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Reducing Bitterness and Increasing Antioxidant Activity of Sesame by a Novel Ultrasound Technique

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ABSTRACT

Sesame is an essential source of oilseed and one of the oldest oil-bearing crops in the world. Sesame lignans have strong physiological activity, and sesame lignan extracts may have useful applications in human health. A by-product of sesame oil processing, sesame oil cake is used for fertilizer or feed, which may be a waste of this potentially valuable resource. Therefore, this study was conducted to explore methods of processing sesame oil cake separately in water or ethanol using ultrasonic vibration as a washing process and how these methods affect the nutritional content of the sesame oil cake. Sensory experiments confirmed the level of bitterness in sesame oil cake samples, which were also empirically evaluated by assessing the acid value and peroxide value. The results showed that extraction using ultrasonic vibration to reduce bitterness could be performed at room temperature and that the equipment was simple and easy to operate. Normal water wash also retained more nutrients than did the normal ethanol wash (sesamin content: normal water wash = 0.45 µg/µL vs. normal ethanol wash = 0.32 µg/µL). The water wash could also effectively reduce the acid value by approximately 20%, although the ethanol wash reduced the acid value by approximately 60%. Similarly, the water wash reduced the peroxide value by approximately 25%, whereas the ethanol wash reduced the peroxide value by approximately 50%.

Keywords: Sesame meal, Grain seeds, Sesamol and Ultrasonic extraction, Sensory

INTRODUCTION

Sesame oil cake was previously extracted using methanol as the extraction solvent [1]. This process was followed by the application of soxhlet extraction technology and by the extraction of extreme polar solvents. According to high-performance liquid chromatography (HPLC), lignin constituted approximately 15% of sesame seeds, rendering it the main component of such seeds.

The lignan sesamin was extracted from sesame residue by using anhydrous methanol and purified through crystallization. Quantitative analysis with HPLC yielded experimental results indicating that the sesame residue had a sesamin content of 0.251%, confirming that sesame residue contains sesamin and that sesame residue has the potential to be used as a source of raw materials for further extraction [2].

Sesame has long been used in folk medicine and as an edible crop, containing a variety of essential amino acids, as well as vitamin E, vitamin B1, calcium, linseed oil, and lecithin. However, these important healthy components constitute only approximately 0.5% of the crop's mass. After a large amount of oil has been extracted, the resulting sesame residue has a low oil of content, is dry and hard, and tastes bitter, rendering it no longer suitable for use in human food products. However, this substance does contain a high level of nutrients that have the potential for recovery, such as sesamin.

Sesamin is a lipid-soluble lignan that has been suggested to promote alcohol metabolism, antioxidation, liver protection,

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blood cholesterol reduction, and anticancer mechanisms. However, with the prevalence of healthy and the pursuit of the reusability of "green" resources, sesame residue with low fiber, low fat, and high calcium content has been subjected to research to determine its further use.

The purpose of this study was to investigate sesame oil cake, the traditional residue or meal remaining after sesame oil processing or extraction. Currently, sesame oil cake is only used as livestock feed or fertilizer, and therefore may be underutilized. Although investigations into the secondary extraction of sesame oil from sesame oil cake have been conducted, extraction and purification of the active substances (e.g., sesamin and sesamol) directly from sesame oil cake have been largely overlooked. Sesame oil cake is rich in protein, dietary fiber, minerals, and lignans, which are beneficial to human health. Sesame is widely used, but its major use is still as sesame oil and other culinary products. This is not only because of its unique aromatic flavor but also because of its strong health benefits [3].

The reason for sesame's unique physiological functions is that it contains many types of lignan compounds (mainly lignan antioxidants) that have key physiological activities, mainly in the form of lipid-soluble lignan compounds such as sesamin, sesamol, sesamolin, and sesaminol, as well as water-soluble lignan compounds such as lignan glucosides. Lignan glucosides are highly powerful glycosides formed by the combination of sesame lignan and one to three glucose molecules, which mainly include sesame glucoside glycosides (sesaminol glucosides), sesamolinol glucosides, and pinoresinol glucosides [4]. In recent years, extraction has been an important technology in the development of plant-based and other naturally sourced products. Extraction can accelerate the separation of active components and increase their concentration to achieve optimal results. New extraction methods are also gradually replacing traditional extraction methods. For example, the ultrasonic extraction method has been shown to be particularly successful in the extraction of active components.

