Database Development of Carboxymethyl Lysine Content in Foods Consumed by Indonesian Women in Two Selected Provinces

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Abstract

Advanced glycation end products (AGEs) in foods are increased by heat processing, and high consumption of these compounds could contribute to the pathogenesis of non-communicable disease. Yet, the information on carboxymethyl lysine (CML) content, as a part of AGEs, in dietary intakes with predominantly traditional foods with diverse food processing is lacking.

We developed a database of Indonesian foods to facilitate studies involving the assessment of dietary and plasma CML concentration by liquid-chromatography-tandem-mass spectrometry. We estimated dietary CML values of 206 food items from 2-repeated 24-h recalls of 235 Indonesian women with the mean age of 36±8 years old in a cross-sectional study.

All foods were listed and grouped according to the Indonesian food composition table, completed for cooking methods, amount of consumptions, and ingredients. CML values were obtained from published databases, analyzed with similar methods or calculated using other criteria. We searched and reviewed papers published between 2000 and 2017 using the keywords: “advanced glycation end products”, “carboxymethyl lysine”, “diet”, and “food”.

The highest CML content per 100g of Indonesian foods were from instant noodles, chocolate, and cereal drinks, being 3.3mg, 2.9mg, and 2.6mg, respectively. While median CML content among food groups ranged between 0.1 to 0.8 mg. The major contribution of dietary CML were from steamed white rice, instant noodle, and plain rice rolls, boiled.

This database can be used for estimating dietary CML in Indonesian people and should be updated by uploading new foods, revising the CML values, or conducting direct analyses.

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Introduction

Chronic non-communicable diseases (NCDs) account for the highest cause of mortality in Indonesia.[1] The shift in eating behavior due to the urbanization, westernization, intensity of food industry marketing, and the ease to buy fast and processed food would result in poor nutrition and may lead to increased risk of NCDs.[2,3] Beside its high content of fat, sugar, or salt consumption, food processed with dry heat would increase the content of advanced glycation end products (AGEs) and lead to the pathogenesis of NCDs.[4]

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Carboxymethyl lysine (CML) is a non-fluorescent protein adduct[5] that is frequently used as marker for the presence of AGEs in food.[6] Initially, CML was measured by enzyme-linked immunosorbent assay (ELISA) in foods, especially heat-processed milk. Subsequently ELISA was used in a large US study in 2003-2008 by Uribarri et al.[4] measuring CML as an AGE parameter, in more than 500 food samples. To date there are two large studies from England and Europe in 2011 and 2016 by Hull et al.[7] and Scheijen et al.[8] which measured CML with liquid chromatography coupled with tandem mass spectrometry (LC-MS/MS).[6]

The CML content in foods is known to be increased by heat processing, especially at high temperature and low moisture (eg frying, grilling, roasting, and broiling).[4] Uribarri et al.[4] showed that animal-derived food high in protein and fat had a higher CML content than carbohydrate-rich foods.[4,9] In contrast, Hull et al.[7] observed the highest levels of CML in cereal while Scheijen et al.[8] observed the highest levels of CML in high-heat processed nut, grain products, and canned meats.

The high intake of CML may increase level of this substance in the blood and induce inflammation, oxidative stress, and insulin resistance that is related to the progression of chronic diseases.[10] The CML database will support studies that need to estimate the dietary CML and for considering food choices to reduce dietary CML. The Indonesian Food Composition Table (IFCT) contains a variety of data on raw and processed foods from various provinces and regions in Indonesia, but does not have data on CML values.[11] This lack of information could be problematic, resulting in different interpretations of CML values among researchers.

Given the importance of estimating CML to be used by studies in predicting NCDs, and in order to estimate the dietary CML, as a part of AGEs, we developed a special database of Indonesian foods to facilitate studies involving the assessment of dietary and serum CML concentration by liquid chromatography-tandem-mass spectrometry.

Materials and methods

Study design and subject. A cross-sectional study has been conducted from data on involving 235 Indonesian reproductive-aged women residing in selected coastal and mountainous area of West Sumatera and West Java provinces (**Figure 1**). These provinces represented diets of animal- and plant-dominant foods, respectively. Lists of the foods consumed were obtained by trained enumerators using 2-day nonconsecutive 24-hour recall data, representing one weekday and one weekend. All the foods were listed and grouped according to the IFCT[11] then listed also by cooking method, amount of consumption, and the ingredients in the dishes.

