International Journal of Advanced Research in Engineering Technology & Science

ISSN: 2349-2819

Email: editor@ijarets.org Volume-9, Issue-11 November – 2022 www.ijarets.org

SOLVENT EXTRACTION IN ORGANIC SEEDS – A CASE STUDY

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ABSTRACT

For the world's population to be nutritionally secure, organic seeds are essential. Solvent extraction is the traditional method used to extract organic material from organic seeds. Because of its characteristics, including its non-polar nature, low latent heat of vaporization (330 kJ/kg), good solvent selectivity, and ease of recovery, n-hexane is utilized as a solvent in solvent extraction. But using hexane as a solvent has had a number of negative effects, including air pollution, toxicity, and harmfulness, which has made people search for other solutions. Green solvents might be a viable solution in lieu of solvent extraction to get around the issue. According to this study, water aided enzyme extraction and green solvents are superior methods for extracting organic materials from organic seeds. Enzyme-mediated extraction helps to get co-products without causing any harm and is economical, eco-friendly, and capable of producing larger yields. In the organic seed sector, enzyme technology has significant promise for organic extraction. Similar to this, green solvents with exceptional solvent qualities, such terpenes and ionic liquids, make it possible to extract organic materials in an environmentally responsible way. The energy-saving, environmentally friendly, non-toxic, and non-harmful qualities of these green technologies and solvents make them such. As a result, the evaluation primarily focuses on the potential applications and difficulties of green solvents and technology as the ideal substitute for traditional techniques without sacrificing the quality of the extracted goods.

Keyword's: *Organic seeds, hexane, technology*

INTRODUCTION

One method of achieving solvent extraction is to crush the seed. The oil in the crushed seed is then released by purging or washing it with a petroleum distillate (hexane is the most often employed chemical). The oil is then heated in an enclosed room to "flash off" the solvent. The solvent is then removed from the oil/solvent mixture by heating it to 212º F (100º C). Hexane is the recommended solvent for solvent extraction, a chemical oil extraction technique used to extract oil from nuts, seeds, and vegetables. The solvent extraction stage of industrial oil processing, which may or may not come before pressing, is often included in the edible oil processing process. Processes based on hexane have long been used in the business world. When using these techniques, oil yields over 95% may be achieved with solvent recovery above 95%, as opposed to 60–70% oil yields when using the mechanical expeller pressing method. With the exception of around ½% of leftover oil, the solvent extraction technique consumes less horsepower and needs less maintenance. The main method for extracting massive amounts of oil from protein meal is solvent extraction since it is comparatively dependable and effective.

Applications of the solvent extraction method

- For the production of vegetable oil, biodiesel, and fragrances, solvent extraction is used.
- It is also used in the process known as nuclear reprocessing, which is used to recover plutonium from radioactive nuclear fuel.
- Nuclear fuel may then be produced again using the recovered plutonium.

Liquids that are immiscible split into layers when shaken together and cannot be blended together. Typically, these liquids consist of an organic solvent and water. The process of transferring a substance from one solvent to another due to the difference in distribution coefficient or solubility between these two immiscible (or marginally soluble) solvents is known as solvent extraction. It is a technique for quantitatively separating substances. The solute from the original solvent is transported into an extracting solvent when the extracting solvent and solute-containing solution are mixed together. Once the stirring is stopped, the extracting solvent separates and becomes a layer containing the solute of interest. It provides a greater degree of selectivity and quicker mass transfer than the ion exchange technique, and it performs better in terms of separation than chemical precipitation. Solvent extraction offers many benefits over distillation, including low energy consumption, high production capacity, quick action, simple continuous operation, and simplicity in automation.

Method of Solvent Extraction for Edible Organic

Hexane is the recommended solvent for solvent extraction, a chemical procedure used to extract organic materials from vegetables, organic seeds, and nuts. The solvent extraction phase, which may or may not come before pressing, is often included in industrial organic processing for the edible organic product. Processes based on hexane have long been used in the business world. In contrast to the 60–70% organic yield obtained by the mechanical expeller pressing technique, such methods may provide organic yields exceeding 95% with solvent recovery exceeding 95%. With the exception of around ½% of leftover organic material, the solvent extraction process consumes less horsepower and needs less upkeep. The main method for extracting massive amounts of organic from protein meal is solvent extraction since it is comparatively dependable and efficient.

