AGRICULTURAL AND FOOD PROCESS ENGINEERING

Mechano-Thermal Extraction Model Approach of Evaluating Extract Recovered from Agro-Based Seed Materials for Oil Production

Kingdom Matthew Umah, Wali Obinuchi, Kenneth K. Dagde

Department of Chemical/Petrochemical Engineering, Rivers State University, Port Harcourt, Rivers State, Nigeria

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Abstract

The application of mechano-thermal techniques for production of oil from native pear seed obtained from fruit garden in Port Harcourt Local Government Area of Rivers State, Nigeria and the Native pear seed (raw material) was subjected into washing, drying, crushing (mechanical operation), and distillation (thermal operation). The direct extraction and distillation concepts were combined to operate simultaneously to achieve increase in oil recovery from the process. The operational conditions considered in this research include temperature effect, mass of the raw material introduced into the distillation unit expressed in terms of initial concentration, final concentration after the raw materials has undergo the mechano-thermal treatment and the volume of oil extracted or recovered at the end of each process. Extraction model approach was integrated in the process and the obtained results revealed decrease in raw material utilization with increase in the volume of oil recovered as well as the final concentration of the product. The useful parameters considered from the extraction model used include the extraction time, area of extract as $3.4159 \times L^2$, Length of cylinder containing the extract (30 mm), volume of extract, thickness of extract, initial concentration of feed, and diffusion Coefficient of 1.12×10^{-8} m^2. This has shown that the functional parameters of the extraction model influence the characteristics of the end product as well as properties of the oil to be recovered from the process.

Keywords: mechano-thermal; extraction; model; oil recovery; agro-based seed materials; native pear seed; oil production

1 Introduction

Solvent-based extraction, particularly through the use of the Soxhlet apparatus, has long been a widely adopted technique for isolating oils from seeds. However, the present study emphasizes an emerging approach known as the **mechano-thermal extraction technique**. Unlike conventional extraction processes, this method does not involve chemical solvents, steam, or traditional thermal systems. Instead, oil recovery is achieved through controlled mechanical action combined with low-temperature heating and distillation. This approach enables the production of high-quality, natural seed oil while minimizing contamination and degradation. The mechano-thermal method has been observed to offer improved efficiency, operational simplicity, and enhanced yield performance. To evaluate oil quality and composition, physicochemical characterization and gas chromatography analyses were conducted, confirming the presence of essential components suitable for industrial applications. These findings indicate that the extracted oil can serve as a viable raw material for chemical processing, pharmaceutical formulations, and food-related industries [1, 2]. One of the most significant industrial applications of the selected seed oils is their potential use as feedstock for biodiesel production.

Growing uncertainty surrounding the long-term availability of fossil fuel resources has intensified the global search for renewable and sustainable energy alternatives. In response, selected seed oils have been identified as promising raw materials for biodiesel synthesis through methanolysis. In earlier studies, seeds were sourced locally, air-dried, and oil extraction was performed using n-hexane [3]. At present, the majority of global energy consumption is still derived from non-renewable fossil fuels such as petroleum, coal, and natural gas. These resources are finite and subject to eventual depletion. Additionally, fluctuations in fuel prices, monopolistic control of crude oil markets, and recurring energy crises linked to industrial and technological growth further justify the urgent need to diversify energy sources. Consequently, sustained research efforts are being directed toward the development of affordable, renewable, and environmentally friendly energy alternatives [4].

The increasing global emphasis on sustainable development and environmental protection has accelerated research into biotechnology-driven fuel alternatives. As a result, there is heightened interest in clean and renewable energy systems, including biomass, solar, wind, hydroelectric power, geothermal energy, and hydrogen fuels, among others [4]. Renewable fuels present significant opportunities to mitigate environmental challenges such as air pollution and climate change while promoting long-term energy sustainability [5]. Moreover, excessive reliance on petroleum-based energy, combined with rising global energy demand, suggests that future supply may be insufficient. This has necessitated extensive research into vegetable oils and their derivatives as alternative engine fuels.

Biodiesel represents one of the most promising renewable fuel options, as it is derived from biological sources such as vegetable oils and animal fats [6]. It is a biodegradable, oxygenated, ester-based fuel that burns cleanly and can be synthesized from both virgin and waste oils. The production process, commonly referred to as transesterification or alcoholysis, involves reacting oils or fats with short-chain alcohols—most often methanol or ethanol. Converting vegetable oils into biodiesel significantly improves fuel characteristics by lowering viscosity and enhancing volatility. Depending on the alcohol used, the process may be classified as methanolysis or ethanolysis, and it can be conducted using catalytic systems or non-catalytic supercritical conditions. Although several seed oils have been explored for biodiesel production, competing applications in food and industry have limited their large-scale commercial adoption [7]. This challenge highlights the need to investigate underutilized seed oils as alternative biodiesel feedstocks.