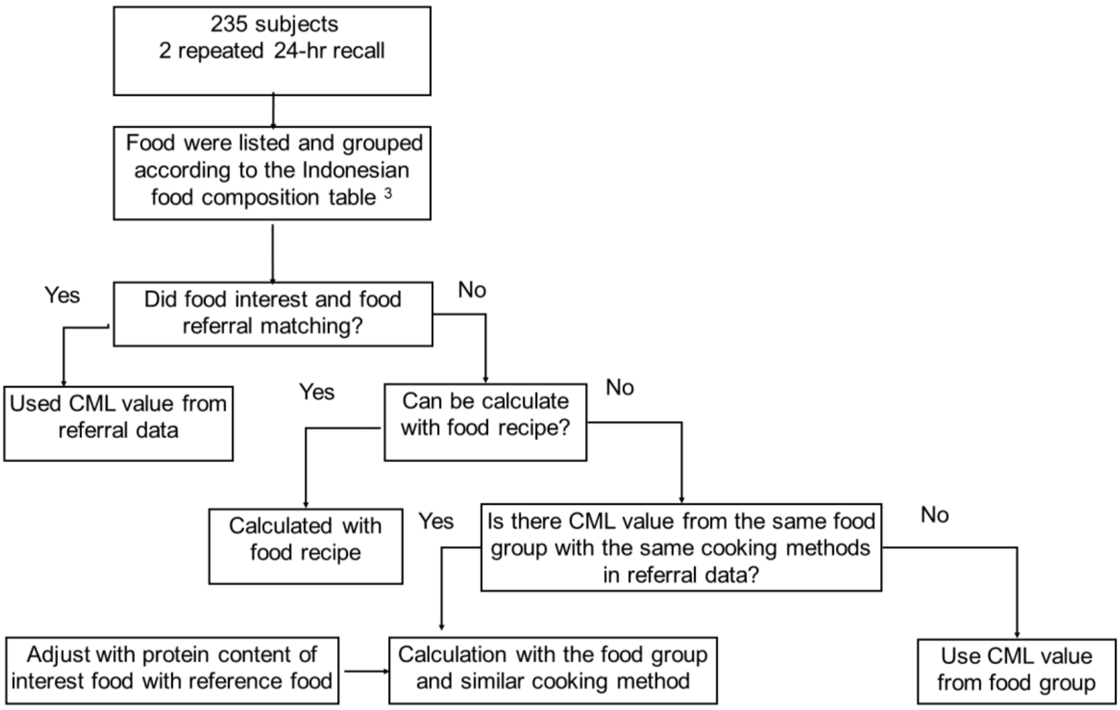


Figure 1. Flowchart built a carboxymethyl lysine database
Note: CML: carboxymethyl lysine

Food grouping and CML content determination. After obtaining a list of the subject's foods, the CML content was calculated by [1] matching and [2] calculating of CML values. Food matching was done between the reference food and the food of interest, based on the similarity of names, description of food types, and of processing methods. In order to choose referral databases, we searched and reviewed published papers between the years 2000 and 2017 from several sources, such as PubMed, NCBI, ScienceDirect, Elsevier, and ProQuest. The keywords used were combinations of the terms "advanced glycation end products", "carboxymethyl lysine", "diet", and "food". The referral database used for determining CML values in this study was from Hull et al.[7] If no identical food could be found in the database, we used other databases based on the same method i.e. liquid chromatography-tandem-mass spectrometry (LC-MS/MS).[8,12,13] The calculation was done if a food item was not included in these databases.

Food recipes were used in adjustment of AGE content if the food was not in the database but the ingredients of the food were available in the database. Calculation of CML content used data from other foods in the same botanical or zoological genus or family or using foods in one group that were processed using the same cooking method. Calculation of CML content by values of food group was used if there was no similar food item in the referral database with the food of interest. We grouped cereal snacks that was not in the database into sweet and salty snacks, and then used the average CML value of these food groups. We expressed CML values as mg per 100 g edible portion.

