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Nutritional Values and Their Potential Applications in Food Products of Krabok Seed (*Irvingia malayana*)

Sutthidech Preecharram[1], Santi Phosri[2], Tinnakorn Theansungnoen[3,4], Wuttichai Roschat[5,7], Supakorn Arthan[5,6,7], Sudkamon Lasopha[5,7] and Jinda Jandaruang[5,6,7*]

[1]Department of General Science, Faculty of Science and Engineering, Kasetsart University, Chalermphrakiat Sakon Nakhon Province Campus, Sakon Nakhon 47000, Thailand
[2]Department of Chemical Engineering, Faculty of Engineering, Burapha University, Chonburi 20131, Thailand
[3]School of Cosmetic Science, Mae Fah Luang University, Chiang Rai 57100, Thailand
[4]Green Cosmetic Technology Research Group, School of Cosmetic Science, Mae Fah Luang University, Chiang Rai 57100, Thailand
[5]Chemistry Program, Faculty of Science and Technology, Sakon Nakhon Rajabhat University, Sakon Nakhon 47000, Thailand
[6]Center of Excellence on Modern Agriculture, Sakon Nakhon Rajabhat University, Sakon Nakhon 47000, Thailand
[7]Center of Excellence for Innovation in Chemistry for Community, Chemistry Program, Faculty of Science and Technology, Sakon Nakhon Rajabhat University, Sakon Nakhon 47000, Thailand

([*]Corresponding author's e-mail: jinda.j@snru.ac.th)

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Abstract

This investigation examined the nutritional value, mineral content, total phenolic content, antioxidant activity and cytotoxicity of uncooked and cooked Krabok seeds. Proximate analysis was carried out to determine the nutrient composition of uncooked and cooked Krabok seeds. The average fat, protein, carbohydrate, moisture, ash, and fiber contents were found to be 75.42, 11.78, 6.72, 2.68, 1.85 and 1.54 %, respectively. The Folin-Ciocalteu method was employed for the quantitative analysis of total phenolic compounds. All 6 samples of Krabok seeds extracted, both cooked and uncooked, were extracted using hexane, ethyl acetate, and ethanol, and subjected to the test. All the extracted samples contained phenolic compounds, with amounts ranging from 29.10 to 130.26 µg GAE/mL. The highest levels of phenolic compounds were observed in the ethanolic extract of cooked Krabok seeds. The antioxidant properties were evaluated using the DPPH assay. The scavenging activity of the extracted Krabok seed samples ranged from 9.84 to 62.31 %. The ethanolic extract of uncooked Krabok seeds exhibited the highest antioxidant activity. To assess the toxicity of the Krabok seed extract, HaCaT, Vero and RAW 264.7 cell liness were employed using the MTT technique. The results revealed that cell survival remained above 80 % for all doses of both uncooked and cooked Krabok seed extracts. These findings suggest that Krabok seeds are a valuable source of fat and other essential nutrients. The crude ethanolic extract exhibited a significant amount of phenolic content and antioxidant activity. Therefore, it could be utilized in the production of snacks or cosmetics.

Keywords: Krabok seed, Phenolic, Antioxidant, Proximate, Cytotoxicity, *Irvingia malayana*

Introduction

The Irvingia plant is of great importance to the economy. Typically, the fruit of these plants contains oil, which can be utilized in various applications. It can be used to produce food items such as bread, chocolate, cheese, and butter, as it contains lipids and proteins. Additionally, it can be used to thicken sauces. Furthermore, the oil derived from Irvingia fruit can be used in the production of non-food items like candles and soap [1] *Irvingia gabonensis* seeds have been found to possess antimicrobial properties, potentially inhibiting the growth of microbes [2]. Moreover, extracts from the bark and leaves of *Irvingia gabonensis* also exhibit anti-diabetic effects [3]. Similarly, extracts obtained from the leaves, twigs, and bark of *Irvingia malayana* contain noteworthy chemical compounds that could potentially reduce the growth of cancer cells [4].

