Trace Element Content and Food Safety of Traditional Crackers (*Kerupuk*) Collected from Java Island, Indonesia

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Abstract: *In this study, trace elements in crackers were determined using Instrumental Neutron Activation Analysis (INAA) to assess their intake, food safety, and health contribution. The 62 samples of crackers were collected and purchased from local markets in five provinces of Java during 2013–2014. The validation method was performed using SRM Wheat Flour 1567a, with 80–110% accuracy (% recovery) and precision less than 10% (% RSD). The concentration of trace elements such as Cr, Co, Fe, and Zn was analyzed and found in the range of 0.03–1.4, 0.01–0.32, 14.49–85.70, 0.15–17.26 µg/g, respectively. Daily intake of elements in crackers contributes less than 1% to Recommended Dietary Allowances (RDA). Based on food safety evaluation through the calculation of Hazard Quotient, the value of Cr, Co, Fe, and Zn is less than 1, indicating that the crackers are safe for consumption and do not possess non-carcinogenic health risks due to heavy metals content. Therefore, the crackers in all Java provinces meet the current standards and are safe for consumption.*

Keywords: *crackers; trace element; intake; food safety; INAA*

■ INTRODUCTION

Crackers are a popular snack in several Southeast Asian countries, including Indonesia. They are also known as keropok in Malaysia, keawkrab pla in Thailand, and banh phongtom in Vietnam [1]. Indonesians commonly consume crackers as supplementary food or snacks, particularly those living on Java Island. Traditionally, crackers are made of gelatinizing starch. Ingredients of cracker dough include tapioca flour, salt, sugar, monosodium glutamate, and water [2-4]. Cracker drying is a technique used to preserve the freshness of crackers during storage. The method is traditional for food preservation in which the water content is reduced to a safe level to prevent the growth of bacteria, yeast, and fungi [5]. Since crackers are still produced on a small scale using home-based methods, sun-drying usually occurs in people's yards. Crackers are dried in the sun, but this method takes longer, has a higher moisture content, and is unhygienic. Moreover, there are several months of the rainy season in Java Island (due to the transition period from the monsoon winds). The meteorological conditions affect the drying process, which involves the cleanliness and hygiene of the produced crackers [6].

In addition, foods containing diseases caused by microorganisms and other food contaminants pose a serious health threat in developing and developed countries. World Health Organization (WHO) estimates that less than 10% of cases of congenital disease have been reported, compared to less than 1% of cases in developing countries [7]. This study conducts a food safety risk assessment to ensure customers' safety. According to Jiang et al., nutrients consist of necessary and non-essential components in the human body [8]. The content of inorganic substances in food is essential, such as minerals found in all tissues and body fluids needed to maintain several physicochemical processes in the body. Mineral nutrients classify into primary, secondary, micro, or trace elements needed by humans. Deficiency and excess of these minerals can cause health problems [9]. Some trace elements such as Cr, Co, Fe,

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and Zn, present in sufficient concentrations, play an essential role in ensuring consistent physiological activities. On the other hand, excessive intake of crucial elements with different biochemical functions has harmful effects on the body [8].

Chromium (Cr) is an important mineral in the body since it stimulates insulin action and is a major hormone in the metabolism of carbs (which helps to regulate blood sugar levels), lipids (which helps to prevent heart disease), and protein (fertility and fetal growth) [10]. Low chromium concentrations can be carried down through vegetables or plant products. According to Salau and Hasan, most plant meals, such as white flour and sugar, have been refined to have minimum Cr content [11].

Cobalt (Co) is an essential element present in considerable concentrations in bones, kidneys, and liver and found throughout all body tissues in a normal distribution. Cobalt is also essential for red blood cell development and is an active vitamin B12 to make cobalamin, which is important for nerve function. Heart failure, goiter, hypothyroidism, vomiting, and diarrhea are all symptoms of cobalt insufficiency, commonly known as vitamin B12 deficiency [12].

Recommended Dietary Allowance (RDA) for iron (Fe) in adult males is 8 mg/day, whereas the RDA for adult females is 18 mg/day; the value of Fe contribution in males is higher than in females. Due to Fe loss during the menstrual month, Fe in adult females is lower than in men. Fe is found in hemoglobin, myoglobin, ferritin, hemosiderin, and cytochrome enzymes. Hemoglobin is a protein that carries oxygen to all body tissues. A lack of iron in the blood causes anemia, poor cognitive development, and impaired immune function[13-14].