Sesamin is a natural lignan compound and the main active ingredient of sesame seeds and sesame oil. Regarding the pharmacological activity of sesamin, research into its effectiveness as a medicine has found that sesamin is not only of nutritional value but also has antioxidant, antibacterial, liver-protecting, lipid-regulating, blood pressure-regulating, and tumor-inhibiting properties, as well as other biological activities [5]. The structure of sesamin is shown in **Figure 1.**

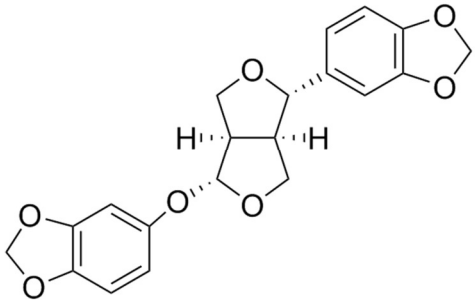

Figure 1. Chemical structure of sesamin

OBJECTIVES

The main aim of this study was to enhance the value of sesamin in sesame oil cake, a byproduct widely available in South Africa and Taiwan. Sesame oil cake contains a high amount of sesamin, which has antioxidant, antitumor, antiatherosclerotic, and serum lipid-lowering properties.

MATERIALS AND METHODS

1. Sample collection and preparation

Samples of 500 g (n = 6) were collected from residue in the production of sesame oil from fresh sesame seeds in an oil factory (Thailand). The sesame residue obtained was in the form of a hard, round cake. Samples were checked for mold, pests, odor, and other changes before acceptance.

2. Crushing pretreatment

The cake-shaped sesame oil dregs were broken into smaller chunks. Subsequently, they were crushed and treated with a grinder and sieved using a 40-mesh sieve (**Figure 2A**). After the sesame residue was crushed into powder, samples were mixed with 95% ethanol, loaded into serum bottles (**Figure 2B**), and placed in an ultrasonic cleaning machine. After the completion of ultrasonic shock, the sesame residue powder and ethanol solution were separated using a suction filtration device (**Figure 2C**). The solid sesame residue was transferred into an oven at 40 °C for 5 hours to dry, facilitating ethanol volatilization (**Figure 2D).**

Figure 2. Schematic of sample preparation

3. Analytical procedure

Sample preparation for determination of sesamin content: Extracted sesamin samples were prepared according to the method shown in **Figure 3.**

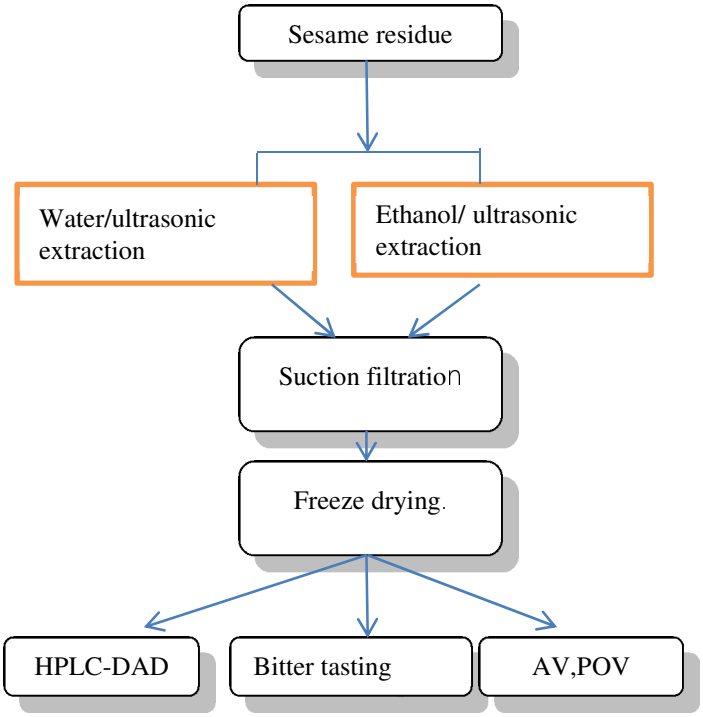

Figure 3. Schematic of the sample preparation method

Seasmin was determined by comparing its retention times with individual reference standards of sesamin obtained from Sigma Chemical Co. (St. Louis, MO, USA). The quantification of sesamin was conducted according to its relative area percentages compared with appropriate calibration curves.