Differences in CML value were adjusted for protein content with the equation:

CML value of food of interest = CML value in reference food multiplied by protein value of food of interest divided by protein value of reference food.

$$CML\ value\ of\ food\ of\ interest = \frac{CML\ value\ in\ reference\ food \times protein\ value\ of\ food\ of\ interest}{protein\ value\ of\ reference\ food}$$

Protein values in Indonesian foods were assessed using the IFCT[11] as reference, but if these were not available in the IFCT[11], we used the ASEAN or USDA food composition tables.[14,15] The protein values of the reference foods used the reference database of the corresponding country. For example, foods from the English database[7] were matched with the UK food composition database, while foods from the Dutch database[8] used the online Dutch Food Composition Database. As an illustration, in order to calculate the CML content for "Nile tilapia, boiled", we borrowed the CML content of "cod, poached, boiled" from Hull et al. The protein value of cod was from the UK food composition database with Food-code 16-490, 16-015 and 16-016, while the protein value of "Nile tilapia, boiled" was from the ASEAN FCT with Food-code AAG221. Therefore, the CML content of "Nile tilapia, boiled" per 100 gram was equal to the protein value of "Nile tilapia, boiled" (21.4g) multiplied by the CML content of "cod, poached, boiled" (0.01mg) and then divided by the average protein value of "cod, poached, boiled" (23.9g).

The final food groups that were analyzed in this study were cereals, starchy foods, legumes, meat and poultry, fish, shellfish and shrimps, eggs and milk products. While the processed foods were grouped into four groups, i.e. raw, fried, boiled, and grilled. Foods were assigned to the fried group if the dish was fried or stir-fried, to the boiled group if the food was boiled, steamed, or stewed, and to the grilled group when the type of food processing was grilling. Food groups with low CML content (fruits, vegetables, oils) or those lacking supporting data on CML content (spices and syrups) were not included and analyzed.

Prior to the start of the study, all subjects signed written informed consent. Moreover, this study was approved by Health Research Ethics Committee, Faculty of Medicine, Universitas Indonesia-Dr. Cipto Mangunkusumo Hospital.

Results

There were 117 women from West Sumatera and 118 women from West Java. The median age (mean ± SD) of the women in this study was 37 ± 8 years old and their ages were not statistically significant between the two areas.

The 24-hr food recall showed that 55% of consumption was from carbohydrate, while intake of protein and fat was 13% and 32%, respectively.

We presented 206 CML values, mostly from Indonesian traditional foods. As much as 18% of food matched with the referral database, 54% were obtained from calculations from another food item with the same cooking method, 3% were obtained from recipes, and 25% were obtained from the values of food group.

The highest value of CML content/100g of food was from instant noodles, which contained 3.3 mg CML/100g edible food (Table 1). The CML values of chocolate bars and cereal drinks per 100 edible food were 2.9 mg and 2.6 mg, respectively. The highest median value of CML content based on food groups was from cereals with 0.8 mg per 100 edible food (Figure 2). The CML values in fish were mostly below 1.0 mg CML per 100 g edible food in different kinds of dishes.

Figure 3 shows the contribution of food items to dietary CML in this study. Food items that highly contributed to dietary CML were from cereals (white rice, as a staple food in Indonesia, instant noodles, and boiled plain rice rolls for 19.1%, 15.1%, 6.9%, respectively). Among the protein source, tofu and tempeh also highly contributed to dietary CML. Meanwhile, the consumption of animal-based foods such as fish with frying method has lower contribution to dietary CML if compared to plant-based foods eg. tofu or tempeh.

