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Research paper

Temperature and pretreatment effects on the drying of Hass avocado seeds

M.R. Avhad, J.M. Marchetti*

Department of Mathematical Sciences and Technology, Norwegian University of Life Sciences, Drøbakveien 31, Ås, 1432, Norway

A R T I C L E I N F O

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A B S T R A C T

The objective of the present experimental work was to determine the influence of five different drying air temperatures (313, 323, 333, 343, and 353 K) on the drying kinetics and the degree of moisture evaporation from Hass avocado seeds. The drying experiments of the non-pretreated and pretreated (sliced and crushed) Hass avocado seeds were performed in a heating furnace, where the pretreatment process was found to accelerate the drying process. The obtained results suggested that increase in the operating air temperature stimulated the rate of moisture evaporation, but resulted in the charring of the seed surface. The drying air temperature of 313 K was concluded to be suitable for the reasonable drying of Hass avocado seeds. The slicing pretreatment process was found to be better indicative of the total moisture amount present in Hass avocado seeds. The drying process removed a maximum of 58% of the initial water mass of Hass avocado seeds. An additional investigation was performed where the physical appearance of Hass avocado seeds immersed in water at different temperatures (303, 318, 325.5, 333, and 348 K) was examined. The observed study suggested that the surrounding temperature higher than 313 K could damage the physical appearance and reduce the quality of Hass avocado seeds.

1. Introduction

The data presented by the statistics division of the Food and Agriculture organization of the United Nations suggested that the production of avocado fruit in the year 2013 was 2.81 times higher than that in 1983; Mexico being the top producer of the fruit [1]. The presence of micro- and macro-nutrients, such as minerals, dietary fibers, proteins, lipids, vitamins, and phytochemicals in the fruit pulp is the prime reason for the consistent rise in the requirement, and in consequence, for the agriculture of avocado fruit [2]. Among the different varieties of avocado fruit, Hass variety is commonly grown because of its longer shelf life and demand in foreign markets [3]. However, it is important to understand that only the pulp of the fruit is consumed; the seed of avocado, which is about 13% of the total fresh weight of the fruit, is considered as an agricultural waste and is discarded with no further applications. The average share of the pulp, skin, and seed in Hass avocado fruit is presented in Fig. 1.

The world total production of avocado in the year 2013 was 4.71 million tonnes [1]; thus, it could be estimated that in the year 2013 alone, approximately 613 thousand tonnes of avocado seeds were treated as a waste material. In addition, there are reports suggesting that avocado plant leaves and, fruit seed and skin are all potentially poisonous to animals and cannot be served as food because of the presence of substance named Persin. The consumption of avocado waste by animals could trigger several carcinogenic effects, such as fluid accumulation around the heart, difficulty in breathing, and even death due to oxygen deprivation. Moreover, high fat content of avocado can lead to pancreatitis [4,5]. However, reports on the possible utilization of avocado seeds for human benefit purpose are available. Furthermore, a market established from the usage of avocado seeds could also help in reducing the overall cost of avocado fruit. Dabas et al. [6] reported that Hass avocado seeds, when crushed in the presence of water and incubated at 297 K for 35 min, resulted in the generation of orange pigments. It was proposed that the development of color was assisted by enzyme, while, the excess heat treatment (373 K) has a negative impact on the extraction of color from seeds. Lacerda et al. [7], and Weatherby and Sober [8], in their study, revealed that avocado seeds consist also of a natural biopolymer, i.e. starch. Reports on the utilization of carbonized avocado seeds as an adsorbent are also available. Bhaumik et al. [9] reported a study focused on the usage of carbonized form of sulfuric acid modified avocado seed for the removal of toxic

* Corresponding author.
E-mail address: jorge.mario.marchetti@nmbu.no (J.M. Marchetti).

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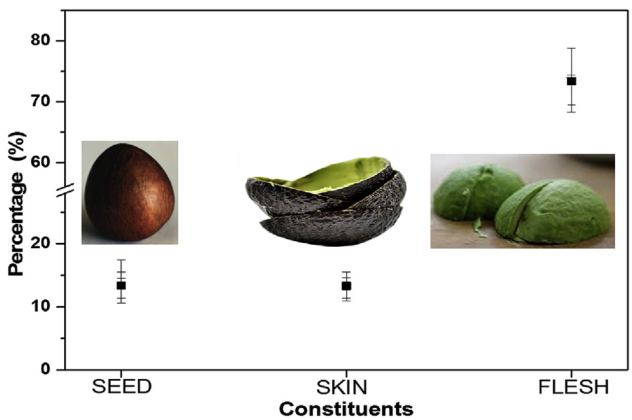

Fig. 1. Constituents of Hass avocado fruit.

hexavalent chromium (Cr (VI)) from the aquatic system. Moreover, a study reported by Rodrigues et al. [10] demonstrated that avocado seeds, after the carbonization process, could be utilized for the removal of phenol from the wastewater. In addition, several reports are available which confirm the presence of lipid components as well in avocado seeds [11–14]. Therefore, we assume that the derivatization of combustible oil from a waste resource, such as Hass avocado seed could be of industrial relevance. This is because its combustion would have negligible contribution on the net increase in the atmospheric carbon dioxide, while, the feedstock might necessitate less monetary investments. However, reports on the utilization of avocado seeds for biofuel generation are scarce. The study reported by Rachimoellah et al. [15] and Risnoyatiningsih [16], have demonstrated a possibility for the synthesis of biodiesel from avocado seed oil, in the presence of methanol and a sodium hydroxide catalyst.

