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Research Article

Biotechnology of Traditional Cold Pressing of *Hibiscus Sabdariffa* Seed Oil from Senegal

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Abstract

In recent years, the increasing awareness of health benefits associated with natural oils has led to a burgeoning demand for seed oils of plants such as hibiscus. This plant is well known for the richness of its oil in nutritional and bioactive compounds used in medicine and cosmetics. Oil extraction is one of the most critical steps in seed oil production, because it is linked to the quality and the quantity of the extracted oil. These processes play a pivotal role in ensuring the production of high quality of vegetable oils derived from seeds. Cold press oil extraction is more environment friendly than other oil extraction methods as it preserves the natural flavor, aroma, and nutritional content of the oil. Here, the cold pressing method was used to optimize oil pressing from hibiscus seeds. The carefully selected and dried seeds were directly introduced into a semi-automatic device consisting of a cylindrical screw press at approximately 50 ℃, which allowed the oil and seeds to be recovered separately. The collected oil is then left to settle overnight before being filtered and stored in clean, dry containers. The oil content of the seeds was evaluated by comparing the mass of virgin oil obtained with that of the crushed seeds and gave a yield of about 17.87%. The natural and harmless potential of this traditionally pressed hibiscus oil allows it to contribute to the prevention of many diseases and to promote human health and well-being. At the same time, many by-products, including oilseed cakes, were obtained, constituting a basic feed for animals.

Keywords

Hibiscus Sabdariffa L, Cold Press Extraction, Vegetable Oil, Seed Cakes, Senegal

1. Introduction

Hibiscus sabdariffa is a small, hardy plant that has grown in tropical and subtropical areas, particularly in Asia, Africa and Latin America [1]. *Hibiscus sabdariffa*, commonly known as roselle, is an ideal crop for developing countries as it is relatively easy to grow and can be used as food and fiber. The plant is extensively cultivated for its edible calyces, which are used in beverages, food, and traditional medicines [2]. In Africa, particularly in countries like Senegal, and Nigeria, the plant is traditionally used for its medicinal properties and as a source of nutritious beverages [3]. Similarly, in Asia, especially in India and Thailand, hibiscus is cultivated both for its flowers and its medicinal benefits, such as antihypertensive

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and antioxidant effects [4]. The persistent red calyx of the hibiscus houses the round fruit, which contains a large number of tiny seeds. When ripe, the fruit splits open to reveal the seeds. Although *Hibiscus sabdariffa* has been widely studied for its calyxes, very little writing has focused on the potential of the oil and cakes contained in its seeds cultivated in Senegal. Typically, hibiscus seed oil contains a high percentage of unsaturated fatty acids, primarily oleic, linoleic, and linolenic acids, which contribute to its nutritional and therapeutic properties. Additionally, it includes phytosterols such as β-sitosterol, campesterol, and stigmasterol, as well as antioxidant vitamins like tocopherols (vitamin E), which enhance its stability and health benefits [5, 6]. The process of separating oil from oilseeds is referred to as extraction. Extraction is typically performed using a variety of chemical, biochemical and mechanical methods to maximize yields, shelf-life and sensory qualities while minimizing alterations [7]. It is the most important part of oil processing and depends on the part that contains the oil, which is the kernel, the seed, or the pulp [8]. The separation of bio-active compounds of interest in different industries such as food and pharmaceutical often employs the use of large amounts of solvents (water, n-hexane, ethanol, chloroform, methanol, petroleum ether, etc.). Over the last decades researchers have concentrated lots of efforts on the design of efficient and more sustainable methods of extraction which are less detrimental to the environment [9]. Extractions have moved from the conventional solvent to improved mechanical and conventional techniques such as supercritical fluid extraction, extraction assisted by ultrasound, microwaves and cold mechanical pressing which is more used in Africa [10, 11].