Food item		**mgCML/ 100 g of food**
Food name, English	**Food name, local**	
Cereals		
Steamed bun	Bapau	0.07
Coconut cakelets	Bandros	0.13
Glutinous rice porridge, boiled	Bubur ketan, rebus	0.13
Rice flour porridge, boiled	Bubur sumsum	0.13
Cakwe, snack, dough, fried	Cakue, goreng	0.13
Tapioca dough, boiled	Cilok, rebus	0.13
Starch dough, fried	Cimol, goreng	0.13
Tapioca dough, fried	Cireng, goreng	0.13
Rice pasta	Kwetiaw	0.13
Filled glutinous rice rolls	Lemper	0.13
Sticky rice dumpling	Leupeut	0.13
Savoury and spicy dish	Seblak	0.13
Chips, from cassava flour, fried	Kerupuk aci, goreng	0.14
Rice crackers, fried	Kerupuk ladu, goreng	0.14
Rice, white, cooked in coconut milk	Nasi uduk	0.19
Vegetable with wheat flour, fried	Bala-bala, goreng	0.2
Fish dumpling, fried	Batagor, goreng	0.2
Tapioca dough with spring roll skin, fried	Cibay, goreng	0.2
Corn rice, cooked	Nasi jagung	0.2
Turmeric rice, steamed	Nasi kuning	0.2
Rice, white, steamed	Nasi putih	0.2
Corn-and-wheat flour, fried	Perkedel jagung, goreng	0.2
Rissole, fried	Risoles, goreng	0.2
Noodle, with meatball	Mie bakso	0.23
Rice vermicelli, boiled	Bihun rebus	0.24
Noodle, with chicken	Mie ayam	0.3
Noodle, raw	Mie basah	0.3
Noodle, yellow, boiled	Mie kuning rebus	0.3
Noodle, white, boiled	Mie putih, rebus	0.3
Macaroni	Makaroni	0.43
Bread, sweet	Roti manis	0.45
White bread	Roti tawar	0.66
Pandanus flavoured cake	Bolu pandan	0.74
Cake, modern	Kue bolu	0.74
Rice vermicelli, fried	Bihun goreng	0.81
Tapioca noodles, fried	Sohun goreng	0.81
Plain rice rolls, boiled	Lontong	0.96
Fried rice	Nasi goreng	0.96
Tapioca crackers, grilled	Opak bakar	0.96
Rice flour with peanut, fried	Rempeyek, goreng	0.96
Doughnuts, fried	Donat, goreng	1.14
Biscuits	Biskuit	1.18
Snack, traditional cake	Bika ambon	1.29
Wheat dough, fried	Kue stik, goreng	1.29