Globally, the annual production of *Carica papaya* exceeds 10 million metric tons, positioning papaya among the most economically important fruit crops. While the edible pulp is consumed by humans and the leaves are used as livestock and fish feed, the seeds and their oil remain largely underexplored and underutilized [8].

The diversity of pear varieties across regions is extensive, with each geographical area possessing unique cultivars. Historical accounts describe collectors who cultivated dozens of distinct pear types within a single orchard, illustrating the vast genetic and morphological diversity of the fruit. Given the sheer number of varieties, detailed descriptions of each would be impractical; therefore, only representative forms are typically discussed using both Latin and English classifications [9]. Throughout history, pears have carried strong symbolic significance across cultures. In ancient Egypt, the fruit was associated with the goddess Isis, while Christian iconography often linked pears to divine love and compassion [10]. In East Asian cultures, particularly in China and Korea, pears symbolize purity, justice, wisdom, longevity, and moral virtue. Korean folklore frequently attributes pears with qualities such as fertility, good fortune, intelligence, and health, while the delicate white pear blossom

represents feminine beauty and the fleeting nature of life. In Western floral symbolism, pear blossoms signify affection and are associated with birthdays in mid-August. Owing to its shape, the pear has also been viewed as a symbol of the human heart [11].

The distinctive form of the fruit has given rise to the term "pear-shaped" or "pyriform," derived from Latin nomenclature. This shape has influenced design terminology, particularly in gem cutting, where teardrop diamonds are commonly described as pear-shaped. Cultural references to this form appear in literature, music, and popular media, reflecting its enduring aesthetic appeal [12].

The medicinal applications of pears date back to ancient Roman writings. Pliny the Elder noted that raw pears were difficult to digest, particularly for individuals in poor health, but acknowledged that cooked pears—especially when combined with honey—were beneficial to the stomach. Pears were also used in poultices and decoctions to treat inflammation, poisoning, and digestive disorders [13]. Traditional practices further indicate that dried wild pears and pear leaf decoctions were used to manage gastrointestinal conditions, while ashes from pear wood were believed to counteract fungal poisoning [14].

Historical records also describe the physical burden associated with transporting pears and apples, noting their weight as a source of fatigue for pack animals—a challenge reportedly alleviated by allowing animals to consume or inspect the fruit beforehand [15]. Herbalists such as Gerard described pears as cooling fruits with binding properties, particularly effective in treating diarrhea and related ailments [16]. In traditional Chinese medicine, pears are classified as "cold" foods within the yin-yang framework, contrasting with fruits considered warming or neutral. Wild pears were also believed to promote wound healing more effectively than cultivated varieties [17].

Collectively, these historical and medicinal accounts suggest that early scholars may have relied more on inherited knowledge than extensive personal consumption, as some of their characterizations appear inconsistent with modern dietary experience. A native pear tree is shown in Figure 1.

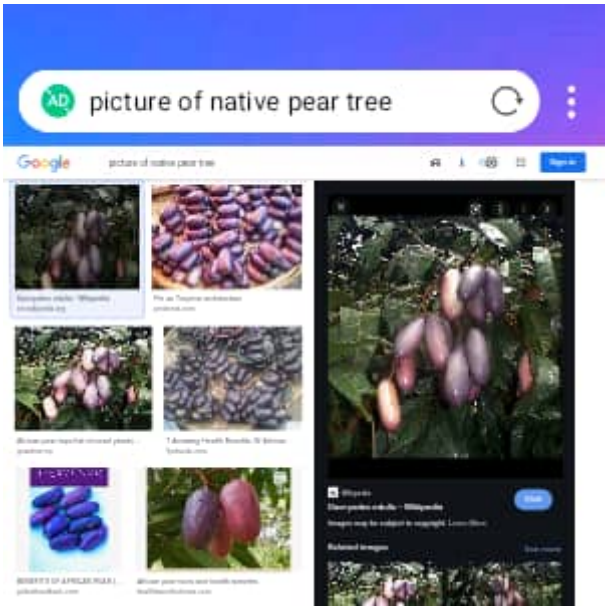


Figure 1. Native pear tree [11].