4. HPLC–Diode Array Detection instrument:

The conditions of HPLC detection were as follows: The detection wavelength was 235 nm, flow rate was 1 mL/min, detection time was 20 minutes, mobile phase was methanol: water (75:25, v/v), and sample injection volume was 40 µL.

5. Statistical analysis

All data are expressed as mean ± standard error and were analyzed by one-way analysis of variance (ANOVA). Statistical significance was determined by Dunnett's test using tissue culture polystyrene as a control. Probability values less than 0.05 were considered significant.

Results and Discussion

The sesamin standards used for qualitative and quantitative analyses were first examined, and two peaks appeared in the map (**Figure 4**), which are referred to as Sesamin_1 and Sesamin_2. To change injection volume to calculate the two peaks of the checking line **(Figures 5 and 6**). The linear accuracy of Sesamin_1 was 0.9997 and that of Sesamin_2 was 0.9998, indicating the high accuracy of these standards and their suitability as control standards for analyzing the content of sesamin sesame residue in this study. Sesamin_2 was selected as the control.

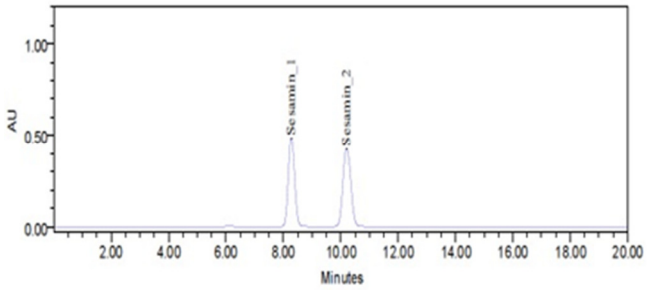

Figure 4. HPLC chromatogram of Sesamin_1 and Sesamin_2 standards

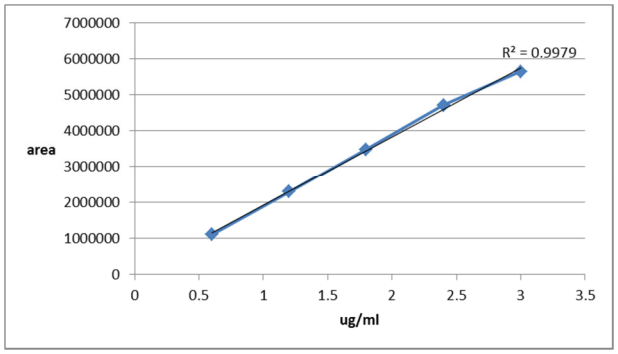

Figure 5. HPLC chromatogram of Sesamin_1 inspection line

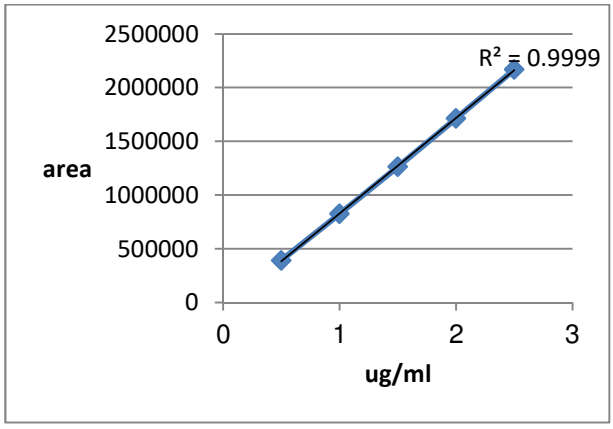

Figure **6**. HPLC chromatogram of Sesamin_2 inspection line

1. Determination of sesamin data

The derived sesame residue, before and after bitterness removal, was subjected to a quantitative analysis for determining sesamin content by using light detection maps (**Figures 7 and 8).** The following results were obtained after

data calculation: The sesame residue contained 1.26 mg/g sesamin before bitterness removal and 1.17 mg/g after. These results indicate that the effects of bitterness removal on the sesamin level were extremely low.