Krabok's wood is known to contain a significant amount of phenolic compounds [5]. Its scientific name is *Irvingia malayana* Oliv. ex A.W.Benn, and it is commonly referred to as Krabok. This evergreen tree is widespread in Thailand, particularly in the Northeast and North regions. The majority of Krabok trees are found in Sakon Nakhon province, located in the Phu Phan Mountain range. Krabok is highly regarded as an herb with therapeutic properties, and almost all parts of the Krabok tree can be utilized. Both the fruit and seeds of Krabok are edible and can be consumed by both humans and animals. The flesh of Krabok seeds is known for its sweet and greasy flavor, attributed to its oil content. Bandelier *et al.* have described the mineral, amino acid, fatty acid, and tocopherol composition of *Cambodia nut I. malayana* [6]. Furthermore, the utilization of Krabok seeds as a food additive in bakeries has been addressed in previous literature [7]. Krabok seed oil can be utilized for the production of biodiesel, as well as in the creation of food and medicine [8-10]. Villagers in Sakon Nakhon Province harvest Krabok seeds to sell as a means of earning additional income.

Based on the information provided, it appears that most of the research conducted on Krabok has focused on the oil, leaves, and bark of the plant. Only a limited number of studies have specifically investigated the bioactivity of Krabok seed extract. Additionally, there is no available information regarding the bioactivity of Krabok seed extract in Sakon Nakhon Province, Thailand. This study aimed to investigate the nutritive value and bioactivity of cooked and uncooked Krabok seed extracts. The findings of this study can contribute to enhancing people's understanding of the benefits associated with Krabok seeds. In addition to their potential applications in food products, Krabok seeds may have future uses in cosmetics, pharmaceuticals, and other nutritional supplements. This could serve as an additional source of revenue locally. Another important aspect of safeguarding Krabok is promoting sustainable living practices among the community and fostering harmonious relationships with neighbors.

Figure 1 Showing (A) Uncooked Krabok seed and husks, (B) Uncooked Krabok seeds, (C) Cooked Krabok seed and husks, and (D) Cooked Krabok seeds.

Materials and methods

Reagents and standards

The 2,2-diphenyl-1-picrylhydrazyl (DPPH) and the Folin-Ciocalteu phenol reagent used in the study were provided by Sigma-Aldrich Chemical Co., USA. The human keratinocyte cells (HaCaT), African green monkey epithelial cells (Vero), and murine macrophage cell liness (RAW 264.7) were obtained from the American Type Culture Collection (ATCC, USA). All compounds utilized in the proximate analysis, as well as the assessments of cytotoxicity and antioxidant activity, were of analytical quality.

Krabok seed samples

The hard, dark-brown husks were removed from the samples obtained from uncooked Krabok seeds. The resulting Krabok seeds were finely crushed, and the powdered samples were stored at 4 °C. Similarly, samples from cooked brown husked Krabok seeds were subjected to baking at 120 °C for 30 min to produce

cooked Krabok seeds, which were then dehusked. The seed pulp was processed into a fine powder and stored at 4 °C. **Figure 1** illustrates examples of both uncooked and cooked Krabok seeds.

Krabok seed extraction

Three hundred grams of each Krabok seed variety were mashed and completely dissolved in hexane in an Erlenmeyer flask. The samples were then shaken at 150 rpm for 24 h. The supernatant was separated through centrifugation at 3,500 rpm for 10 min. The extracts were evaporated using a rotary evaporator under vacuum [11,12]. The resulting crude extracts were stored at −40 °C. These crude extracts were utilized to examine the antioxidant activity, total phenolic components and cytotoxicity. However, for subsequent experiments, ethanol and ethyl acetate were used as substitutes for hexane in the extraction process.

Proximate analysis

The proximate composition of Krabok seeds was determined using the AOAC method [13], and reports from Pimpa *et al.* [14], Roschat *et al.* [15], Onuegbu *et al.* [16], and Mansouri *et al.* [17].