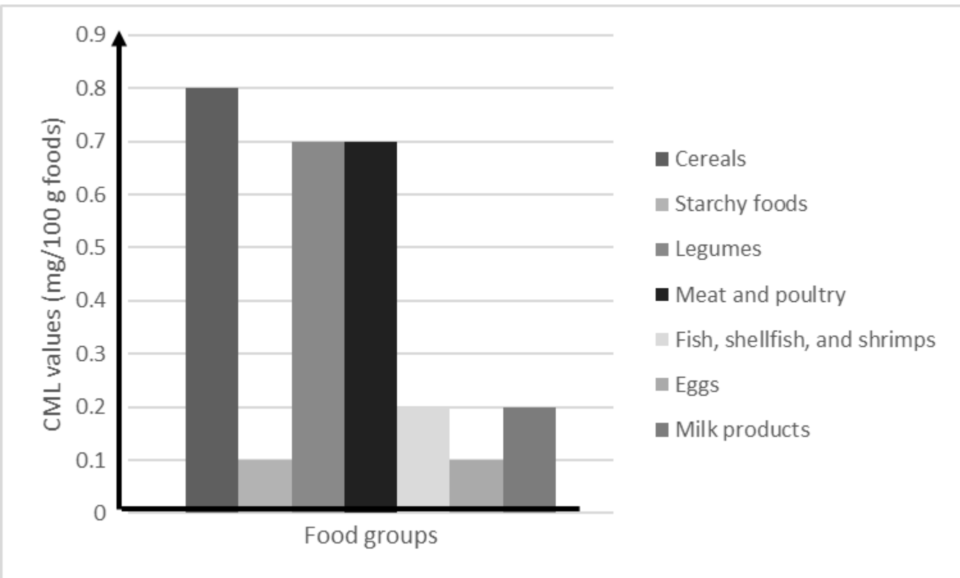
Noodle, fried	Mie goreng	1.44
Rice porridge	Bubur nasi	1.72
Snacks, chiki	Chiki	1.81
Snack, traditional cake, sweet dish	Dodol	1.81
Snack, traditional cake, sweet dishes	Kue apem	1.81
Chocolate sandwich cake	Kue coklat sanwich	1.81
Snack, pinch cake	Kue cubit	1.81
Peanut cookies	Kue kacang	1.81
Layered soft rice flour pudding	Kue lapis	1.81
Snack, traditional cake	Kue mangkok	1.81
Pia cake	Kue pia	1.81
Snack, traditional cake, sweet dish	Kue pukis	1.81
Snack, traditional cake	Kue putu ayu	1.81
Snack, rice flour, tapioca flour, wheat flour with coconut, fried	Kue saroja, goreng	1.81
Snack, traditional cake	Kue talam	1.81
Plain rice snack, boiled	Lopis	1.81
Pancakes with sweet filling	Martabak manis	1.81
Glutinous rice balls	Onde onde	1.81
Snack, soft glutinous rice flour cake, filled with sweet grated coconut.	Papais/menut/bugis	1.81
Popcorn	Popcorn	1.81
Coconut cupcake, steamed	Putu ayu	1.81
Pancake	Serabi	1.81
Cereal drink	Sereal	2.25
Instant noodle, boiled	Mie instant, rebus	3.3
Starchy food		
Potato, boiled	Kentang, rebus	0.01
Cassava, white, boiled	Singkong, rebus	0.01
Potato, boiled	Kentang, rebus	0.01
Taro, boiled	Talas, rebus	0.01
Yam, boiled	Ubi, rebus	0.01
Potato, fried	Kentang, goreng	0.05
Cassava, white, fried	Singkong, goreng	0.05
Potato, fried	Kentang, goreng	0.05
Taro, fried	Talas, goreng	0.05
Yam, fried	Ubi, goreng	0.05
Taro crackers, fried	Keripik talas, goreng	0.14
Cracker, rice and tapioca flour, fried	Kerupuk gendar, goreng	0.14
Chips, cassava, fried	Keripik singkong, goreng	0.16
Cracker, yam, fried	Kerupuk ubi, goreng	0.16
Cracker, cassava, fried	Opak beca, goreng	0.16
Potato fritters	Perkedel	0.17
Legumes		
Soy, ketchup	Kecap	0.01
Kidney beans, boiled	Kacang Merah rebus	0.09
Mungbean porridge, boiled	Bubur kacang hijau, rebus	0.12
Kidney beans, fried	Kacang Merah goreng	0.19
Tofu, boiled	Tahu, rebus	0.44
Stinky bean, boiled	Pete, rebus	0.47
Soy milk	Susu kacang kedelai	0.47
Soy bean paste	Tauco	0.47
Tempeh, boiled	Tempe, rebus	0.47
Stinky bean, fried	Pete, goreng	0.68
Peanut, boiled	Kacang tanah rebus	0.72
Cowpea, boiled	Kacang tolo/tunggak, rebus	0.72
Tofu, filled with vegetables, fried	Gehu/tahu isi, goreng	0.94
Tofu, scrambled	Orak arik tahu	0.94
Tofu, fried	Tahu, goreng	0.94
Tempeh battered with flour and egg, fried	Bala-bala Tempe, goreng	1.00
Tempeh, lightly fried battered	Mendoan tempe/cipe, goreng	1.00
Tempeh, fried	Tempe, goreng	1.00
Fermented peanut press cake, fried	Oncom, goreng	1.10
Peanut, fried	Kacang tanah goreng	1.52
Meat and poultry		
Beef, meat, fried	Daging sapi goreng	0.36
Chicken, meat, breast, boiled	Ayam, dada, rebus	0.38
Chicken, drumstick, grilled	Ayam, paha bawah, rebus	0.38