The aim of this work, is to optimize the quality and the quantity of seeds oil from hibiscus cultivated in Senegal, by a traditional extraction method using a mechanical screw press powered by a 2.2 kW and to collect oilcake as animal feeds. It focuses on the entire biotechnology of oil processing, from seed harvesting until the production of virgin hibiscus oil.

2. Materials and Methods

2.1. Origin of Samples

The plant material (*hibiscus sabdariffa* seeds) used was harvested in fields in the Kaolack region, located at center-west of Senegal (14° 30' and 16° 30' West and 13° 30' and 14° 30' North). It is a region of Sudano-Sahelian climate, with an annual rainfall of 800 to 900 mm, from July to October (Figure 1). The region is also characterized by a wide variety of vegetation, including dense shrub savannah in the north and forest savannah in the south and southeast [12].

Figure 1. *Geographical location of the Kaolack region.*

2.2. Plant Material

hibiscus sabdariffa L. seeds were collected in January 2024 in Kaolack in the west-central Senegal. Hibiscus sabdariffa seeds are harvested at the end of the rainy season, when the calyxes are dried and the capsules have reached full maturity, usually in October (Figure 2).

a) b) c)

Figure 2. *The aerial parts of Hibiscus sabdariffa L a) calyxes; b) pods; c) seeds.*

2.3. Harvesting Seeds

This degree of maturity is visible by the change in color of the capsules, indicating that the seeds are ready to be harvested. It is essential to intervene before their natural hatching in order to avoid their dispersal [13]. The change in color, from green to red and sometimes yellow, is the primary criterion for determining fruit maturation. The traditional harvesting of *Hibiscus sabdariffa* seeds typically involves manual collection once the seed capsules or pods have fully ripened and turned to a mature color, often red or brown. Harvesting is usually done by hand to ensure the seeds are not damaged, followed by drying the seeds in the sun to reduce moisture content before storage or processing [14]. It is the action of friction or mechanical effort that allows the capsules to be broken and the seeds to be effectively separated. This method is common in many traditional cultures where mechanized harvesting is less accessible.

2.4. Seed Cleaning and Drying

The harvested seeds are first cleaned to remove impurities such as dirt, plant debris, stones, and damaged seeds (Figure 3). Winnowing with an air jet can also complement this process to remove defective seeds and shell remnants [15]. This ensures high quality oil extraction. The cleaned seeds are then sun-dried for three days, to reduce moisture content, which helps prevent microbial growth and spoilage during storage and extraction [16]. Calculating the dry weight of the seeds then makes it possible to evaluate the yield characteristic of the quality of the seeds.

a) b)

Figure 3. *a) untreated seeds; b) cleaned seeds.*

Before beginning the cold pressing of hibiscus seeds that are very hard or strong, a pre-treatment process is often necessary to improve oil extraction efficiency.

2.5. Seed Soaking

Soaking the seeds in warm water for four hours softens the seed coat, making the seeds easier to crush and extract oil (Figure 4). This soaking of the dry seeds allows to considerably increase the quantity and quality of the extracted oil [17].

Figure 4. *Soaking process in warm water.*

Unlike moringa, hibiscus seeds do not require roasting. The soaked hibiscus seeds are cold-pressed directly.

2.6. Seed Pressing

The prepared seeds are loaded into the feed hopper of the screw press. The screw press is a cylindrical device equipped with a rotating screw shaft that applies pressure to the seeds (Figure 5). The mechanical action compresses the seeds between the screw shaft and the barrel wall, exerting high pressure. The pressure causes the oil to be expelled from the seed cellular structure, flowing through the gaps and being collected in a designated container or outlet. The process is typically maintained at low temperatures (hence “cold” extraction) to preserve the bioactive compounds, vitamins, and natural flavors, while maximizing yield [18]. A mass of 30 kg of clean seeds was introduced into the screw press, which was put into operation for a little over half an hour. At the end of extraction process, 22.3 kg of hibiscus seed cake were obtained, in addition to a certain quantity of crude oil to be purified.