To determine the crude fat content, a 5 g sample was placed inside a thimble made of Whatman filter paper. The thimble was then inserted into a Soxhlet extraction apparatus, which was connected to a 200 mL flask filled with hexane. The hexane was heated, causing it to vaporize and condense back into the flask. The sample inside the thimble was repeatedly soaked with the solvent for a duration of 4 h. After extraction, the defatted sample was removed, and the solvent was recovered, leaving behind the oil extract in the flask. The flask was then dried in an oven at 60 °C for 30 min to eliminate any remaining solvent. Subsequently, it was cooled in a desiccator and weighed to determine the weight of the crude fat extract. The weight of the oil (fat) extract was determined by calculating the difference between the initial weight of the sample and the weight of the defatted sample. The resulting weight of the oil extract was then expressed as a percentage of the weight of the sample analyzed.

$$\text{Fat (\%)} = [(W_f - W_e) / \text{weight of sample (g)}] \times 100$$

where: W_e is the weight of empty extraction flask (g), W_f is the weight of the flask with fat extract (g).

To determine the total crude protein content, a sample weighing 1.5 g was mixed with 15 mL of concentrated sulfuric acid and a catalyst tablet ($CuSO_4$). The mixture was then heated until a clear solution was obtained. The obtained solution was mixed with an equal volume of 32 % sodium hydroxide and distilled with 4 % boric acid, which contained methylene blue and methyl red indicators. The resulting solution was titrated against 0.05 N hydrochloric acid until the endpoint was reached, indicated by a deep red color. To ensure accuracy, a reagent blank was also performed. The total nitrogen content obtained from the titration was multiplied by a factor of 6.25 to calculate the protein content. The protein content was determined from the nitrogen content using the following formula:

$$\text{Protein (\%)} = \text{N (\%)} \times 6.25$$

$$\text{N(\%)} = [1.4 \times (V_s - V_b) \times \text{Conc. HCl}] / \text{weight of the sample (g)}$$

where: V_s is the HCl volume for titrating sample, V_b is the HCl volume for titrating blank.

Moisture contents, a 5.0 g sample was weighed into a moisture can and then dried in an oven at 105 °C for 3 h. The weight of the sample was recorded after each cooling and drying cycle until a constant weight was achieved. The weight of moisture lost was then calculated as a percentage of the initial sample weight using the following formula:

$$\text{Moisture contents (\%)} = [\text{weight loss/initial weight}] \times 100$$

In the formula, weight loss refers to the weight of the empty can with the sample before drying, minus the weight of the can with the sample after it has been dried to a constant weight. The initial weight refers to the weight of the empty can with the sample before drying, minus the weight of the empty moisture can.

To determine the total ash content, a 5 g sample was weighed into a crucible that had been pre-weighed. The crucible with the sample was then placed in a muffle furnace and burned at 550 °C to obtain the ash. Once the sample was fully burned, it was cooled in a desiccator and reweighed to determine the weight of the total ash content. The proportion of ash was determined by calculating the weight of the total ash obtained and expressing it as a percentage of the initial weight of the sample.

$$\text{Ash content (\%)} = (W_T - W_B) / W) \times 100$$

where: W_T is the weight of the crucible with ash (g), W_B is the weight (g) of the empty crucible (g), W is the weight (g) of the sample (g).

Crude fiber, the experiment involved boiling a 5.0 g sample in 200 mL of 0.13 M H_2SO_4 solution for 30 min under reflux. After boiling the sample in 200 mL of 0.13 M H_2SO_4 solution for 30 min under reflux, it was washed with hot water. Subsequently, the sample was boiled again, this time in 200 mL of 0.31 M NaOH for an additional 30 min. After draining the sample and ensuring it was dry, it was transferred to a pre-weighed crucible. The crucible with the sample was then dried in an oven at 105 °C until a constant weight was achieved. The sample was subsequently burned in a muffle furnace, leaving behind only ash. The weight of the fiber was determined by calculating the difference between the initial sample weight and the weight of the remaining ash. This weight was then expressed as a percentage of the initial sample weight.

$$\text{Crude fiber (\%)} = [(W_1-W_2)/W]\times 100$$

where: W_1 is the weight of the crucible with the sample after drying, W_2 is the weight of the crucible with ash, W is the weight (g) of the sample (g).