Chicken, wing, boiled	Ayam sayap rebus	0.38
Chicken, meat, boiled	Daging ayam rebus	0.38
Chicken, meat, breast, grilled	Ayam, dada, bakar	0.40
Chicken, meat, wing, grilled	Ayam sayap bakar	0.40
Chicken, meat, grilled	Daging ayam bakar	0.40
Chicken, meat, breast, fried	Ayam, dada, goreng	0.51
Chicken, drumstick, fried	Ayam, paha bawah, goreng	0.53
Chicken, wing, fried	Ayam sayap goreng	0.53
Chicken, meat, fried	Daging ayam goreng	0.53
Beef, meat, grilled	Daging sapi bakar	0.54
Beef, meat, boiled	Daging sapi rebus	0.67
Meat dumpling, fried	Bakso cuanki, goreng	0.70
Meat balls, fried	Bakso, goreng	0.70
Sausage, fried	Sosis goreng	0.76
Meat dumpling, boiled	Bakso cuanki, rebus	0.83
Meat balls, boiled	Bakso rebus	0.83
Chicken gizzard, fried	Ampela ayam, goreng	0.86
Chicken gizzard, boiled	Ampela ayam, rebus	0.86
Beef tripe, boiled	Babat sapi, rebus	0.86
Beef, knee, boiled	Dengkul sapi rebus	0.86
Chicken, liver, fried	Hati ayam goreng	0.86
Beef, meat adhering to bones, boiled	Tetelan rebus	0.86
Sausage, grilled	Sosis bakar	1.04
Nuggets	Nuget	1.11
Meat ball chips, fried	Basreng	1.81
Fish, shellfish and shrimps		
Pomfret, boiled	Ikan bawal rebus	0.01
Anchovy, boiled	Ikan bilis rebus	0.01
Carp, boiled	Ikan mas rebus	0.01
Tilapia, boiled	Ikan mujahir rebus	0.01
Nile tilapia, boiled	Ikan nila rebus	0.01
Scad, boiled	Ikan sarai rebus	0.01
Java barb, boiled	Ikan tawes rebus	0.01
Snapper, boiled	Kakap rebus	0.01
Mackerel, boiled	Kembung rebus	0.01
Crab, boiled	Kepiting rebus	0.01
Catfish, boiled	Lele rebus	0.01
Mud clam, boiled	Lokan rebus	0.01
Fermented fish, boiled	Peda rebus	0.01
Mackerel tuna, boiled	Tongkol rebus	0.01
Gourami, boiled	Ikan gurame rebus	0.02
Ponyfish, boiled	Ikan maco rebus	0.02
Anchovy, dried, salted, boiled	Ikan teri rebus	0.02
Shrimp, boiled	Udang rebus	0.02
Carp, grilled	Ikan mas bakar	0.04
Shrimp, grilled	Udang bakar	0.06
Shrimp, fried	Udang goreng	0.06
Shrimp paste, fermented	Terasi	0.11
Fish belt, fried	Ikan beledang goreng	0.13
Snack, fish-and-wheat flour in vinegar sauce, fried	Pempek, goreng	0.13
Anchovy, fried	Ikan bilis goreng	0.15
Carp, fried	Ikan mas goreng	0.18
Fish crackers	Kerupuk ikan	0.18
Scad, fried	Ikan sarai goreng	0.20
Mackerel, fried	Kembung goreng	0.20
Milkfish, processed, fried	Bandeng pindang goreng	0.27
Grouper, fried	Ikan kerapu goreng	0.29
Eel, fried	Belut goreng	0.30
Squid, fried	Cumi goreng	0.33
Mackerel tuna, fried	Tongkol goreng	0.34
Catfish, fried	Lele goreng	0.45
Fermented fish, grilled	Peda bakar	0.45
Fermented fish, fried	Peda goreng	0.45
Pomfret, fried	Ikan bawal goreng	0.51
Fish nugget, fried	Nugget ikan, goreng	0.52
Fish cake, grilled	Otak-otak	0.52
Fish finger, fried	Sala ikan goreng	0.52
Fish, fried	Burayak(anak ikan) goreng	0.75
Gourami, fried	Ikan gurame goreng	0.75