Zinc (Zn) is an essential element of biochemical activities in the body, such as immune system function, protein synthesis, nucleic acid synthesis, muscular contraction, and insulin production. People with diabetes frequently suffer from zinc insufficiency. Furthermore, Zn deficiency causes malabsorption syndromes, liver and renal illness, and inflammatory bowel disease in children, inducing growth retardation. Acrodermatitis enteropathica is a hereditary disorder affecting zinc absorption and transport in the intestines [15-16].

Nasreddine et al. [16] conducted a risk assessment procedure for toxic trace elements in the food to determine the influence of intake on food safety in calculating the level of information consumed every day. Risk assessment for nutrition is defined by the association between excessive consumption toxicity and the relationship between excessive intake and nutritional deficiency. Dietary References Intake (DRI), which includes Recommended Daily Intake, has assisted medical institutions in the food and nutrition sector in the United States overcome nutritional deficiencies and trace element toxicity. Reference values for nutrition and toxicity utilizing as benchmarks in food risk assessment [16]. Due to low element content in crackers, a high precision and sensitivity method is required, such as Instrumental Neutron Activation Analysis (INAA). INAA method is qualitative and quantitative for evaluating elements in samples, has a low detection limit, and determines elements in small amounts, such as trace elements in food samples [14]. This project aims to determine the concentration of elements (Cr, Co, Fe, and Zn) present in crackers, estimate the daily nutrient intake in crackers, and assess potential health risks to determine food safety consumed by Javanese.

■ EXPERIMENTAL SECTION

Sample Collection

The 62 samples were collected and purchased from local markets in five provinces of Java during 2013–2014. Five provinces are West Java (n = 8), Central Java (n = 23), East Java (n = 23), Special Capital Region of Jakarta (n = 5), Special Region of Yogyakarta (n = 3). The sampling location can be seen in Fig. 1-3. Java is a very dense island with more than half of Indonesia's population or about 160 million countries, and 241 million people reside.

The ingredients for making *kerupuk* are starch or sago flour and spices (pepper, garlic, salt, sugar, monosodium glutamate). Crackers are manufactured on a small and large scale. The quality of cracker products is inconsistent depending on the type of raw material and the difference in the cracker manufacturing process [17]. According to Mubarok's study [18], the consumption of

Fig 1. Sampling location in West Java and Special Capital Region of Jakarta (source: google earth)

Fig 2. Sampling location in Central Java and Special Region of Yogyakarta (source: google earth)

Fig 3. Sampling location in East Java (source: google earth)

Indonesian people per capita of crackers in 2003 was 0.166 ounces/month. On the other hand, based on the National Bureau of Statistics, the average consumption of crackers data was 0.093 ounces/week in 2015 [19].

Sample Preparation and Standards

The Materials used in this activity include Standard Reference Material (SRM), Wheat Flour 1567a from the National Institute of Standards and Technology, and demineralized water (> 18 MΩ cm²). Other materials used in this activity are a standard multi-elemental E-Merck tritisol solution and a polyethylene vial.

The crackers were weighted and then mashed in an agate mortar for homogenization. The sample was then weighed again and placed in the oven. Moisture content was determined by drying the sample in a forced air oven at 100 °C for 8 h [4]. A total of 60 mg of cracker samples weighed with analytical balance (AG 245 Mettler Toledo Ltd., Melbourne, Australia) were inserted into a polyethylene vial of 0.3 mL and then sealed with heating.

The standard solution ICP multi-element VI E-Merck was prepared with elements concentrations of Cr, Co, Fe, and Zn, which were 1, 1, 49.9, and 10 μg, respectively. A total of 100 μL of the standard solution was piped and placed into a 0.3 mL polyethylene vial, dried with an infra-red lamp, then sealed with heating. Validation of the NAA method using SRM NIST Wheat Flour 1567a was done by weighing as much as 60 mg into a polyethylene vial of 0.3 mL, then sealed by heating.