Determination of total carbohydrate: The value of total carbohydrates in a sample was calculated using the following formula:

Total carbohydrate content (%) = 100 - (percentage of ash + percentage of total lipids + percentage of protein + percentage of crude fiber)

Energy value: The Atwater factor (4 for protein and carbohydrate and 9 for crude fat) was used to compute the energy.

Minerals analysis

The minerals in both uncooked and cooked Krabok seeds were analyzed using the mineral analysis standard method, specifically AOAC (999.10-2019) [18].

Determination of total phenolic compounds

The total phenolic content of the sample was determined using the Folin-Ciocalteu method. To each well in a 96-well plate, 50 µL of crude extract was added, followed by 80 µL of 10 % Folin-Ciocalteu phenol reagent and 150 µL of 7 % sodium carbonate. The mixture was then incubated for 2 h in the dark at room temperature. The absorbance was measured at 765 nm, using gallic acid as the standard. Methanol was used as a control. The results were expressed as gallic acid equivalents in µg/mL, referring to previous studies [11,12].

Determination of antioxidant activity by DPPH scavenging assay

The antioxidant activity of the crude extracts was assessed using the DPPH radical scavenging assay. In this assay, 50 µL of crude extract was mixed with 0.1 mM DPPH methanolic solution in a 96-well plate. The mixture was then incubated for 20 min in the dark at room temperature, and the absorbance was measured at 515 nm using a microplate reader. The DPPH radical solution in the extraction solvent was used as the negative control. The percentage of DPPH scavenging activity was calculated using a specified equation.

$$\text{DPPH scavenging activity (\%)} = [(A_{control} - A_{sample})/A_{control})]\times 100$$

$A_{control}$ is the absorbance of the DPPH radical solution in the respective extraction solvent. A_{sample} is the absorbance of each Krabok seed extract in the DPPH radical solution [11,12].

Cell viability

The MTT (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) assay was utilized to assess cell viability by measuring the reduction of MTT to formazan, which is dependent on mitochondrial activity and serves as an indicator of cell respiration. RAW 264.7, Vero and HaCaT cell liness were cultured overnight in a 96-well plate at a density of 1×10^4 cells/well. After 24 h of incubation in a 5 % CO_2 atmosphere at 37 °C. The cells were treated with different concentrations (25, 50, 100, 200 and 400 µg/mL) of crude extracts obtained from cooked and uncooked Krabok seeds for a duration of 24 h. After the 24 h treatment and medium change, 0.5 mg/mL MTT was added to the cells, which were then incubated for 1 h

at 37 °C in a 5 % CO_2 atmosphere. After the incubation period, the medium was removed, and the formed formazan precipitate was dissolved in DMSO. The absorbance of the dissolved formazan was measured at 570 nm using a microplate reader (Molecular Devices SpectraMax ABS) [19,20]. Cell viability was determined by comparing the absorbance of the treated cells to that of the control cells, according to the equation provided.

$$\text{Cell viability (\%)} = [(A_x - A_y) / (A_z - A_y)] \times 100\%$$

where A_x is the average absorbance of cells treated with the extract. A_y is the average absorbance of a blank medium. A_z is the average absorbance of cell control.

Results and discussion

Proximate contents

The nutritional content of cooked and uncooked Krabok seeds is presented in **Table 1**. The soxhlet extraction analysis revealed that cooked Krabok seeds contained 76.67 % fat, while uncooked Krabok seeds contained 74.17 % fat (**Table 1**). The high-fat content indicates that Krabok seeds are predominantly composed of fat. When compared to findings from other studies, it was observed that Krabok seeds contained 60.4 and 63.58 % fat [8,21]. Moreover, it was found that a major portion of the fat content was saturated fat which makes it suitable to produce soaps, lotions, lipsticks, and other cosmetic products [8].