a) b) c)

Figure 5. *a) Screw press, b) crude seed oil (c) and seed cakes.*

After cold pressing of hibiscus seed oil, the purification

process typically involves several steps to remove impurities and improve oil quality:

2.7. Oil Purification Process

The crude extracted oil is transferred to a container and left undisturbed for about one night. During this period, heavier impurities such as seed particles, sediments, and some residual moisture settle at the bottom, allowing clearer oil to be separated from the sediments [19]. After decantation, the clarified oil is carefully decanted or siphoned off from the top, leaving behind the sediment and impurities at the bottom of the container. The decanted oil is then passed through a funnel fitted with a fine filter to remove any remaining fine particles or debris [20]. The result is a cleaner, higher quality oil suitable for storage or later use, such as consumption, medicine or cosmetics (Figure 6).

After all these operations, a mass of 5.36 kg of virgin hibiscus crude oil was obtained. Extraction yield was calculated, using the following formula:

$$Y\ (\%) = \frac{M_o - M_1}{M_s} 100$$

Mo: represent mass of the container with extracted virgin oil after purification process.

M_1: represent mass of the empty container.

Ms: represent mass of clean hibiscus seeds.

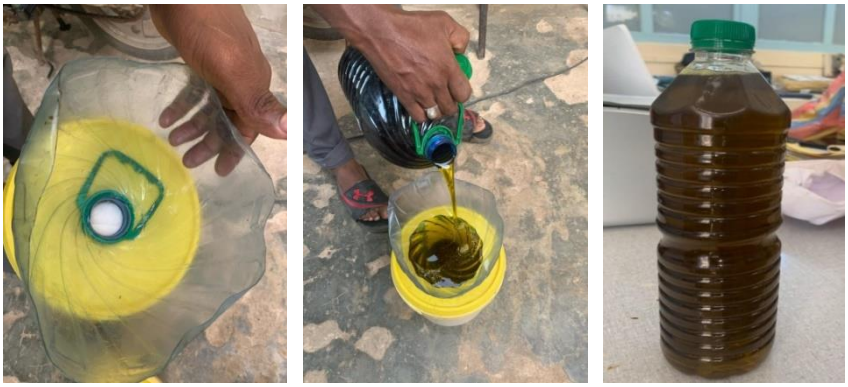

Figure 6. *Oil filtration process after decantation.*

3. Result and Discussions

3.1. Virgin Oil Yield

This screw press extraction technique, generally used in agricultural campaigns in Senegal, can be considered a cold extraction technique as long as the temperature does not exceed 50 ℃. The extraction yield of oil from hibiscus seeds is 17.87%. The average value of oil content in hibiscus seeds is usually between 15 and 22% [21, 22]. It depends on several physicochemical parameters, such as extraction temperature, duration, seed preparation and particle size. Each factor plays a crucial role in maximizing oil recovery while preserving the quality.

Elevating the extraction temperature generally increases oil yield by reducing viscosity and enhancing mass transfer. However, excessive temperatures can cause thermal degradation of sensitive bioactive compounds, affecting oil quality [23].

Drying seeds to optimal moisture levels (below 10%) improves yield and shelf stability [20]. Studies have shown that soils with optimal fertility, particularly nitrogen, phosphorus, and potassium lead to better seed weight, oil yield, and biochemical composition [23].

Rainfall and climate have also an influence as drought stresses can reduce seed size, seed oil content, and alter biochemical profiles [24]. In addition, optimal growing conditions are crucial for maximizing the yield, shelf-life and quality of *hibiscus sabdariffa* seed oil.

Timely harvesting, typically when seeds are fully matured and dried, prevents seed loss and deterioration. Manual harvesting allows more careful selection and reduced damage, while mechanized harvesting can increase efficiency but may cause seed bruising or breakage if not done properly [13].

The interplay of all these factors determines the efficiency and sustainability of the extraction process.