Irradiation, Counting, and Data Analysis

Samples, NIST Wheat Flour reference material (SRM), and multi-element ICP standards were irradiated for 2 h using thermal neutron sources with a neutron flux of 10^{13}n.cm^{-2}.s^{-1} in rabbit systems at the G.A. Siwabessy multipurpose reactor facility in Serpong. Sample decay was performed for one month, then the sample, SRM, and ICP standards were measured for ± 50000 sec using Gamma spectrometer, Canberra USA, and multi-channel Analyzer (MCA). The spectrum of ^{51}Cr, ^{60}Co, ^{59}Fe, and ^{65}Zn have gamma energy characteristics 320.08, 1332.50, 1099.25, 1115.52 keV, respectively, and determined by Genie 2000 software.

The calculation of the concentration of this element was carried out using a comparative method, namely comparing the concentration of elements in the sample with a standard with a known concentration. Elemental content in the sample was calculated following the formula. In this method, standard ICP (W_{std}) and sample (W_{spl}) have a known value weight concentration, are simultaneously irradiated, and measured under the same conditions. The concentration of elements in the sample was determined by comparing the activity between the sample ($A0_{spl}$) and the ICP standard ($A0_{std}$) in the formula [20]:

$$C = \frac{A0_{spl}}{A0_{std}} \times \frac{W_{std}}{W_{spl}} \qquad (1)$$

where $A0_{spl}$: Activity of sample (cps), $A0_{std}$: Activity of standard (cps), W_{std}: Weight of standard (μg), W_{spl}: Weight of sample (g), C: Concentration of element (μg/g).

Quality Assurance of the INAA Method

Standard reference material is used to assess data validation quality control. The SRM result value measured is compared to the value of the certificate whose concentration is known. Accuracy and precision were evaluated by calculating % recovery and % RSD (Relative Standard Deviation). Accuracy measures the degree of agreement between the concentration of the determination result and the actual concentration of the element. Accuracy can be defined as a measure of a result that is close to the true value, while precision can be expressed as a measure of the repeatability and reproducibility of results. Accuracy can be defined as %Rec. Recovery is a comparison of the measurement results with the certificate value and is expressed by the following formula:

$$\%Rec = \frac{X_{test}}{X_{cert}} \times 100\% \qquad (2)$$

with X_{test} is the result of the analysis value, and X_{cert} is the certificate value.

Precision is a measure that indicates the degree of conformity between individual test results, measured through the dissemination of individual results from the average. Precision tests are counted as standard

deviations or relative standard deviations (RSD) obtained through formula (3) [11] with SD_{test} is the standard deviation testing, $mean_{test}$ is the average test scores, and RSD is relative standard deviation:

$$RSD = \frac{SD_{test}}{Mean_{test}} \times 100\% \tag{3}$$

Estimated Daily Intake of Crackers and Their Contribution to Recommended Dietary Allowance (RDA)

The daily intake of each element depends on the concentration of elements in the diet and the intake consumed daily. Estimated daily intake is calculated based on the following formula [21]:

$$EDI = C \, metal \times D \, food \, intake \tag{4}$$

EDI is the daily intake estimation of elements in mg/day or μg/day of each element. C metal is the concentration of elements in food samples (mg/kg wet weight), whereas D food intake is the average amount consumed per day [14]. In this activity, the average consumption per capita of crackers in Indonesia, based on the National Statistics Agency data, was 0.093 ounces/week; therefore, the average daily consumption of crackers consumed was 1.33 g/day [19].

Risk Assessment

The term human health risk assessment refers to determining the carcinogenic and non-carcinogenic effects of chemicals that enter the body. The HI (Hazard Index) is the sum of each metal's Hazard Quotient (HQ), estimating various heavy metals' overall potential non-carcinogenic health consequences in diets. Quantifying non-cancerous health implications, HQ is used, followed by HI [22]. A formula can be used to calculate the daily intake of each element (g/kg bw/day):

$$Daily \, intake = \frac{\sum C \times I}{Bw} \tag{5}$$

$$Hazard \, Quotient = \frac{Daily \, intake}{TDI} \tag{6}$$

where C: concentration of element (μg/g), I: the average consumption rate (g/day) of Indonesians for crackers of 1.33 g/day, Bw: the average body weight of Indonesian adults, as 60 kg.