Kjeldahl protein determination method utilizes the measurement of total nitrogen to estimate the protein content in food samples. According to the results presented in **Table 1**, cooked Krabok seeds had a crude protein value of 11.33 %, while uncooked Krabok seeds had a value of 12.23 % (**Table 1**). These values are like the findings reported by Laohawinit *et al.* [21], which reported a protein content of 13.6 %. The amino acid lysine is present in dried defatted meal Krabok pulp meal [21]. Lysine is an essential amino acid that plays a vital role in repairing various bodily tissues, enhancing immune function, supporting the production of hormones and enzymes, facilitating the utilization of fatty acids for energy, and promoting calcium absorption to prevent osteoporosis [22].

According to the results presented in **Table 1**, cooked Krabok seeds have a moisture content of 2.49 %, while uncooked Krabok seeds have a moisture content of 2.87 %. The findings indicate that cooked Krabok seeds have lower moisture levels compared to uncooked Krabok seeds. This reduction in moisture can be attributed to the high-temperature ripening process during cooking. However, it is noteworthy that even uncooked Krabok seeds exhibit a relatively low moisture content. Both cooked and uncooked Krabok seeds adhere to the general guideline for dry foods, which states that moisture content should be below 15 %. This low moisture content contributes to reduced microbial contamination and enzyme activity, allowing for extended storage periods.

Table 1 Percentage of proximate content and energy values of Krabok seeds.

Samples	Proximate content (%)						Energy (kcal)
	Crude fat	Protein	Carbohydrate	Moisture	Ash	Fiber	
Cooked Krabok seed	76.67 ± 0.18	11.33 ± 0.36	7.01 ± 0.58	2.49 ± 0.03	1.85 ± 0.02	0.65 ± 0.032	763.39
Uncooked Krabok seed	74.17 ± 0.57	12.23 ± 0.46	6.43 ± 0.26	2.87 ± 0.03	1.86 ± 0.02	2.44 ± 0.032	742.17

Values are presented as Mean ± SD

According to **Table 1**, cooked Krabok seeds have an ash content of 1.85 % while uncooked Krabok seeds have an ash content of 1.86 %. These values are quite similar to the ash content of 2.10 % reported by Laohawinit *et al.* [21]. Ash content is a measure of the inorganic components remaining after complete organic decomposition at high temperatures. It can serve as an estimation of a food's mineral content. Minerals play a crucial role in maintaining the body's normal functions, including the establishment and maintenance of the blood's acid-base balance and the regulation of blood sugar levels [16].

Fiber is a type of carbohydrate that undergoes minimal to no digestion. Among other things, the fiber analysis showed the existence of cellulose, hemicellulose, and a little amount of lignin [23]. In the present study, cooked Krabok seeds had a crude fiber content of 0.65% while uncooked Krabok seeds had a content of 2.44 % (**Table 1**). These fiber content values were lower than those reported by Laohawinit *et al.* [21] which indicated a fiber content of 3.90 %.

The calculated carbohydrate content in Krabok seeds consists of sugars and easily absorbed carbohydrates. When cooked, Krabok seeds contain 7.01 % of their weight in carbohydrates, while uncooked Krabok seeds contain 6.43 % (**Table 1**). These carbohydrate content values are lower than the value reported by Laohawinit *et al.*, which was 20.10 % [21]. It is important to note that variations in sample sources, processing methods, and analytical techniques across different studies can contribute to differences in reported carbohydrate content.

Based on the nutritional composition of each species, the energy values were calculated and the results for Krabok are presented in **Table 1**. When cooked Krabok seeds have an energy value of 763.39 Kcal while uncooked Krabok seeds have an energy value of 742.17 Kcal. It is noteworthy that Krabok seeds possess approximately 2.4 times the energy content compared to RD 6 sticky rice [12]. The energy values of food samples can vary due to factors such as variations in seed quality, processing methods, and analytical techniques utilized in different studies. These factors can impact the accuracy and consistency of the reported energy values.