The derivatization of value-added chemicals and biofuel from a waste biomass material, such as Hass avocado seeds may require several steps. The drying of Hass avocado seeds is a primary step for the oil and chemical extraction process, but is a critical one due to the fact that the presence of moisture could cause irreversible damage to the seeds and reduce the quality of the final product. Additionally, the quantity of substrate utilized for the value-added chemicals and biofuel production processes is based on dry matter content. Furthermore, deciding the drying conditions could also be of foremost importance. This is because the drying temperature might have a significant impact on the nature of oil cell walls, which in return, would decide simplicity or complexity for the oil extraction process. It is also worth noting that the mechanical cold pressing methodology that promises to yield best quality oil demands seeds with moisture content below 100 g kg^{-1} [17]; thus, hinting the need for the absolute moisture removal from Hass avocado seeds. The comprehensive removal of moisture from Hass avocado seeds is supposed to prevent the growth and reproduction of microorganisms, and subsequently, minimize several possible moisture-mediated deteriorative reactions. The drying process will also reduce the bulk weight of Hass avocado seeds, minimize the required storage space, facilitate its transportation, and enable its storage for a long period. Therefore, deciding the appropriate drying conditions and understanding its proficiency in minimizing moisture from Hass avocado seeds might be basic, but could be of a foremost importance. To our knowledge, till date, no effort on studying the influence of different temperatures on the degree of moisture removal from, and on the physical appearance of Hass avocado seeds is reported. In the present study, we investigated the impact of five different drying air temperatures (313, 323, 333, 343, and 353 K) on the moisture removal rate and on the final yield of dry matter. The influence of different pretreatment process on the overall speed of moisture evaporation during the drying process was also studied. In addition, the physical appearance of Hass avocado seeds when immersed in water at different temperatures (303, 318, 325.5, 333, and 348 K) was carefully monitored.

2. Materials and methods

2.1. Materials

Riped Hass avocado fruits were purchased from a local market of Norway. For the crushing pretreatment process, a bowl-shaped mortar-pestle, made from stone, was employed to pulverize Hass avocado seeds. For another pretreatment process, Hass avocado seeds were sliced using a stainless steel slicer to maintain a uniform thickness of every sample. All the seed samples were weighed on a digital balance machine having 1 mg accuracy (Mettler-Toledo, PG 5002 Delta Range, Switzerland). The drying experiments of the seed samples were performed using a heating furnace (Narbetherm P300, Germany). The initial and residual water content in Hass avocado seeds were determined using the automated Karl Fischer (KF) volumetric system (Metrohm, Tampa, FL, USA) consisting of an oven sample unit (Model 774) for water extraction, a dosing device (Model 901) connected to two mechanical burettes (Model 80; one for titrant and other for methanol) for control of titrant, and a titration cell with electrode and stirrer (Model 801). The complete system was operated by a computer using the software Tiamo 2.3, for the data analysis. For the moisture analysis, methanol (Sigma–Aldrich), and CombiTitrant 5 (Merck, Darmstadt, Germany) was used.

2.2. Experimental procedure

This work was performed on Hass avocado fruits of unknown provenance, for which the chain of custody is not known; while, the authors believe that this work exemplifies the drying process of Hass avocado seeds, there is a reasonable concern that there may be substrate factors that influence the results obtained. Hass avocado seeds were carefully separated from the mesocarp and cleaned under continuous flow of tap water. Subsequently, water attached to the seed surface while cleaning was removed with the help of tissue paper. The seeds were then separated in three sections. The first section of Hass avocado seeds were dried without any pretreatment. In the second section, Hass avocado seeds were crushed before applying for the drying process. The average particle size of the pulverized Hass avocado seeds was on average 4.2 mm; the smallest and largest unit size being 3.5 mm and 5.5 mm, respectively. In the third section, Hass avocado seeds were sliced, and utilized for the drying experiments. The average length, width, and thickness of the sliced seed samples were 43.7 cm, 30.6 cm, and 2.7 mm, respectively. All the seed samples were kept in separate pyrex glass petri plates and then placed in the heating furnace for the drying process. The efficacy of five drying temperatures (313, 323, 333, 343, and 353 K) on the moisture evaporation from Hass avocado seeds was systematically investigated for 5760 min. To understand the rate of moisture evaporation, the seeds samples were weighed at a predetermined time interval taking less than 0.25 min to weigh the samples. The seed samples were weighed until the weight of two consecutive samples fluctuated less than 1% to ensure acceptable moisture evaporation. Every experiments were replicated twice to obtain reproducibility in the experimental findings.