By comparing daily intake with Tolerable Daily Intake (TDI), Hazard Quotient (HQ) can be calculated (Formula 6). TDI is the value of a daily intake tolerance approach for all harmful compounds that humans are exposed to daily without causing harm [23].

■ RESULTS AND DISCUSSION

Quality Control and Assurance

In this activity, the method was validated by assessing the accuracy and precision of the results using SRM NIST 1567a Wheat Flour. SRM used has a similar matrix and was determined using the same measurement settings as the sample. The results of the determination of trace elements in SRM are shown in Table 1. The table shows a good agreement with the certificate. The precision values characterized by the percentage value RSD were in the range of 4–6%, while the accuracy values described by the percentage recovery were in the field of 99–101%. According to the Association of Official Agricultural Chemists (AOAC) International Guidelines, analytical accuracy and precision are acceptable [24]. Thus, the elemental analysis results in SRM NIST 1567a Wheat Flour have good accuracy and precision. Hence, the analytical method used is valid, and the data obtained can be trusted.

Previously, the method validation using SRM WF 1567a to determine selenium in tempeh using the INAA technique was carried out by Kuniawati et al. [20]. Another researcher, Syahfitri et al., analyzed the trace element content in tofu with INAA using SRM WF 1567a

Table 1. Determination of quality control using SRM NIST 1567a wheat flour

| Element | SRM NIST Wheat Flour 1567a | | | | Acceptable | |
	Result (μg/g)	Certified value (μg/g)	Accuracy (% recovery)	Precision (% RSD)	Accuracy range (% recovery)	Precision (% RSD)
Co	0.006	0.006	100	6	80–110	5.66
Fe	14.2±1.63	14.1±0.5	101	4	80–110	4.00
Zn	11.5±0.23	11.6±0.4	99	4	80–110	4.00

to validate the method [25]. Meanwhile, the validation of the technique with other SRM WF was carried out by Kurniawati et al. in selected trace elements of cassava [26]. According to research conducted by Pompa et al., SRM Wheat Flour 1567b NIST flour was used and treated the same way as the analyzed test samples for quality control (accuracy and precision); in Pb and Hg recovery study, SRM was spiked to 0.020 ppm [27]. From several studies that have been carried out, SRM WF 1567a can be used to validate the INAA method, and the result showed good agreement and was acceptable for accuracy and precision values.

Element Characterization in Traditional Crackers (*Kerupuk*)

In analytical techniques, determining a food sample's moisture content or water content is a crucial first step. INAA technique analyzes solid and dry samples. Therefore, the water content of cracker samples must be determined [20]. The water content of crackers in this activity was 3.12–16.43%, with an average of 6.5 ± 2.16%. According to Indonesian National Standards, the moisture content of crackers is 12%. In this study, the water content of crackers showed no significant differences from the water content allowed by Indonesian National Standards [28]. The dry weight was carried out to quantify the number of elements present in crackers. Element concentrations are converted to wet weight by measuring the water content in each sample to obtain daily consumption recommended levels. According to a recent study by Suseno et al., water content is controlled by various factors, including methods and product quality. The water content in a product can affect its resistance to microbial and enzymatic activities and be harmful [4].

The determination of Cr, Co, Fe, and Zn elements in crackers from Java Island can be seen in Table 2. The results showed the concentration of cracker samples followed the order Fe > Zn > Cr > Co. The average concentration of each element in crackers was multiplied by the amount of crackers consumed by Indonesians to calculate daily consumption. According to food consumption data, the average cracker consumed is 1.33 g/day [19]. Estimated daily trace element intake was then calculated and compared to the recommended

dietary allowance (RDA). RDA is a number that represents the average daily requirement for nutrients for all people of a certain age, gender, degree of physical activity, and physiological circumstances. As a benchmark for determining the adequacy of daily intake, RDA meets the dietary requirements of (97–98%) of healthy people [11,22]. Discussion of results obtained as well as comparison of data reported in other studies on the concentration of elements in crackers are as follows:

The highest concentration of Cr in a crackers sample cracker was 0.46 µg/g in Central Java, and the lowest was 0.06 µg/g in the Special Capital Region of Jakarta, as seen in Table 2 and Fig. 4. Previous studies by Salau and Hasan compared these found the amount of Cr in crackers was 0.55 µg/g, which seems similar to the concentration found in this study [11]. However, the average concentration of Cr in West Java and the Special Region of Yogyakarta are lower than crackers in Malaysian studies. The estimated daily intake of trace elements in crackers and their contribution to the nutritional adequacy rate are shown in Table 3. The chromium estimated daily consumption of 0.47 µg/day resulted in RDA values for males and females being 0.001%, respectively.