Plant for Extracting Solvents

With a solid reputation worldwide, KMEC is the top supplier and producer in China for edible organic manufacturing and solvent extraction. We provide comprehensive solutions for solvent extraction plants, including everything from everyday operations to plant design. KMEC can always locate the most appropriate relevant solvent extraction equipment for you thanks to its years of practical expertise. With cutting edge solvent extraction equipment, a staff of knowledgeable experts, and trained labor, we guarantee that our customers get only the highest caliber goods at the most affordable costs!

Workshops for Solvent Extraction Plants

Thus far, we have assisted in the establishment of several solvent extraction projects for diverse vegetable organic seed and nut raw materials. Below, we'll take you through a few of the extraction workshops.

In general, when the organic seed comprises more than about 23% organic, a pre-press system followed by solvent extraction may be an alternative. The pressing operation eliminates the larger percentages of organic, which are by far the simplest to squeeze out of the solids, and the solvent extraction method is excellent at eliminating organic from around 20% down to almost 0.5%. This combination incorporates the greatest features of each system. It is important to note that a rapeseed processing plant that uses prepressing and extraction will frequently reduce the organic content from roughly 40% to 20% in the presses and from 20% to 0.8% in the extraction. Additionally, the press organic produced may be approximately 25.8% of the raw seed, while the extraction organic may be approximately 13.7% of the raw seed (after adjustments for moisture changes during the process). Press organic will comprise most of the organic.

Rapeseed contains over 40% organic content, while soybeans have approximately 20% of its weight in organic matter. Pre-pressing is often necessary as an additional step for higher organic goods. In other words, it is challenging to sufficiently flake the organic seed and boil it for solvent extraction without the organic separating from the seed and clogging machinery due to the high organic content. Moreover, the 40% organic content would need much more energy than is ideal for extracting the solvent from the miscella. In order to effectively prepare the high organic seeds for the extraction process, the screw press technology is used prior to extraction. Pre-press systems are used before extraction for the majority of high organic percent seeds; this is due in part to greater plant optimization or balance, as well as to practical experience. Common examples of these seeds include rapeseed, canola, sunflower, safflower, and similar ones.

OBJECTIVE

1. To Research the Extraction of Solvents from Organic Crops
2. To Research the Use of Green Solvents for Organic Extractions

CLASSICAL ORGANIC RESEARCH

Hydraulic pressing, expeller pressing, and solvent extraction have all been used in conventional organic seed extraction (SE). Solvent extraction is one of these techniques that has been extensively used for practical and financial reasons. The organic seeds are prepared (flaked, cracked, powdered, or pressed) in order to maximize the organic recovery using solvent extraction. Hexane is used in the SE process to wash organic seeds, and then evaporation and distillation are used to extract the hexane from the organic material. Due to its high solubilizing ability, narrow borganicing point (63–69 °C), and ease of organic recovery, hexane has been utilized extensively for organic extraction.

On the other hand, hexane released into the environment during the extraction and recovery procedures reacts with the contaminants to produce photochemicals and ozone. Furthermore, due to its solubility in brain lipids, hexane has been shown in several studies to have an adverse effect on the human nervous system when breathed. Piglets given de-fatted food that included leftover hexane after the treatment have shown signs of toxicity. Therefore, the need to find an alternative to n-hexane without sacrificing organic yield has arisen due to health, safety, and environmental concerns. Therefore, technology combined with environmentally friendly solvents is a good substitute for organic extraction.

The goal of green technology and solvents is to provide an environmentally friendly extraction procedure for organic materials while also reducing pollution. Therefore, green technologies like aqueous enzymatic extraction (AEE) in conjunction with environmentally friendly solvents have enormous potential to replace n-hexane without sacrificing the process's ability to recover organic material. In order to comprehend the benefits and drawbacks of the technology, a thorough explanation of the possibilities and problems presented by AEE has also been provided.