2 Materials and methods

Mature mango, Avocado and native pear fruits of different species were bought from fruit garden in Port Harcourt city. The fruits were cut into two longitudinal halves and seeds removed by hand. The seeds were cleaned by squeezing the seeds with hand and then allowed to dry for 3 days in a digital Memmert oven at 35 °C in the unit operation laboratory Chemical/Petrochemical Engineering Department Rivers State University Nkpolu-Oroworukwo Port Harcourt. After drying, the seeds were ground using a crushing machine, while grinding, the cake of the various seeds were moist with 250 millilitres of distilled water to 500 g of the seeds to form slurry. After the slurry stage, an extracting machine was used to separate the liquid slurry from the cake. The liquid slurry was introduced into the first distillation flask fixed on the first heating mantle connected with condenser and glass tubing with glass adaptor/corks. Extraction processes were carried out in batches at different temperatures of 50 °C, 55 °C, 60 °C, 65 °C, 70 °C and 75 °C using mechano-thermal distillation/extraction processes. During this first stage, the moisture content and the oil in the seeds is transported to the second flask that was fixed in another heating mantle through the glass tubing. The second stage of distillation/ Extraction processes which is called recovery stage, the distillation was carried out at the temperatures of 45 °C, 50 °C, 55 °C, 60 °C, 65 °C and 70 °C. Condenser, glass tubing/cork was also connected to distillation flask with outlet connected from the top of the distillation flask cork to the receiving flask where the pure oil is received. In this second stage, the moisture content in the oil is separated from the pure oil at different temperatures, time and concentrations by mass. The entire processes went on simultaneously.

A trial soxhlet solvent extraction process was also carried out using hexane as solvent which was compared with that of mechano-thermal process which was carried out without any solvent with respect to oil recovery.

2.1 Apparatus and reagents

The apparatus used were 2 retort stands, condensers, receiving flasks, connecting tubes, 250 mL and 300 mL beakers, electronic weighing balance (500 g–0.01 g, DT-500B), temperature controller and a contactor, 10 L round bottom flask, stoppers, funnel, rubber, fittings, electric heaters (temperature control), clean water, low temperature extractor device, concentrated sulphuric acid, heating mantle, fume cupboard, Kjeldahl Distillation unit, digestion flask, burette, retort stand, analytical balance, air oven, metal dishes (Aluminium or platinum) with lids, desiccator containing calcium chloride or granular silica gel, Agilent 6890N Gas Chromatograph with Agilent 5975 Mass Selective Detector, autosampler vials, 150 µL vial inserts, and crimp seals, vial crimper and decrimper, 2.5 mL airtight syringe or 3 mL disposable hypodermic syringe, 10 µL auto sampler syringe and Super capillary column (HP-INNOWax, Agilent, 100 m × 0.25 mm i.d., 0.20 µm).

The reagents used were 40% sodium hydroxide, Kjeldahl catalyst tablets (or 3 g Na_2SO_4 and 0.3 g $CuSO_4$), 0.1 N HCl, boric acid indicator, glacial acetic acid, 10% potassium iodide solution, 0.1 N sodium thiosulphate solution, carbon tetrachloride, Wijs solution, acetic acid, starch indicator (1%), petroleum ether (optima grade), air (zero grade), nitrogen gas (UHP grade), n-hexane, methanol, potassium hydroxide, sulfuric acid and FAME standards (internal standard).

2.2 Mechano-thermal extraction method

Mechano-thermal extraction/distillation is a modern innovation process of extracting oil from agro seed material using crushing and extraction machines to grind and extract the lipid/moisture of seed

and also applying heat in the process to recover pure oil without using solvent.(Mechano: ***use of mechanical approach for grind and extracting lipid/moisture from agro seed,while thermal: indicate the use of in extracting the pure product, oil.)*** A total of 155 g of the dry samples of Native pear seeds were weighed from one specie, a total of 36 samples was measured out and placed individually in distillation flask. Each specie had 36 samples for the extraction process. Each of the measured sample was poured into the low temperature extractor and extracted at 30 °C at the regulated time. The extracted juice was poured into the distillation flask. Heat was then applied to the flask containing the sample to be distilled/Extracted at the temperatures of 45 °C, 50 °C, 55 °C, 60, 65 and 70 °C. Each process took a particular time duration which was recorded for the 36 samples. The temperature was varied / fixed in order to get its effect on the samples oil yield. The extraction process goes simultaneously with distillation.