Table 2 and Fig. 5 present the data of cobalt concentrations in crackers. East Java and the Special Capital Region of Jakarta have similar cobalt values of 0.14 and 0.11 µg/g, respectively. Central Java and the 0.09 µg/g, as shown in Table 2. West Java has the lowest concentration of Co, which is 0.07 µg/g. Cobalt concentration in crackers was also compared to the Malaysian study and was found to have a value of 0.17 µg/g, which is similar to East Java in this report's results [11]. Meanwhile, West Java, Central Java, and the Special Region of Yogyakarta have lower results than Malaysian studies. Due to there being no RDA for cobalt, the value is determined from the Upper-Level Intake (UL).

In this activity, the determination of iron concentration in crackers is given in Table 2 and shown in Fig. 6. Central Java has the highest Fe concentration of 52.3 µg/g, while the lowest concentration of Fe in crackers was found in the Special Region of Yogyakarta.

Table 2. The concentration of the elements in *kerupuk* from Java Island (μg/g)

| Province	Concentration (μg/g)							
	Cr		Co		Fe		Zn	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
West Java	0.11–0.35	0.19±0.03	0.06–0.20	0.07±0.004	29.94–62.18	42.81±2.98	1.78–17.26	5.01±0.2
Central Java	0.10–1.40	0.46±0.04	0.01–0.32	0.09±0.004	20.93–85.70	52.3±3.05	0.15–16.06	5.02±0.2
East Java	0.06–1.06	0.34±0.07	0.01–0.29	0.14±0.01	14.49–84.59	48.72±4.11	0.51–12.07	4±0.26
Special Capital Region of Jakarta*	0.03–0.09	0.06±0.04	0.10–0.13	0.11±0.01	32.55–60.38	45.03±4.70	3.22–7.48	5.34±0.24
Special Region of Yogyakarta	0.09–0.20	0.13±0.03	0.07–0.10	0.09±0.004	20.62–45.51	33.96±3.04	1.98–4.05	3.1±0.13