Green solvent extractions (GS) for organic materials

Green solvents come from petroleum sources, which have similar excellent solubilizing qualities to traditional solvents, or from naturally occurring sources like water and carbon dioxide from agriculture. The organic sector has been greatly impacted by recent improvements in "green" techniques, primarily due to terpenes, or green solvents (d-limonene, p-cymene, and α-pinene). Isoprene units (C5H8), which make up terpenes, are mostly obtained from agricultural sources. For instance, orange peels are the source of the widely used compound d-limonene. Analogously, α-pinene and p-cymene originate from pine forests and tree organic matter, respectively. It's interesting to note that these solvents dissolve similar compounds well due to their excellent Hansen solubility characteristics (HSP). Hansen postulated three characteristics, also known as Hansen properties, based on the energy of dispersive (δd), dipolar (δd), and hydrogen bond forces (δh) between molecules to define the behavior of a particular solvent [8]. According to a research, terpenes have the same properties as n-hexane, which supports their capacity to dissolve similar compounds. Furthermore, since terpenes have a higher flash point than n-hexane, they have significantly more dissociating power owing to a tiny variation in dielectric constant.

Ionic Solutions

Ionic liquids are non-aqueous salt solutions that may be kept liquid at moderate temperatures (0–140 °C) and include both anions and cations. Ionic liquids are used in the petroleum and organic industries, where they are regarded as green solvents or green "designer" solvents due to their many uses. Ionic liquids are environmentally benign because they don't produce any pollution since they don't have any measurable vapor pressure. These also don't catch fire and can withstand a large temperature range in their liquid condition. These solvents have made it possible to build an appropriate solvent with particular conductivity, hydrophobicity, polarity, and solubility dependent on the composition of the solute for effective recovery since they contain both the ions and adaptable physico-chemical features. It's interesting to note that 600 different molecular solvents were used in different procedures due to these characteristics.

Ionic liquids were used as solvents in the catalysis, extraction, and synthesis of several kinds of chemicals. They may also be employed as a biphasic system separation medium, an enzyme co-solvent, and a medium for multiple processes. There aren't many studies on the use of ionic liquids for organic extraction, thus further research is needed to confirm the practicality from both a technical and financial standpoint. Ionic liquids from Schisandra chinensis Baill fruit were used in a study by Ma et al. to extract important organics. The results showed that utilizing an ionic liquid in conjunction with a microwave might save time, energy, and be more environmentally friendly. In another investigation, the ionic liquid was used as a co-solvent for the one-step bio-organic extraction of microalgae. But according to a meta-analysis research, the ILs must be carefully selected and their negative effects must be understood. While this approach shows promise, additional research is required to support the theory of organic extraction from ionic liquids. Switchable solvent, another promising green solvent, has shown promise for organic extraction from soy bean flakes. Furthermore, there is a need to research the application of super critical fluid, deep eutectic solvents, natural deep eutectic solvents, and supramolecular solvents in organic extraction, since they are gaining popularity.

Aqueous Extractions

In the organic seed extraction business, hexane (or n-hexane, the isomerized version) is the most often employed organic solvent because of its cheap cost, low heat of vaporization, low borganicing point (63–67 °C), recyclability, and efficiency in organic recovery. The most popular organic vegetable in the United States is soybean oil, which is produced specifically using hexane extraction. Hexane is dangerous for workers in food processing facilities because it is explosive. Moreover, it may pollute the environment and is a dangerous air pollutant and neurological toxin. Hexane is prohibited from being used in the manufacturing of certain foods, such as all organic foods, even if it is possible to reduce these worries with appropriate safety measures. There is proof that vegetable organics contain hexane residue in the range of 1 ppm and that soy components may have up to 21 ppm. The European Union (EU) forbids hexane residual levels over 10 parts per million (ppm), while the Food and Drug Administration (FDA) has not established maximum hexane residue standards for soy foods. Other hexane residue limitations that change based on the food product have also been imposed by the EU.