The mechano-thermal process is unique hence it does not require solvent. This made it possible to trap pure/original oil with different concentration as the samples and species varies. There was continuous flow of cold water through the attached condenser in order to condense the extract and also get an effective extraction process.

The yield of oil was determined by measuring the volume of the extract on an electronic using measuring cylinder. Subsequently, analysis and characterizations were carried out using GC-MS and HPLC Techniques, other instruments for physical/chemical properties.

2.3 Steam distillation extraction

Distillation is a thermal separation technique in which a liquid or a mixture of two or more components is divided into individual fractions of specific purity through controlled heating and subsequent cooling. In practical terms, the process involves releasing volatile oil compounds from plant trichomes or cellular structures by applying heat in the presence of moisture, followed by condensation of the vapor phase to separate the oil from the aqueous fraction.

This technique is widely employed for the extraction of aromatic and volatile substances from botanical materials such as rose petals and orange blossoms. During the process, plant materials are heated, allowing fragrant compounds to evaporate and later condense into a liquid distillate. Depending on the distillation approach—whether steam-based or dry—the collected products are referred to as essential oils or hydrosols.

Currently, the majority of commercially available essential oils, including lavender, peppermint, and eucalyptus oils, are produced through distillation. Various plant parts such as flowers, leaves, bark, wood, roots, seeds, and fruit peels are typically placed in a distillation vessel (alembic) containing water, where heat facilitates the release of volatile components.

The methodology adopted in this study differs significantly from conventional steam or solvent-assisted distillation techniques. A total of 36 experimental runs were conducted using varying temperatures and sample masses for each seed species. Notably, neither water nor organic solvents were introduced during the extraction phase. Instead, only the plant samples were processed, resulting in a significantly reduced extraction time when compared to traditional Soxhlet extraction methods.

In this approach, dried seeds were first mechanically crushed and then introduced into a low-temperature extraction unit. The resulting extract, containing both residual moisture and oil, was subsequently transferred into a 10-liter distillation flask for further processing. Final distillation was

performed at controlled temperatures of 60 °C, 70 °C, 80 °C, 90 °C, and 100 °C, depending on the sample under investigation.

During distillation, oil and water were simultaneously recovered through condensation, enabling continuous regulation of inlet temperature. The resulting distillate, commonly referred to as a hydrosol, did not require additional solvent-based separation using a separating funnel. The oil phase was recovered directly and efficiently without the need for further purification steps. Consequently, chemicals such as dichloromethane and drying agents like magnesium sulfate were not required for moisture removal or preservation. The oil obtained at the conclusion of the process was therefore unaltered, pure, and representative of its natural composition [18].

2.4 Extraction model concept

Equation of mass transfer in extraction process related to the functional parameter of time, recovery temperature, volume of extract and thickness of extract was simplified as:

$$C = C_s\left(1 - e^{-\frac{KAt}{Vb}}\right) \tag{1}$$

where t is the extraction time, A is the area of the extract (= 3.4159 × L^2), L is the length of the cylinder containing the extract (30 mm), V is the volume of the extract, b is the thickness of the extract, C_s is the initial concentration of the feed (g) and K is the diffusion coefficient (= 1.12 × 10^{-8} m^2).

Applying the extraction mass transfer equation:

$$\ln C = \ln\left[C_s\left(1 - e^{-\frac{KAt}{Vb}}\right)\right]$$

$$\ln C = \ln C_s + \ln\left(1 - e^{-\frac{KAt}{Vb}}\right)$$

$$\ln C = \ln C_s + \ln 1 - \ln e^{-\frac{KAt}{Vb}} \tag{2}$$

But ln 1 = 0, so Equation (2) yields:

$$\ln C = \ln C_s - \ln e^{-\frac{KAt}{Vb}} \tag{3}$$

Mathematical analysis of Equation (3) gives

$$\ln C = \ln C_s + \frac{KAt}{Vb} \tag{4}$$

Upon separation of variables or rearrangement of Equation (4):

$$\ln C_s = \ln C - \frac{KAt}{Vb} \tag{5}$$

Therefore, a plot of ln C_s against t using Equation (5) gives a straight line with intercept ln C and slope equal to $-KA/(Vb)$.

3 Results and discussion

The outcomes result obtained from this research are presented in Figures and Table and the output results shown in the research for the relationship of extraction parameters of extract recovered from native pear seed oil with respect to initial concentration of mass, volume recovered and final concentration against time of 150 g to 400 g dosage of Eludicote species in the distillation unit.