Mineral composition

The mineral composition of cooked and uncooked Krabok seeds is displayed in **Table 2**. The investigation focused on the top 3 macrominerals and microminerals. According to the experimental findings, the mineral compositions of cooked and uncooked Krabok seeds were similar in terms of calcium (Ca), phosphorus (P), potassium (K), iron (Fe), and copper (Cu). Except for Mn minerals, uncooked Krabok seeds are twice as abundant as cooked Krabok seeds. The average Ca level for these Krabok seeds was 822 mg/kg, which is lower than the 1,700 mg/kg found in the Cambodia nut (*I. malayama*) but close to the 900 mg/kg content of the Grenoble walnut [6]. In this experiment, it was discovered that the calcium content was higher than that of *I. gabonensis* (3.278 mg/kg) and *I. wombolu* (6.373 mg/kg) seeds [24]. Ca and P are key components of bones and teeth, and they are minerals that the body requires in significant amounts. Additionally, phosphorus plays a crucial role as a component of DNA and RNA. In the current test, the P content was approximately 1,829 mg/kg (average) while the K content was around 3,746 mg/kg (average). The average iron content was 12.05 mg/kg. These results differ from those reported by Laohawinit *et al.* [21], as iron and copper were not detected.

Table 2 Mineral composition of cooked and uncooked Krabok seeds.

Minerals	Mineral contents of Krabok seeds (mg/kg)	
	Cooked	Uncooked
Ca	873.55	772.30
P	1860.50	1798.00
K	3837.50	3655.00
Fe	10.93	14.08
Mn	23.24	59.48
Cu	6.76	5.80

However, the Fe content found in this study is lower than the level present in the Cambodian nut (*I. malayama*) which is 108 mg/kg [6]. It was discovered that the Fe content was higher than that of *I. gabonensis* (0.04 mg/kg) and *I. wombolu* (0.304 mg/kg) seeds. Important microminerals include Fe, which is a crucial component of myoglobin and hemoglobin found in warm-blooded animals while cold-blooded animals require Cu for the same purpose. Fe is also a component of several key enzymes involved in body metabolism, such as cytochrome oxidase, as well as other enzymes like catalase and peroxidase [25]. Cu had a mean level of 6.28 mg/kg which was lower than the 19 mg/kg found in the Cambodia nut (*I. malayama*) [6]. The mean Mn value was 41.36 mg/kg which was lower than Laohavinij *et al.* [21] reported value of 80 mg/kg and the reported value of 300 mg/kg for Mn in the Cambodia nut. The results of the testing show that Krabok seeds contain vital minerals that the body cannot produce on its own. Therefore, it is essential to consume foods that are rich in these minerals particularly Krabok seeds which are inexpensive and readily available as a natural indoor plant. Additionally, Krabok seeds have a wonderfully sweet and crunchy flavor.

Phenolic contents and antioxidant activity

An examination of phenolic components in both cooked and uncooked seeds revealed that the range of phenolic compounds in 6 samples of Krabok seed extract was 29.10 to 130.26 µg GAE/mL as shown in **Table 3**. The Krabok seeds that have been roasted and extracted with ethanol contain the highest amount of phenolic compounds. This is because phenolic compounds are generally polar substances and thus easily disperse in polar solvents such as ethanol. The temperature has an impact on the extraction of phenolic compounds. Specifically, the high temperature used to ripen Krabok seeds at 120 °C can damage plant tissues [26-28]. This high temperature can potentially hinder the production of phenolic chemicals found in cellulose and hemicellulose when they are heated [29]. Among the samples, uncooked Krabok seeds extracted with ethyl acetate had the second-highest concentration of phenolic components, measuring 62.8 µg GAE/mL.

