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Review

Jojoba oil: A state of the art review and future prospects

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ABSTRACT

Jojoba oil, which is derived from the extraction of Jojoba seed, has a peculiar molecular structure in comparison with the rest of conventional oils. Jojoba oil is formed by long monounsaturated esters whereas the rest of the oils are usually composed by triglycerides. This unconventional structure confers to Jojoba oil unique properties and characteristics that are very valuable for fine chemical industry and for the production of pharmaceuticals. In addition, Jojoba oil can be an excellent source of fatty acid alkyl esters or biodiesel after the transesterification process and the purification steps. This review presents general information about the production of Jojoba oil and its derivatives, its composition, oil extraction process and the applications of this oil when it is used directly or after chemical transformation as well as the possible purposes of Jojoba meal after extraction.

In addition, this paper contemplates the advantages and disadvantages of the use of homogeneous and heterogeneous catalysts for the Jojoba oil transesterification as well as different methods to obtain long monounsaturated alcohols, which have pharmaceutical applications, after being separated from biodiesel. The properties of the products derived from the transesterification of Jojoba oil are broadly discussed. Moreover, this review suggests future research opportunities such as a possible biorefinery using Jojoba oil as main raw material, supercritical methods and simultaneous extraction/reaction process which are fully discussed.

Contents

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1. Introduction

Jojoba plant or Simmondsia chinensis is a desert-like perennial shrub, which is linked to the Buxaceae family [1], and it is the raw material necessary to obtain one-of-a-kind mixture of high-molecular weight monounsaturated esters [2] in the range of C_{34} to C_{50}. Jojoba plant is native to the Sonoran desert and it is extremely tolerant to different environments. For example, Jojoba might be cultivated at sea level and at 1500 m altitude [2], showing its versatility at completely different conditions. Jojoba is mostly cultivated in arid and semi-desert zones such as different zones of the US, Israel, Mexico, India and South Africa [1,3]. Jojoba plant oil yield is approximately 1818 kg/ha which is a little bit lower than Jatropha plant (1900–2500 kg/ha) but higher than Camelina (800–1200 kg/ha), which are three of the most important non-edible oils nowadays [3]. Thus, this plant has been used to prevent desertification in some parts of India [4] and therefore it could have a double role: economical and environmental. Many studies have been conducted in order to evaluate the resistance of the Jojoba plant and it has been concluded that it tolerates tough conditions in terms of salinity, drought and heat [5]. Nevertheless, it is important to clarify that Jojoba plant needs to improve its productivity when it is cultivated in the desert, under extreme conditions [5]. The height of Jojoba plant is about 1 m and it is easily identified because of its thick, oval shape, bluish-green leaves and dark brown nut-like fruit [1,4,6].

Approximately, 50% of the seed's dry weight comprises Jojoba oil [7], which is a mixture of monounsaturated C_{20} and C_{22} alcohols and acids where the double bond is situated at each side of the ester bond. Jojoba oil composition is unique among the rest of the vegetable oils because of the almost complete absence of glycerine [8]. The particularities associated to this oil had been already known in the past when traditional cures were used to treat diseases such as sunburn, renal colic, chaffed skin, hair loss, headache, wounds and sorethroat [9]. In addition, Jojoba oil is a unique source of straight monounsaturated alcohols such as 11-eicosenol, 13-docosenol and 15-tetracosenol, which they are classified as high-added value products. As it was mentioned, Jojoba oil is formed by a mixture of esters, which confers to this peculiar oil many different properties such as suitability for sulfurization, high dielectric constant and ease to hydrogenate [1]. Thanks to these properties, Jojoba oil could be used in many different industries [10] such as in cosmetics, pharmaceuticals, lubricants, heating insulators, foam control agents, high-pressure lubricants, heating oil, plasticizers, fire retardants, transformer oils and many more [2].

In order to achieve a panoramic view of the current situation of Jojoba oil in terms of economy, extraction process, direct use and blending, transesterification process, product properties and future opportunities of this oil, the available literature has been thoroughly reviewed. This article will underline the current situation regarding Jojoba oil in order to determine its future applications, waste generated from extraction process and its possible utilization.

