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Extraction technique for maximum yield of carotene from crops (carrot)

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Abstract. Carotene from plant could be utilized as the raw material for aromatic compounds synthesis. Since the amount of carotene is limited in plant, the effective technique to obtain as much carotene is need for practical uses. The aim of this study was to obtain an effective method in extracting carotene from carrot. The carotenes obtained will then be used as raw material for the synthesis of aromatic compounds such as ß-ionone and dihydroactinidiolide. The extraction of carotene was conducted by general maceration technique with a non-polar solvent i.e hexane until there was no carotene remains in the sample. As the result, it concludes that the maceration process with ultrasonic assisted extraction could be used to obtain the maximum carotene from carrots. It took 12 times extraction process to extract the maximum yield of carotene from carrots. The maximum carotene extraction is indicated by the loss of the orange color and only leaving a white color in the samples. The result of this study will provide the information about the method on obtaining the carotene from carrot and red sweet potato with maximum yield that could be further utilization.
Keywords: Volatile, carotene, carrot, extraction

1. Introduction

Carotene found in plants and has recognized as the phytochemical compound that has interactive color [1]. As well as food phytochemical and food pigment, the utilization of carotene especially ß-carotene also developed as the raw material for the production of aromatic compounds such as ß-ionone and dihydroactinidiolide [2,3,4]. Since the production of aromatic compounds is still dominated by chemical compounds synthetically, natural raw materials have not been extensively developed. Many research has reported the production of aromatic compound such as ß-ionone and dihydroactinidiolide from degradation of ß-carotene [5,6]. They had successfully to synthesize from ß-carotene using chemical or enzymatic degradation. However, the availability of ß-carotene in nature is limited where most of ß-carotene presence in the form of carotene. Therefore, for a wider application, the availability of carotene is more of a concern than ß-carotene itself.

Carotene is present in plants that have an orange color such as carrots, red sweet potato, papaya and palm. In order to obtain as much ß-carotene from carrots which will be degraded in the production of ß-ionone and dihydroactinidiolide, carotene must be extracted as much as possible until there is nothing left in the plant sample. The extraction technique for carotene from plants has introduced by some researcher by using solvent extraction such as hexane, isopropanol, ethanol etc. However, there is limited information about the maximum condition for obtaining as much carotene form plant including carrot.

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In this study, the simple way of carotene extraction by using hexane as the solvent extractor with maceration technique was emphasized to obtain the maximum carotene from a rich carotenoid agriculture products i.e carrot. The result of this study will provide the information about the method on obtaining the carotene from carrot with maximum yield that could be further utilized for the production of beneficial aromatic compounds such as ß-ionone and dihydroactinidiolide.

2. Materials and methods

The study was carried out on the laboratory of Food and Crops Chemistry, Department of Crop Technology Andalas University West Sumatera Indonesia. Carrot (Daucus carota subsp. Sativus) was used. The samples were purchased from a traditional market at Padang City West Sumatera Indonesia. Hexane as the extraction solvent was obtained for local market with low grade quality.

2.1. Carotenoid extraction

The extraction steps were described in Fig 1. Briefly, each purchased sample was weight as 5 Kg, washed and then cut into small pieces. The sample was then dry in oven at low temperature (60 °C) until the moisture contents reached ≤ 12 %. Dried sample was moved to the 1 L beaker glass and hexane was then added to the sample until sample immerged perfectly. The mixture was sonicated for 5 h, after that the mixture was leave on the room temperature for one night with no light condition. The mixture solution was filtered with gauze to separate the liquid and the solid phase. The liquid phase was collected into closeable glass container and the solid phase was added treated with hexane as previous step. The extraction was stopped when there was no color remains on the solid phase of sample. The collected liquid phases were combined into one container and put into rotary evaporator to remove the solvent (hexane). The viscous extract obtained after solvent evaporation was considered a carotene extract which can be used as a raw material for the process of aromatic compounds production. The number of hexane addition for extraction process, yield and carotenoid content from carrot and orange sweet potato were experimental subjects that pointed out in this study.

2.2. Total carotene analysis

A viscous extract of 0.1 g was transferred to a 25 mL amber volumetric flask. Hexane was used to fill the volume, and the sample was measured using a UV-VIS Spectrophotometer at 446 nm. The following formula was used to measure the total carotenoid content:

$$\text{Coretene}\left(\frac{\mu g}{g}\right) = \left(\frac{25 \times A \times 383}{100 \times \text{sample weight (g)}} \times 100 \qquad (1)$$

Which: A = absorbance at 446 nm, 383 = diffusion coefficient of caroten, V = value of hexane (mL) and W = weight of sample (g).

2.3. Statistical analysis

All values are reported as means of three replicates of each determination. Statistical significance was determined by subjecting the mean values to analysis of variance and the means were compared by Tukey's test at 5% level of significance using R 3.3.2 (R Foundation for Statistical Computing).