*Kurniawati et al. [29]
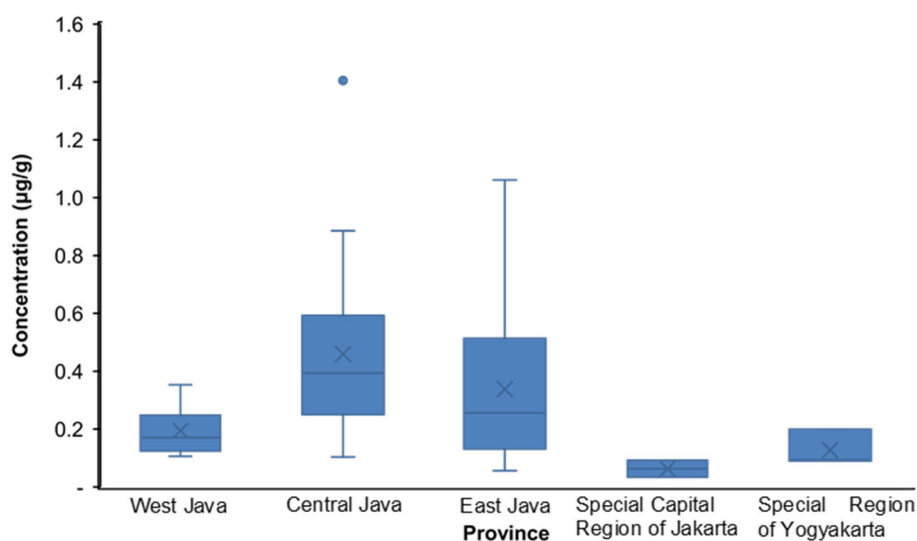
Fig 4. The concentration of chromium in crackers from Java Island
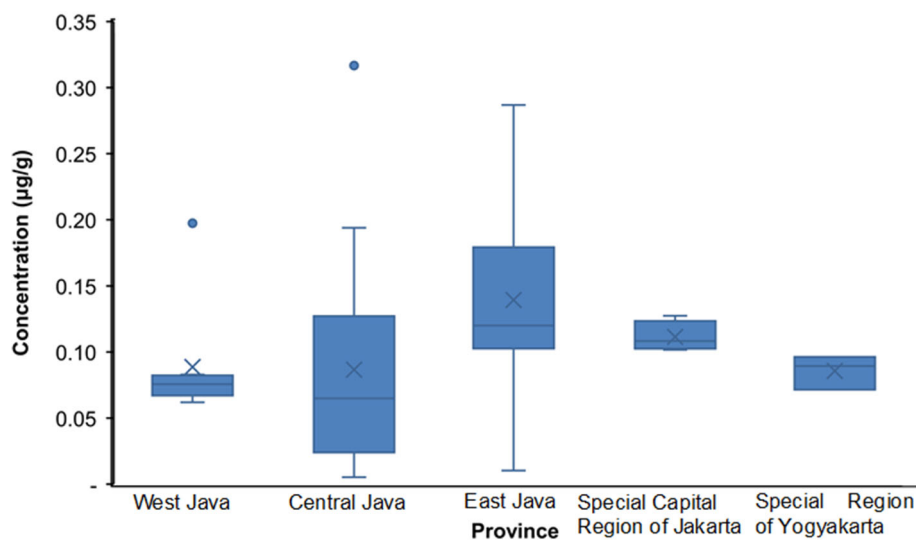
Fig 5. The concentration of cobalt in crackers from Java Island

Fig. 6 showed that West Java and the Special Capital Region of Jakarta have similar concentrations, i.e., 42.81 and 45.03, respectively. In a previous study in Malaysia reported by Salau and Hasan, the concentration of trace elements in Lekor crackers measurement are similar in composition to the crackers in this study. The Fe
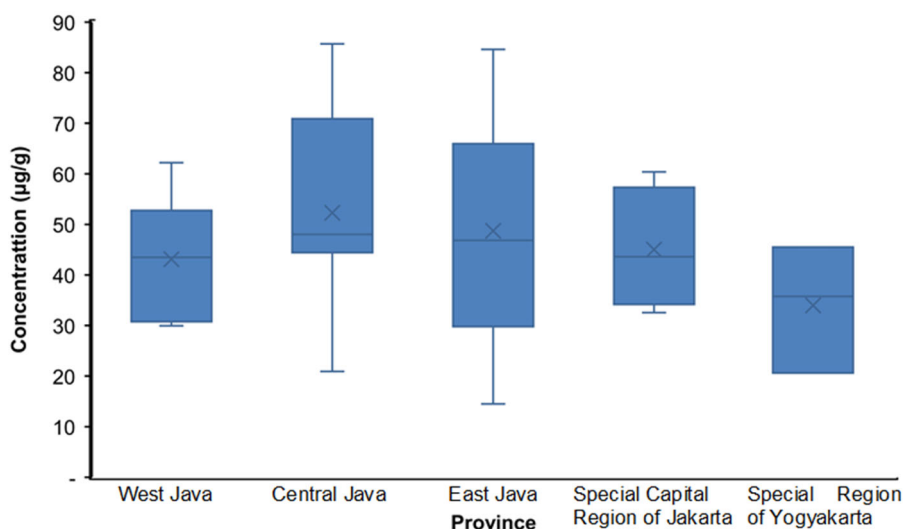
Fig 6. The concentration of iron in crackers from Java Island

concentration of Lekor crackers was 0.063 μg/g [30]. The Fe value of Lekor crackers was lower than in this study. Iron is the most prevalent element in the human body. Fe's estimated daily intake value is 59.4 μg/day, with RDA contribution values for males and females being 0.33 and 0.74%, respectively, as seen in Table 3.

