87
Macadamia Nuts	4	17.79 ± 5.37
Peanut, Crush	6	10.39 ± 1.34
Peanut, Flour Coated	3	10.99 ± 0.43
Pistachio Nut	6	29.39 ± 14.64
Pumpkin Seed	6	17.39 ± 4.03
Sunflower Seed	6	13.72 ± 5.22
	Vegetables	
Baby Corn	6	2.44 ± 0.36
Capsicum, Green	6	1.63 ± 0.15
Capsicum, Red	6	1.77 ± 0.40
Capsicum, Yellow	6	1.57 ± 0.47
	Fruits	
Dragon Fruit, Red	3	1.71 ± 0.45
Dragon Fruit, White	2	1.56 ± 0.36
Honeydew	4	2.2 ± 0.56
Pomegranate	3	2.18 ± 0.28
Watermelon, Yellow	2	2.08 ± 0.33
	Sugar and syrup products	
Aspartame	3	2.15 ± 0.92
Candy, Orange Flavoured	4	1.86 ± 0.71
Candy, Strawberry Flavoured	3	2.38 ± 1.23
Food Group	n	Iodine contents in fresh weight samples (µg/100 g as eaten)
		Mean ± SD
	Sugar and syrup products	
Candy, Grape Flavoured Candy	3	3.61 ± 0.98
Candy, Pineapple Flavoured	1	2.96
Cordial Root Beer	2	8.26 ± 1.97
Cordial, Grape	6	7.18 ± 1.35
Cordial, Guava	4	8.36 ± 1.67
Cordial, Kiwi	4	6.91 ± 1.59
Cordial, Lime	4	7.09 ± 1.24
Cordial, Mango	6	10.42 ± 3.02
Cordial, Orange	5	10 ± 5.34
Cordial, Pineapple	4	14.79 ± 5.42
Cordial, Roselle	6	23.9 ± 5.98
Cordial, Sarsi	6	8.7 ± 1.60
Cordial, Soursop	6	6.01 ± 1.02
Glucose	1	2.23
Jam, Apricot	5	0.06 ± 0.15
Jam, Blueberry	6	0.28 ± 0.48
Jam, Strawberry	6	12.14 ± 34.63
Sugar, Icing	5	0.33 ± 0.27
Sweeteners, Stevia	6	0.27 ± 0.66
	Meat products	
Chicken Burger	4	24.36 ± 2.72
Sausage, Beef	2	5.79 ± 0.14
Sausage, Chicken	6	22.37 ± 13.96

	Eggs	
Hen Egg, White	2	16.88 ± 4.03
Hen Egg, Whole	2	62.94 ± 15.85
Hen Egg, Yolk	2	158.7 ± 26.38
	Fish	
Barracuda	3	46.17 ± 26.42
Frigate Tuna	3	47.41 ± 6.66
Goatfish	3	38.67 ± 1.6
Scad, Oz-Eye	3	42.15 ± 2.14
Trevally, Bigeye	3	53.27 ± 5.62
Sea Catfish	3	25.83 ± 0.34
Indian Threadfish	3	25.21 ± 1.83
Food Group	n	Iodine contents in fresh weight samples (µg/100 g as eaten)
		Mean ± SD
	Milk products	
Butter, Unsalted	6	8.57 ± 15.57
Cheese Spread	2	40.47 ± 2.58
Cheese, Brie	6	13.47 ± 9.54
Cheese, Camembert	6	9.68 ± 10.09
Cheese, Cheddar, Reduced Fat	6	61.63 ± 22.62
Cheese, Chesdale Slices, Processed	6	33.05 ± 11.97
Cheese, Colby	1	40.85
Cheese, Mozarella	5	41.88 ± 26.02
Cheese, Parmesan	5	29.71 ± 28.58
Cheese, Ricotta	3	19.22 ± 4.88
Cream, Whipped	6	14.89 ± 2.89
Cream Cheese	6	26.77 ± 14.23
Creamer, Powder	4	10.98 ± 1.89
Milk, UHT, recombined, chocolate flavoured	2	36.68 ± 27.71
	Oils and fats	
Fish Oil, Cod Liver Oil	2	160 ± 180.18
Margarine Spread, With Salt	4	5.97 ± 0.49
Margarine Spread, Without Salt	2	5.62 ± 0.02
Mayonnaise	6	14.01 ± 8.66
Oil, Blend	6	3.58 ± 4.28
Oil, Canola	6	7.92 ± 7.16
Oil, Coconut	6	11.38 ± 2.74
Oil, Sunflower	6	9.67 ± 10.11
Oil, Vegetable	3	12.63 ± 2.88
Soft Margarine	4	4.47 ± 0.65
Sauce, Thousand Island	6	12.89 ± 5.71
	Beverage	
Tea, Stevia	3	40.73 ± 5.54
	Other food products	
Bird Nest, Soup	1	2.84
Chocolate Rice Cereal	3	30.07 ± 10.92
Chocolate, Bread Spread	1	5.55
English Name	n	Iodine contents in fresh weight samples (µg/100 g as eaten)
		Mean ± SD
	Other food products	
Chocolate, Cashew Nut	2	21.91 ± 9.08
Chocolate, Hazelnut	6	24.63 ± 10.59
Chocolate, Roasted Almond	6	16.88 ± 7.50
Chocolate, White	3	34.7 ± 18.27

Chocolate, Mixed Nuts	1	22.75
Garlic Spread	5	14.26 ± 2.36
Plum Sauce	6	6.6 ± 11.62
Vanilla Wafer	2	39.35 ± 1.52
Wafer, Orange Flavor	2	38.54 ± 0.73
Wafer, Strawberry Flavor	5	56.72 ± 29.37

products such as wholemeal crackers biscuit (73.21 μg/100 g) and butter cookies (67.55 μg/100 g) had high amount of iodine levels. The high iodine content of baked products is likely due to the used of iodates as dough conditioners in some commercially produced baked goods [13].

Starchy root and tuber products, legume products and nut and seed products contained relatively fair amount of iodine with the concentration ranging from 8.78-53.50 μg/100 g, 6.72-30.19 μg/100 g and 8.16-35.98 μg/100 g, respectively. The results found in nut products are in good accordance with those reported by Haldimann et al. [3] (2-37.4 μg/100 g. Fruit and vegetables contained low iodine content ranging from 1.56-2.20 μg/100 g and 1.57-2.44 μg/100 g, respectively. The result for fruit was consistent with previous reported studies (1.8 μg/100 g of dry weight in fresh fruits) [3] and 1.4 μg/100 g dry weight in fruit [5] but lower than those reported by Rose et al. [17] (mean, 4.0 μg/100 g in fresh fruits). While the results for vegetables were slightly lower than those reported by Haldimann et al. [3] (mean 4.7 μg/100 g of dry weight) and Rose et al. [17] (mean 4.0 μg/100 g of fresh weight). In general, plant-based products are relatively poor source of iodine [18].

CONCLUSION

The data showed that iodine content varies widely in Malaysian food products. Overall, eggs contained the highest iodine content and vegetables the least. The high iodine content in foods was contributed by the marine environment, the use of iodized salt in manufacturing process and by fortifying animal feeds. These data provide information on the iodine content of various food products in Malaysia that is necessary for making recommendations to improve the dietary status of individual and for prevention of iodine deficiency disorders among population.

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