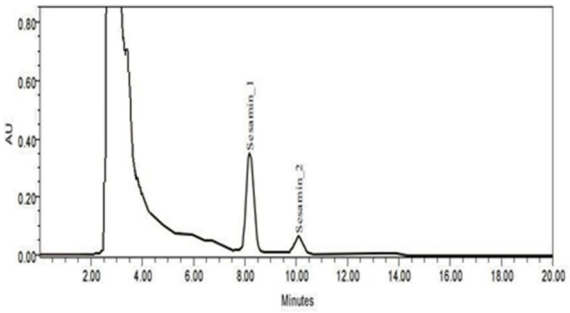

Figure 7. Before bitterness removal from sesame residue

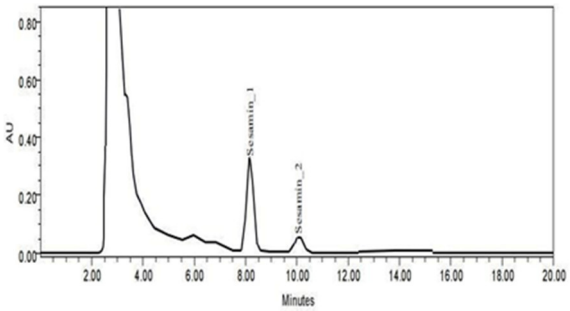

Figure 8. After bitterness removal from sesame residue

2. Quality testing (acid and peroxide values)

In addition, to test multiple bitter taste removal procedures for sesame residue, the acid value (AV) and peroxide value (POV) of the samples before and after bitterness removal were assessed using a spectral brightness meter and an absorbance test. The AV was 1.07 for the sesame residue and 0.82 for the bitter sesame residue (unit: mg KOH/g). Moreover, the oxidation light absorption value was 0.267 for the sesame residue and 0.225 for the bitter sesame residue. From these data, we concluded that the sesame residue in the treated AV standard value was below 2.5 and that bitterness in a spectral brightness meter test before and after treatment of absorbance values also decreased. Therefore, had less influence on the deterioration of the quality of the oil constituents (data not shown).

3. Bitterness

Figure 9 shows the bitterness of the sesame meal, water-extracted sesame meal, and ethanol-extracted sesame oil cake. Functional evaluation tests were conducted to assess the samples using a 5-point scale, with 5 indicating strong or maximum bitterness and 1 indicating weak or minimum bitterness.

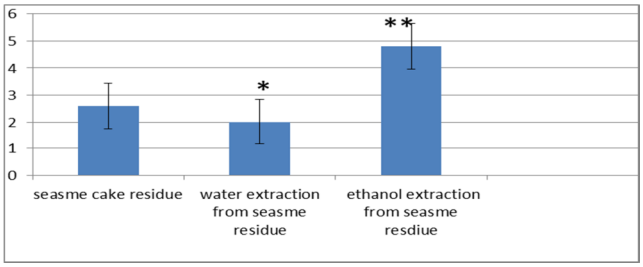

Figure 9. Bitterness values of (A) sesame cake residue, (B) water extracted from sesame residue, and (C) ethanol extracted from sesame residue. (*p < 0.05 **p < 0.001)

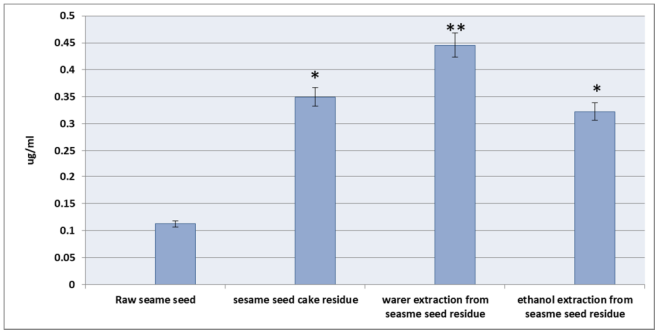

Figure 10. Concentration of sesamin in four different samples: (A) raw sesame seed, (B) sesame cake residue, (C) water-extracted sesame residue, and (D) ethanol-extracted sesame residue. (*p < 0.05 **p < 0.001)

CONCLUSION

The experimental data reveal that sesame residue subjected to bitterness removal to enhance palatability still contained considerable amounts of sesamin. Because sesame oil extraction removes most of the fat, leaving behind only sesame seed fiber, sesame residue is consequently low in calories and high in fiber and calcium. Therefore, sesame oil cake has the potential to function as a dietary source of sesamin, a new alternative for the modern pursuit of health. This low-fat source can be used several processed foods such as pasta and cakes. This experiment was conducted using low-cost raw materials and simple and convenient processing methods. In addition, volatile food-grade alcohol can be used to reduce consumption risks and combined with ultrasound equipment to shorten the reaction time to remove bitterness, enhancing the experimental rate and reducing the amount of auxiliary solvent use.

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