Determination of Zink content in crackers is shown in Fig. 7 and given in Table 2. Zn concentrations in West Java, Central Java, and the Special Capital Region of Jakarta have similar concentrations, i.e., 5.01, 5.02, and 5.34 μg/g, respectively; these are the highest concentrations of Zn in Java. The lowest concentration is in the Special Region of Yogyakarta. This result is higher than in previous studies conducted by Salau and Hassan was 0.012 μg/μg [30]. Zn has estimated daily intakes were 5.90 μg/day and provided less than 0.1% of RDA.

Starch is the main ingredient for making crackers and plays an essential role in determining the quality of crackers. Previous research by Liu Q., and Liu K., stated that starch is extensively used as a thickener, stabilizer, gelling, gelling, binding, or water-retaining agent for numerous meals products [31]. Commercial crackers are manufactured with flour that contains starch, mainly in the form of amylose and pectin. The composition and quality of various types of starch derived from plant products will significantly impact trace element content in crackers. Cassava and sago starches are processed into flour. Therefore, the composition and quality of various types of starch obtained from plant products will influence the elemental content of crackers in several parts of Java Island. Consequently, soil conditions and planting methods significantly impact cracker elemental composition. Organic matter in starch, soil conditions, pH, and chemical inputs, including fertilizers and insecticides, all affect the element composition in the sample [20,32].

Related to RDA values for these trace elements in crackers were not contributed significantly (< 1%). Taewee, T.K., conducted previous research that crackers are considered healthy foods, including carbohydrates and protein. However, the concentration of vitamins and micronutrients has restrictions influenced by high frying temperatures [32].

Risk Assessment

A safety risk assessment is carried out to ensure the safety of products consumed by the public [12]. According to the World Health Organization, food safety is a science that deals with the preparation, handling, and storage of food and beverages to keep them free of physical, chemical, and biological contaminants. The purpose is to prevent food or drinks from being contaminated and limit the risk of foodborne illnesses[23,31]. Mostly, trace elements are essential micronutrients, such as Cr, Co, Fe, and Zn. On the other hand, these trace elements are considered heavy metals

Table 3. The estimation of daily nutrient intake (EDI) and contribution to RDA

Element	Mean (μg/g)	Consumption rate (g/day) [19]	EDI (μg/day)	RDA (%) Female	Male
Cr	0.24	1.33	0.31	0.001	0.001
Co	0.10	1.33	0.14	0.690	0.690
Fe	44.63	1.33	59.4	0.330	0.740
Zn	4.44	1.33	5.90	0.074	0.054
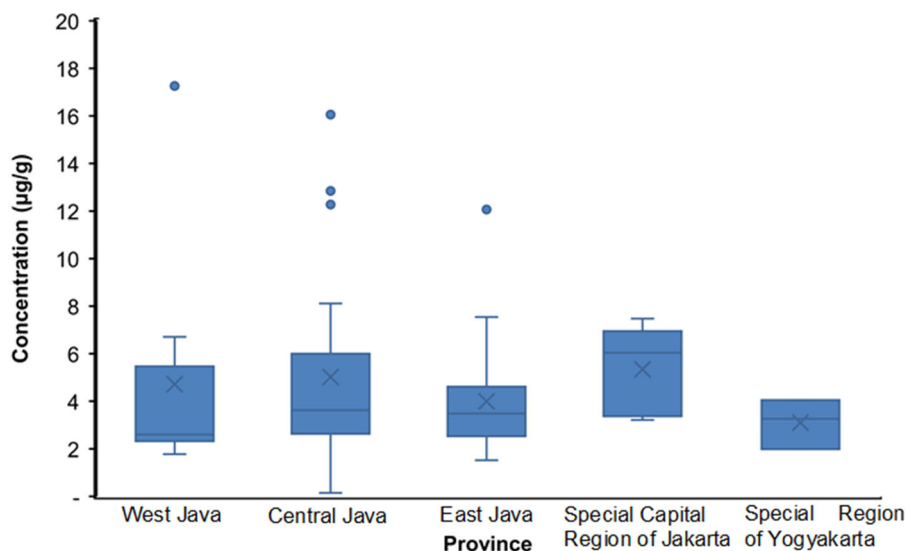
Fig 7. The concentration of zinc in crackers from Java Island

and potentially, such as Cr and Co, harmful if their concentration in the body exceeds a certain level, causing health problems.