Fish, meatball, boiled	Bakso ikan rebus	0.83
Fish, three spot gourami, salted, fried	Asin ikan sepat goreng	0.86
Fish, sea catfish, salted, dried, fried	Asin jambal roti goreng	0.86
Fish, salted, fried	Ikan asin goreng	0.86
Ponyfish, fried	Ikan maco goreng	0.86
Anchovy, dried, salted, fried	Ikan teri goreng	0.86
Tilapia, grilled	Ikan mujahir bakar	1.12
Nile tilapia, grilled	Ikan nila bakar	1.12
Tilapia, fried	Ikan mujahir goreng	1.13
Nile tilapia, fried	Ikan nila goreng	1.13
Sardine, canned, in tomato sauce, broiled	Sarden goreng	1.14
Fish cake, fried	Ikan kere goreng	1.19
Eggs		
Eggs, chicken, raw	Telur ayam mentah	0.05
Eggs, duck, boiled	Telur bebek rebus	0.07
Eggs, quail, boiled	Telur puyuh rebus	0.08
Eggs, chicken, boiled	Telur ayam rebus	0.09
Eggs, carp, freshwater, boiled	Telur ikan mas rebus	0.13
Eggs, quail, fried	Telur puyuh goreng	0.44
Eggs, duck, fried	Telur bebek goreng	0.58
Eggs, chicken, fried	Telur ayam goreng	0.63
Milk products		
Instant coffee	Kopi instant	0.01
Iced yogurt	Es yogurt	0.03
Coffee with sweet condensed milk	Kopi susu dengan susu kental manis	0.04
Full cream milk	Fullcream	0.05
Fresh milk	Susu segar	0.05
Ultra-high-temperature pasteurized milk	Susu UHT	0.22
Powdered milk	Susu bubuk	0.44
Ice cream	Eskrim	0.50
Sweet condensed milk	Susu kental manis	0.66
Cheese	Keju	1.18
Chocolate bars	Coklat	2.92

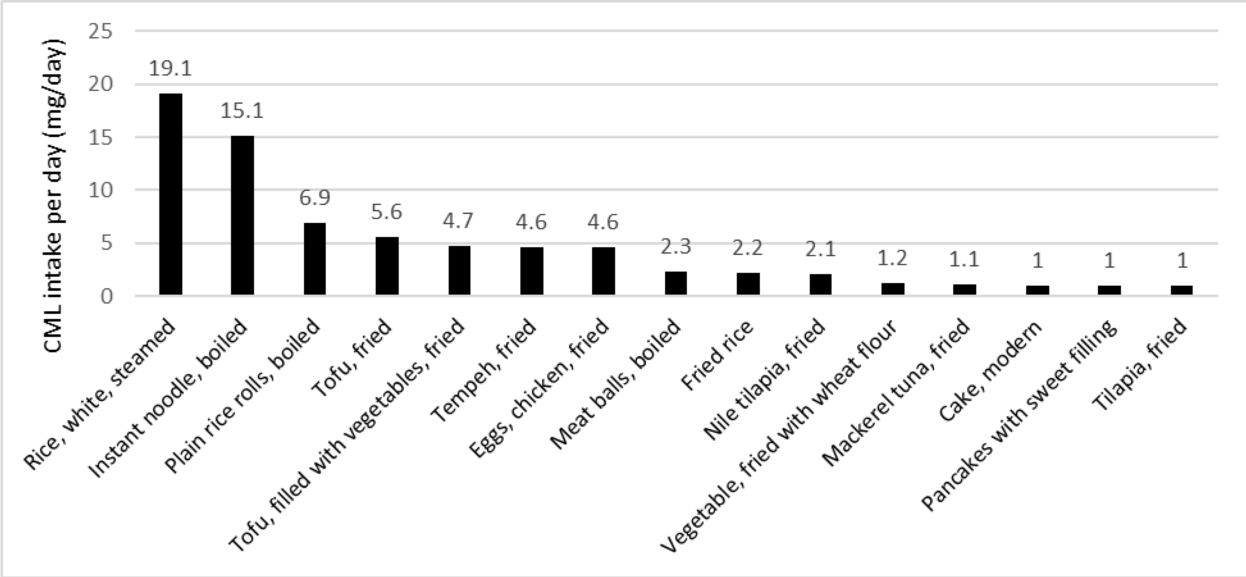
Note: CML: carboxymethyl lysine

Table 1. Database carboxymethyl lysine content of foods consumed by Indonesian women.