3. Results and Discussion

Carotenes is a kind of plant secondary metabolite with low polarity characteristic. Therefore, the best way to extract carotenes is by the utilization of non-polar solvent. In order to extract the carotenes from plant matrix, due to its polarity, the presence of water in plant or sample need to considered. The plant sample should not contain any water when the extraction of carotenes occurred. The presence of water will be able to block the extraction solvent to extract the carotenes by diffusion process. In this study, prior to the extraction process of carotene from carrot, drying process of grinded carrot had done. The grinding process was carried out to reduce the particle size of carrots and break down the cells. While the drying process was carried out to remove water that can interfere with the solvent extraction process

[7]. Carrot particle size less than 80 mesh and moisture content up to 15% were the conditions obtained in this study.

The utilization of hexane as the solvent extraction for carotenes has reported by several publications. In order to extract carotenes from carrot, it was not enough to do one or two solvent extraction processes. At least 12 times the extraction process was required. Figure 1 shows the colour change during the carotene extraction process from carrot sample. The orange colour indicates the high amount of carotenes. Therefore, the decrease in orange color reflects the increasing amount of carotene extracted. On the extraction process of 12 times, the color of the solution was not orange anymore which was indicated the carotenes extraction could be assumed that it has finished.

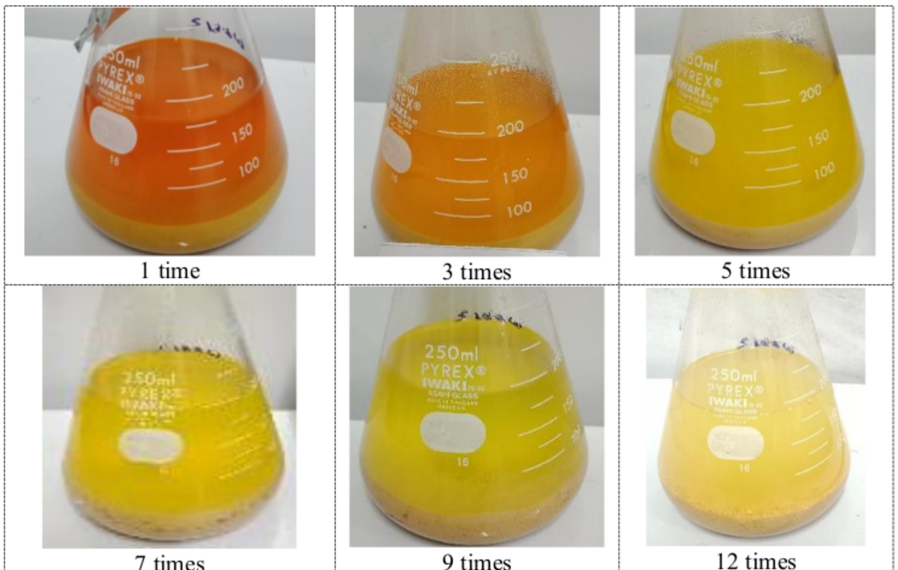

Figure 1. The colour changes during carotenes extraction from carrot by hexane

The confirmation of extracted carotenes was further conducted by spectrometric analysis. Figure 2 indicates the spectrum of extracted solvent that obtained after 12-time extraction. Based on the UV-Vis spectrum, it can be indicated the observation of the maximum wavelength on 446 nm. Some references have been indicating the maximum wavelength of carotenes as 446 nm [8,9]. Therefore, it is certain that the extraction of carotene with solvent extraction with hexane as much as 12 times had been able to obtain maximum carotene yields.

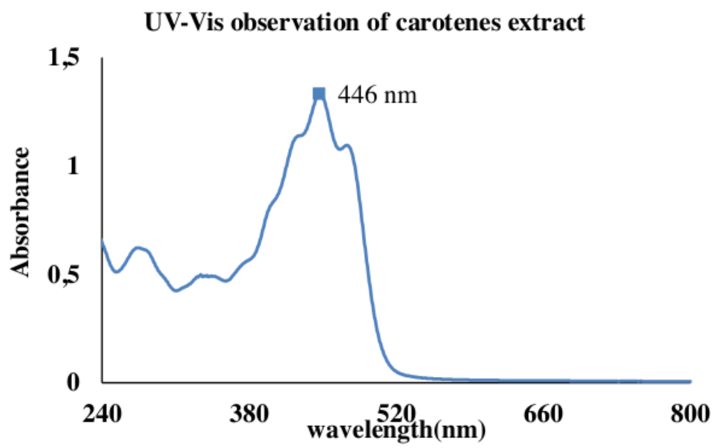

Figure 2. The spectrophotometric observation of extraction solvent of carrot

Further analysis of exact carotenes content in the extract was conducted. The total carotene content of carrot extraction in this study was 147.06 ± 2.66 mg/100g. Previous research done by Pinheiro-Sant Ana [9] also showed almost the same value of 148.76 mg/100g They had observed the loss of carotene in carrots during food processing.

4. Conclusion

This study indicates the appropriate technique on carotene extraction from carrot. Several factors need to be considered in order to obtain the maximum yield of carotene from carrot. Appropriate particle size and moisture content are important parameters that must be considered before the solvent extraction process is carried out. The solvent extraction process at least 12 times has been confirmed as the amount required to extract the maximum carotenoids from carrots.

Acknowledgements

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