Six samples of cooked and uncooked Krabok seeds extracted were tested for their antioxidant potential using an extract concentration of 50 mg/mL. The range of antioxidant activity observed was 9.84 to 62.31 % (**Table 3**). The highest antioxidant capacity was found in the uncooked Krabok seeds extracted with ethanol, presumably due to the presence of phenolic components [30]. Cooked Krabok seeds extracted with ethanol exhibited the second-highest antioxidant capacity, measuring 53.61 %. The extract from uncooked Krabok seeds displayed a higher antioxidant capacity compared to the extract from cooked Krabok seeds. It is likely that during seed ripening, phenolic molecules undergo heat degradation, leading to a decrease in their antioxidant power. On the other hand, high temperatures can promote the synthesis of Maillard reaction products such as melanoid and enhance the release of phenols by hydrolyzing polyphenol polymers and/or glycosylated flavonoids. This process can help remove reactive oxygen species, chelate metals, and reduce lipid peroxidation [31,32]. When compared to other solvents, the ethanol extract exhibited superior antioxidant capacity (**Table 3**). Besides phenolic compounds, vitamin E is also likely to have an impact on the antioxidant capacity of the material. Krabok seeds provide up to 89.5 % of the daily value of vitamin E [6].

Table 3 Total phenolic compound contents and antioxidant activities of Krabok seeds extract.

Samples	Solvents	Total phenolic compound (µg GAE/mL)	Antioxidant activities (%)
Cooked Krabok seed	hexane	35.86 ± 0.21	13.34 ± 0.06
	Ethyl acetate	53.75 ± 0.51	9.84 ± 0.07
	Ethanol	130.26 ± 0.66	53.61 ± 0.07
Uncooked Krabok seed	hexane	29.10 ± 0.48	18.99 ± 0.02
	Ethyl acetate	62.80 ± 0.50	13.58 ± 0.02
	Ethanol	109.03 ± 0.65	62.31 ± 0.03

Values are presented as Mean ± SD

Cell viability

The cell viability assessment of cooked and uncooked Krabok seed extracts against HaCaT cells, a keratinocyte cell, Vero cells, and RAW 264.7 cells by MTT assay. The MTT measures the mitochondrial reductase of intracellular mitochondria by turning formazan purple when it was reduced by mitochondrial reductase. The extracts concentrations of 25, 50, 100, 200 and 400 µg/mL had no cytotoxicity effect. **Figure 2** illustrates that such cells had a survival rate of more than 80 %. According to the test results, Krabok seed extract isn't hazardous to human and animal cell lines. This evidence is consistent with the results published by Kwok-Wen Ng *et al.* [33], which showed that Krabok bark extracts were not cytotoxic [33]. A substance is considered dangerous to cells when the survival rate is lower than 80 % [34]. Due to their high oil content and the presence of antioxidant-rich vitamin E, Krabok seeds can be incorporated into various products, including lipsticks and lotions [6,8].