2. Jojoba oil and derivatives

From an economic point of view, the Jojoba oil market is stronger than ever because their applications do not stop increasing, especially in the cosmetic and pharmaceutical industries [11]. Many researchers are realizing about the great difference between this unique oil and the rest of vegetable oils. Therefore, it is expected that worldwide Jojoba oil production will grow sharply in the next few years as shown in Fig. 1 [5,12–14]. This fact can be confirmed taking into account the estimated Jojoba oil demand in the world, that it is approximately 200,000 tons [15,16] which is enormously higher than the current production.

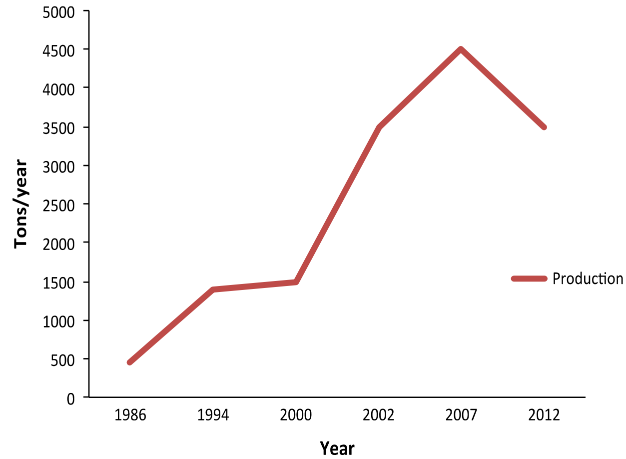

Fig. 1. World total Jojoba oil production.

In addition, the use of Jojoba meal after the extraction process is being thoroughly studied, especially its main component named Simmondsin, in order to increase the global interest of the Jojoba cultivation. Simmondsin reduces the food intake because it induces a satiation process which can be avoided by its simultaneous use with a specific receptor antagonist [17]. The study conducted by Cokelaere et al. [17] proved that the anorexic effect of the Simmnondsin is associated to mild pancreatic hypertrophy and stimulation of the interscapular brown adipose tissue. This fact was confirmed by Ham et al. [18] when they tried two different concentrations of Jojoba meal and were added to the diet of Beagle dogs. When 2.7% of Jojoba meal was part of the diet the dogs did not suffer reduction in their body weight and the food was completely digestible. However, the body weight and the digestibility of the food were affected at 8.1% dose [18]. As it was presented, 50% of the seed is transformed to Jojoba meal after the extraction process [1] and therefore some applications should be taken into account in order to make the most of this waste. Jojoba meal is rich in proteins (32%) and that is why it has been used as animal feed even though it is formed by 15% of toxic glycosides [19,20]. Many researchers have focused their attention on this waste in order to obtain high-added value products. For example, Abbassy et al. [21] isolated two glucosides from the seeds of Jojoba plant (simmondsin and simmondsin-2′-ferrulate) which have insecticidal activity against spodoptera littoralis, antifungal activity against pathogenic fungi and antifeedant properties as it has been tested in other studies [22–24]. Moreover, it has been proved by Al-Anber et al. [25] that the use of defatted Jojoba can succeed in the removal of methylene blue from aqueous water which is a harmful contaminant with an associated serious environmental impact. Another study was conducted by Harry-O'Kuru [26] and it consisted of the extraction of two simmondsin analogues DMS (Dimethylsimmondsin) and DDMS (Didemethylsimmondsin). These analogues have olefinic functional groups, easily converted to epoxides, which are intermediates with further potential uses such as plasticizers, aerosols, insecticides, epoxy resins or coatings. Finally, Jojoba meal can be used as biomass because it has a high heating value (15.34 MJ/kg), and it also can be used in an anaerobic digestion for obtaining biogas from this waste (600 ml per 400 g of Jojoba meal) [27,28].

2.1. Extraction process

Mechanical pressing of the Jojoba seeds together with a hexane extraction of the pressed Jojoba meal is the traditional way to obtain Jojoba oil [10]. The combination of the mechanical pressing