Table 4 showed the hazard quotient values in a trace element Cr, Co, Fe, and Zn were 0.01; 0.002; 0.98; 0.09, respectively. Therefore, the hazard quotient for cracker samples from cities/districts on Java Island is less than 1 (HQ < 1). Trace elements Cr, Co, Fe, and Zn, found in crackers, are safe to consume and present no health hazards. It can be seen in Table 4 that the summary of the Hazard Index was 0.31. The concentration of elements in the HQ is measured as a Hazard Index with a value less than one (HI < 1) overall. These results indicate that the intake of crackers consumed by the population still reaches an acceptable level for the four basic parameters. Health risk estimation showed that the consumption of crackers is safe for the population if no more than two pieces are consumed per day, with an average per capita consumption of 1.33 g/day, based on statistical data on Indonesian food consumption in 2015 [19]. However, the

Table 4. Health risk assessment of trace elements in crackers

Element	TDI (mg/day)	Daily intake (mg/day)	HQ	HI
Cr	0.2*	0.01	0.026	
Co	0.02*	0.002	0.115	Σ 0.31 < 1
Fe	6**	0.98	0.165	
Zn	6.8**	0.09	0.002	

*Mulyaningsih et al. [13]
**Al-Fartusie and Mohssan [33]

HI number may increase if the crackers consumed exceed the recommended cracker consumption limit.

Toxic substances include biological (particularly pathogenic bacteria), chemical, and other (physical) toxic substances or pose a risk to human health. Healthy and safe food consumption are essential for improving public health. This trace element content of crackers is safe for consumption since fresh or processed food contains at least illegal and toxic chemical residues [34-36].

According to WHO, 70% of the world's 1.5 billion people are affected by foodborne illness. The model of a single agency, as found in the United States under the name of the US Food and Drug Administration (US FDA) or in China under the name of the China FDA, can serve as a model or reference for a food control system under the social, cultural and geographical conditions in Indonesia [36]. Therefore, investigating trace elements in crackers as a first step in determining the adequacy and safety of food consumed by the urban Javanese population regarding the aspects under study will serve as a foundation for future monitoring studies.

■ CONCLUSION

Assessment of trace element content in crackers widely consumed by local Javanese people has been carried out. A total of four trace elements (Cr, Co, Fe, and Zn) were determined in the 62 samples collected and purchased from local markets in five provinces of Java during 2013–2014. It was found that the concentration of elements in crackers from Java Island follows the order of Fe > Zn > Cr > Co. The highest levels of Fe were also found in Central Java and East Java, while the highest levels of Zn concentration were in West Java. East and Central Java Province have the highest Cr content, while the highest Co content was found in Central Java. RDA value was not significantly contributed by the daily intake of these elements in crackers. The results of this study have confirmed that the carcinogenic and non-carcinogenic trace elements are indicated by the Hazard Quotient (HQ) and the hazard index value. Both have less than 1, which means trace elements in consumed crackers are still within the permissible value. These results show that the intake of crackers is safe for the population if no more than three pieces are consumed per day, with an average per capita consumption of 1.33 g/day. Overall, the health risks assessment indicates crackers consumed by Java Island residents are safe and meet specific food safety requirements. Further study related to the potential health risks of trace elements such as Pb, As, Cd, Cu, and Se from crackers needs to be done for more comprehensive results.

■ AUTHOR CONTRIBUTIONS

The main contributor to this paper is Indah Kusmartini in sampling, preparation, samples measurement and data analysis, drafting, and finalizing the manuscript. Natalia Adventini, Woro Yatu Niken, Dyah Kumala Sari, and Djoko Prakoso Dwi Atmodjo conducted the sampling, sample preparation, and samples measurement. Endah Damastuti has conducted the sampling, correcting grammar/spelling errors in the manuscript. Syukria Kurniawati has conducted sampling and spectrum analysis. Diah Dwiana Lestiani conducted the data analysis, checked the QA and QC of the data, provided the conceptualization, revised and supervised the drafting of the manuscript, and Muhayatun Santoso designed the research. All authors agreed to the final version of this manuscript.

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