The rather interesting yield of the study [21] could be correlated with the nature of the soil and the average rainfall in this part of the country. Moreover, this region, nicknamed the peanut basin of Senegal, is also the preferred cultivation area for peanuts, another oilseed crop [12]. In this area, mechanical screw press is often used with a lot of crops such as hibiscus, peanut, cotton and jatropha.

Advantages of mechanical extraction include the production of good quality oil which are safer for food applications, even if the yield is lower than with traditional toxic solvents.

The best cold-pressed oils retain the flavor, aroma, and antioxidant properties of bioactive molecules, making them ideal for skin care and cooking. Antioxidants help protect against tumors and infections [25].

In addition, furthermore, unlike other extraction techniques, mechanical extraction makes it possible to obtain cakes used in livestock feed.

3.2. Hibiscus Seed Cakes

Hibiscus seed cake, also known as meal or residual meal, is a valuable by-product obtained after the mechanical pressing of hibiscus seeds for oil extraction. It has garnered significant interest due to its potential as a rich source of protein, fiber, and bioactive compounds, making it suitable for use in animal feed, fertilizer, and even human nutrition in certain contexts [26].

The seed cake is particularly notable for its high protein content, which typically ranges between 20-40%, depending on the seed variety and processing conditions [23].

Its digestible protein makes it a favorable alternative to conventional animal feed ingredients, especially in regions where traditional feed resources are limited or expensive.

Additionally, hibiscus seed cake contains residual oil, which may still possess bioactive compounds such as antioxidants, bioflavonoids, and phytosterols, potentially imparting health benefits when included in animal diets or as functional food components [27].

Moreover, the seed cake is a good source of fiber, which contributes to gastrointestinal health and improves the feed's overall nutritional profile [28].

Its residual elements, such as minerals like calcium, magnesium, and potassium, can also augment its nutritional value for livestock and possibly for human consumption after proper processing. The utilization of seed cake aligns with sustainable agricultural practices by reducing waste and promoting resource efficiency, thereby supporting environmental conservation efforts.

Research indicates that incorporating hibiscus seed cake into animal feeds can improve growth performance, feed conversion ratios, and overall health status of livestock [19] Furthermore, due to its antioxidant properties, it may help in reducing oxidative stress related to intensive farming.

4. Conclusion and Perspectives

The potential of *hibiscus Sabdariffa* seed oil and meal from Senegal was investigated using screw press extraction techniques. *Hibiscus* seeds have undergone the entire classic processing chain, from harvesting to purification, including cleaning, drying, soaking and pressing. This cold extraction gave not only an interesting yield in accordance with the literature, but also a large quantity of hibiscus seed cake was also obtained. This cold screw pressing technique, commonly used in the peanut basin in Senegal, offers an ecological and efficient method for extracting oil from plant seeds, such as peanuts or hibiscus. Simultaneously, the seed cake, a by-product of oil extraction, is a promising source of high-quality protein, dietary fiber, and residual bioactive compounds. Its utilization in animal feed, dietary supplements, or as a natural fertilizer aligns with sustainable practices by reducing waste and adding economic value to hibiscus cultivation. Further research into processing methods, safety, and the bioavailability of its nutrients will enhance its applications and promote circular economy principles within the agri-food industry.

Abbreviations

ANSD National Agency of Statistics and Demography of Senegal

Author Contributions

Dramé Abdoulaye: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – review & editing

Faye Ibrahima: Conceptualization, Investigation, Project administration, Writing – original draft, Writing – review & editing

Diouf Djibril: Conceptualization, Formal Analysis, Supervision, Validation, Visualization

Faye Mada: Data curation, Investigation, Visualization, Writing – original draft

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Dick Brahim: Formal Analysis, Resources, Supervision, Validation, Writing – review & editing

Sy Oumar Mamadou: Formal Analysis, Resources, Supervision, Validation, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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