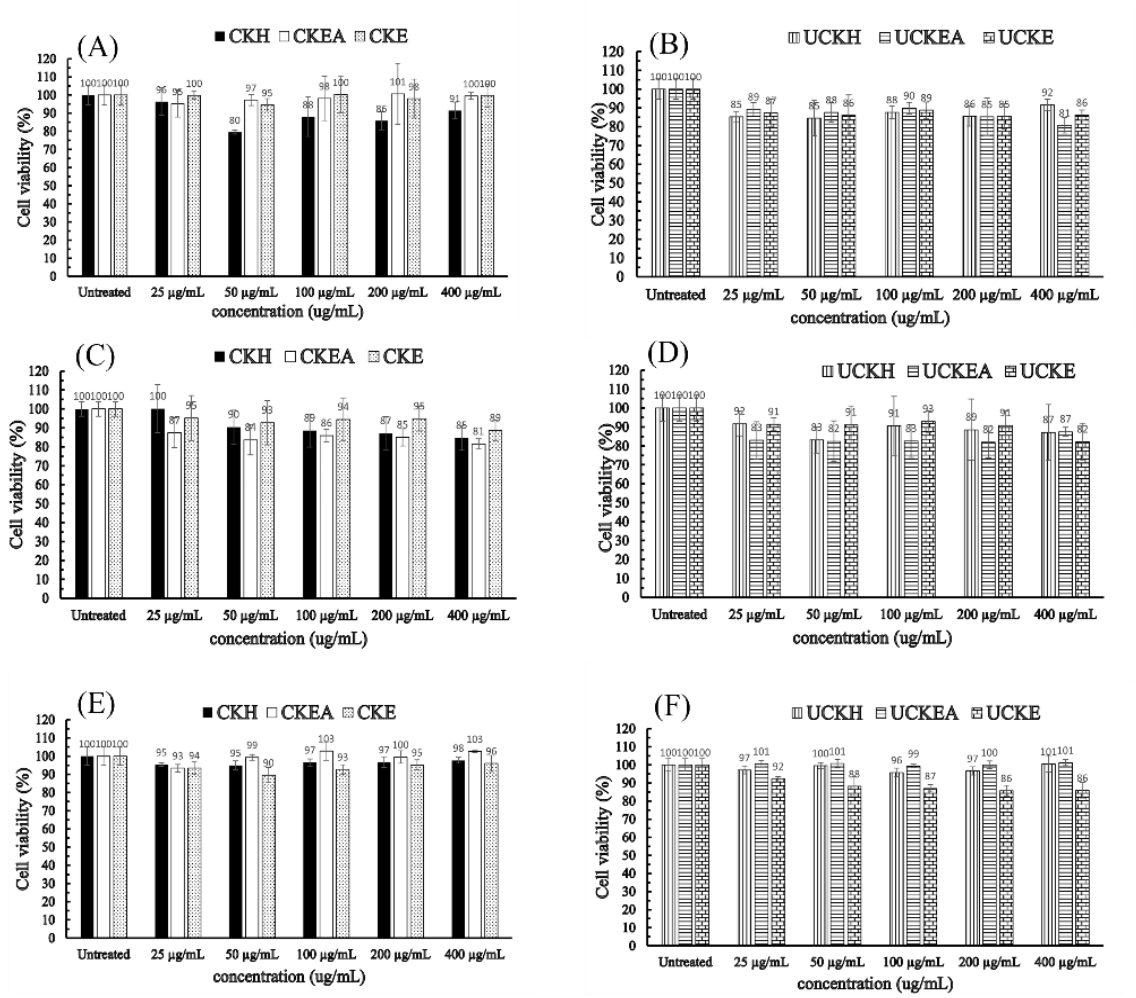

Figure 2 Cell viability when treated with Krabok seeds extracted. HaCaT cells were treated with (A) cooked and (B) uncooked Krabok seeds extracted. Vero cells were treated with (C) cooked and (D) uncooked Krabok seeds extracted. RAW 264.7 were treated with (E) cooked, and (F) uncooked Krabok seeds extracted. CKH and UCKH are cooked and uncooked Krabok seed extract with hexane, respectively. CKEA and UCKEA are cooked and uncooked Krabok seed extract with ethyl acetate, respectively. CKE and UCKE are cooked and uncooked Krabok seeds extract with ethanol, respectively. Data are presented as means SD of determinations made in triplicate.

Conclusions

Based on the research conducted on the nutrient composition, mineral content, total phenolic compounds, antioxidant activity, and cytotoxicity of cooked and uncooked Krabok seeds, it was discovered that Krabok seeds contain a substantial amount of fat and are high in dietary calories. Moreover, they contain macrominerals and microminerals, along with biologically active phenolic compounds that exhibit antioxidant properties. One of these components is Krabok seed extract which has been shown to be non-toxic to both human and animal cells. Based on all the results obtained, it can be concluded that Krabok seeds serve as a valuable source of potential food ingredients for both humans and animals. They can be utilized in the preparation of various food products, thus adding economic value.

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