Note: CML: carboxymethyl lysine

Figure 2. Median values of CML content of food consumed by 235 Indonesian women based on food groups



Abbreviations: CML: carboxymethyl lysine

Figure 3. Food items with major contributions to dietary carboxymethyl lysine in 235 Indonesian women

Discussion

We developed a database that described the values of CML in predominantly Indonesian foods and calculated the dietary CML. Instant noodles had the highest CML value, followed by chocolate bars and cereal drinks. The food group with the highest values was the cereal group, while the lowest was starchy foods and shellfish and shrimps.

If based on food groups, Hull et al.[7] showed that cereals had the highest CML while Scheijen et al.[8] showed that high-heat processed nut or grain products and canned meats had the highest CML value. Our study is consistent with Hull et al.[7], in that the highest CML was from the cereal group. There are different kinds of fish and processing styles between English or European journal and our study. They mostly analyzed deep ocean fish like tuna or salmon with canned or smoked processing, while we mostly analyzed shallow ocean fish like anchovy with salting and drying in the sun for several days as its processing style.

The group of cereals (eg rice, noodles, macaroni, porridges) had higher CML values if compared to starchy foods (eg. potatoes and tubers). Data from IFCT[11] showed that per 100 g edible food, the group of cereals had higher calorie, protein, and carbohydrate content if compared to starchy foods. This could influence the difference in CML content between these two food groups. The median CML values of the meat and poultry group were higher than those of the fish group. Omega-3 fatty acids in fish may possibly decrease the CML content. This study found that steamed white rice and instant noodles ranked first and second, respectively, as the highest contributors to dietary CML, possibly because white rice is the staple food in Indonesia.

A strength of the present study was the use the protein adjustment in calculating the CML values. Importantly, the food recall was taken from two different provinces that represented diets with animal- and plant-dominant foods that could provide the variety and variability of food sources with CML content in the database. In constructing the database, we encountered several challenges due to the many kinds of foods, especially in the group of cereals. We also found some difficulties: (1) many traditional snacks in Indonesia were different from those in European countries in terms of ingredients and preparation methods. (2) In IFCT, some foods presented their protein values in raw form.

There are several limitations in our study. Firstly, the CML values were calculated from CML values in published journal articles, which would result in under- or overestimation of dietary CML in the subject population. To minimize error in the CML calculation, we have tried to adjust CML values in different countries by adjusting the protein value in foods. Secondly, differences in the types of food and preparation methods between the references and our study may have resulted in overestimation of the dietary CML values which were calculated with the inclusion of the average CML value of salty or sweet snacks. To minimize recall bias from the respondents or the inter-interviewers observation bias, we trained the interviewers with multiple-pass interviewing technique, and interviewers utilized the book of food dish photographs from “Survey of Individual Food Consumption 2014”[16] to provide visual aid in estimating the portion size consumed. The inclusion of all females in this study may have advantages in providing better information on food variation and processing method. However, it may also lead to certain type or diverse amount of consumption of the major foods than males, that may lead to different amounts of dietary CML. Further studies involving the direct determination of the CML values in Indonesian foods are needed to minimize over- or under-estimation. The database should be updated annually by uploading new foods or revising the CML values. Determination of actual CML values in Indonesian foods will improve the CML database. In public health practice, the database could be used to recommend low-CML food to reduce the risk of NCDs.

Conclusions

This developed database can be used for estimating dietary CML in Indonesian people and facilitating studies involving the assessment of dietary and plasma CML concentration by liquid chromatography-tandem-mass spectrometry (LC-MS/MS). The database should be updated by uploading new foods, revising the CML values, or conducting direct analyses.

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Conflict of Interest

The authors declare that there is no conflict of interest.

Author’s Contributions

RA was the principal investigator, wrote the main study and obtained the research grant. RA and PBL conceived and designed this current study. RA and her research team conducted the primary study and collected dietary data. PBL listed the food consumed, calculated the CML value in the foods, and analyzed dietary carboxymethyl lysine. PBL and RA drafted the manuscript, and together with RD, interpreted the data and revised the manuscript. All authors read and approved the final manuscript. RA coordinated the final submission of the manuscript.

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