While there are several instances of co-solvents being used in solvent extractions, we will only be discussing single solvent extractions in this article. Research has been done on ethanol, a natural, non-toxic solvent that is permitted in the manufacturing of organic food, as an alternative to hexane. Since ethanol is more polar than hexane, it can extract more polar substances including pigments, soluble carbohydrates, and polyphenols. When extracting sunflower collets (ground organiccake or expanded material), the advantages of utilizing ethanol over n-hexane were shown by the 32% and 23% yields of extracted material (organic and other compounds), respectively. When ethanol extraction was used instead of n-hexane, sunflower collets' tocopherol and phospholipid extractability increased by 38%. Hexane and ethanol extracts from castor seeds had similar organic yields; however, the ethanol extract contained a notably greater concentration of sterols than the hexane extract.

Extra critical CO2 Recovery

Over the last several decades, SCO2 technology has advanced, and as of 2014, there were over 150 supercritical fluid extraction facilities worldwide, the majority of which were in North America and Europe. SCO2 is a versatile tool that can be used for a range of food matrices, including apricot, canola, soybean, sunflower, grape, acorn, and walnut seeds. It is also used to decaffeinate coffee and tea and extract organics, antioxidants, natural food colorings, aromas, and flavors. Pressurized CO2 solvent is combined with solid raw material (often crushed to minimize particle size) during SCO2 extraction, enabling the extraction of the desired chemicals. At its critical point of 31 °C and 7.38 MPa, when the gas and liquid phases combine to create a homogenous fluid phase beyond the supercritical fluid region, a pressured CO2 solvent starts to develop. Higher diffusivity, reduced viscosity and surface tension, and quicker extraction periods are some of the benefits of SCO2 extraction over traditional solvent extraction techniques. Utilizing CO2 also assists the environment since it is recyclable and nonflammable. Because it leaves no residue and maintains the high purity of the extracted components, it enables better product quality. When compared to solvent extraction, it is often seen as a "greener" extraction technique because of these factors.

However, using SCO2 comes with a number of risks. Polar phytochemicals, like phenols, have limited extraction capacities due to CO2's non-polarity. Because it requires high-pressure equipment, which raises the expense of both initial investment and ongoing maintenance, this extraction technique is also costly [48]. Furthermore, continuous systems are needed and lacking in order to increase large-scale manufacturing capacity. These explanations explain why the food sector has not been using this extraction process as widely as it might. Although SCO2 offers advantages over other technologies, its lack of economic competitiveness is a significant barrier to its advancement.

Depending on the kind of seed and compounds of interest, the best SCO2 extraction parameters for pressure, temperature, solvent flow rate, material size, and moisture content must be chosen. Raising the temperature from 40 to 60 °C had no discernible effect on the extraction yield for organic hemp seed, however raising the pressure shortened the extraction time (4.5 hours at 30 MPa vs. 3.5 hours at 40 MPa). By reducing the particle size and increasing the temperature, flow rate, pressure, and extraction time, the organic extraction of peach seeds was enhanced. A 35% organic yield was obtained by applying SCO2 to 0.3 mm powdered peach seeds for three hours at 40 °C, 20 MPa, and 7 ml/min. This was within the stated range for solvent-extracted peach seeds.

CONCLUSIONS

The food business has prioritized sustainability and reducing food waste, which has led to an increase in the promotion of a circular, green economy. Constructing useful byproducts is one method of reducing waste. Converting specialty seeds into palatable organic foods for human consumption has been a goal. Whichever of the several extraction techniques now in use is used should be chosen after taking into account a number of criteria, including sustainability of the environment and profitability. Hexane extractions are thought to be feasible substitutes for ethanol and SCO2 extractions. Furthermore, compared to the conventional hexane extraction method, the aqueous extraction of seeds may be done with less environmental dangers thanks to the employment of enzymes. Valorization of co-products and optimization of extraction parameters are necessary for the adoption of environmentally friendly, commercially viable extraction technologies in an industrial context. Consumer interest in sustainable food products is growing, and the specialized organic sector would profit from enhanced extraction techniques backed by eco-economic studies as well as life cycle and environmental impact assessments.

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