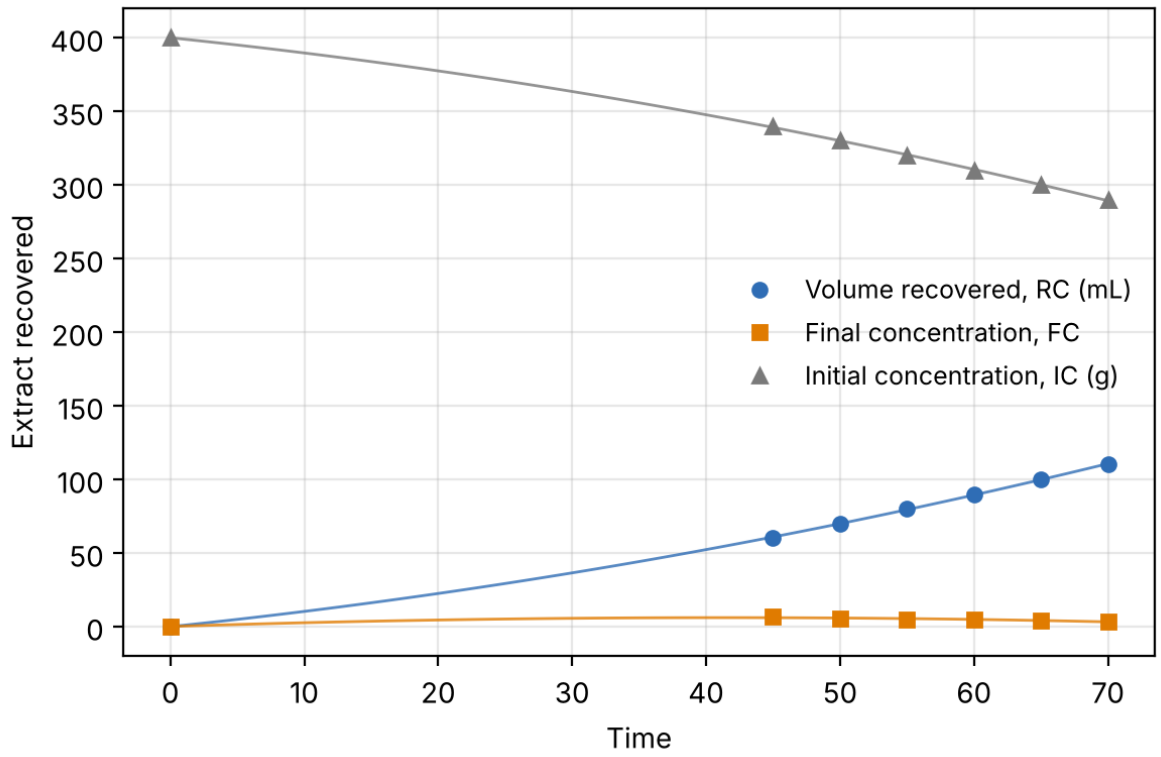


Figure 2. Extraction parameters of the extract recovered from native pear seed oil with respect to the initial concentration of mass, volume recovered and final concentration against time for a 400 g dosage of Eludicote species.

Figure 2 shows the theoretical evaluation of the extract recovered from native pear seed oil of 400 g initial mass (Eludicote species) upon the effect of time. The results demonstrate decrease in the initial feed mass of 400 g of the native pear seed oil with increase in the oil extracted from the process with respect to times. However, the theoretical regression equation of each behaviour is shown in Figure 2 as $Y_{IC} = -0.0091x^2 - 0.9447x + 400.07$ (initial concentration of mass), $Y_{RC} = 0.0091x^2 + 0.9447x - 0.0657$ (recovered volume in mL) and $Y = -0.0035x^2 + 0.2909x + 0.0464$ (final concentration) in terms of polynomial expression of quadratic equation and the best fit of the square root of the polynomial expression in terms of its reliability are $R^2_{IC} = 0.9998$ (99.98 %), $R^2_{RC} = 0.9998$ (99.98%) and $R^2_{FC} = 0.9636$ (96.36 %). The above regression expression of the quadratic equation defines the rate of initial native pear seed mesh conversion with extracted oil. This has further revealed the significance of the extraction model adopted to monitor the initial concentration, volume of oil recovered and the final concentration using the mechano-thermal approach in oil production for domestic application, pharmaceutical, chemical and industrial utilization.

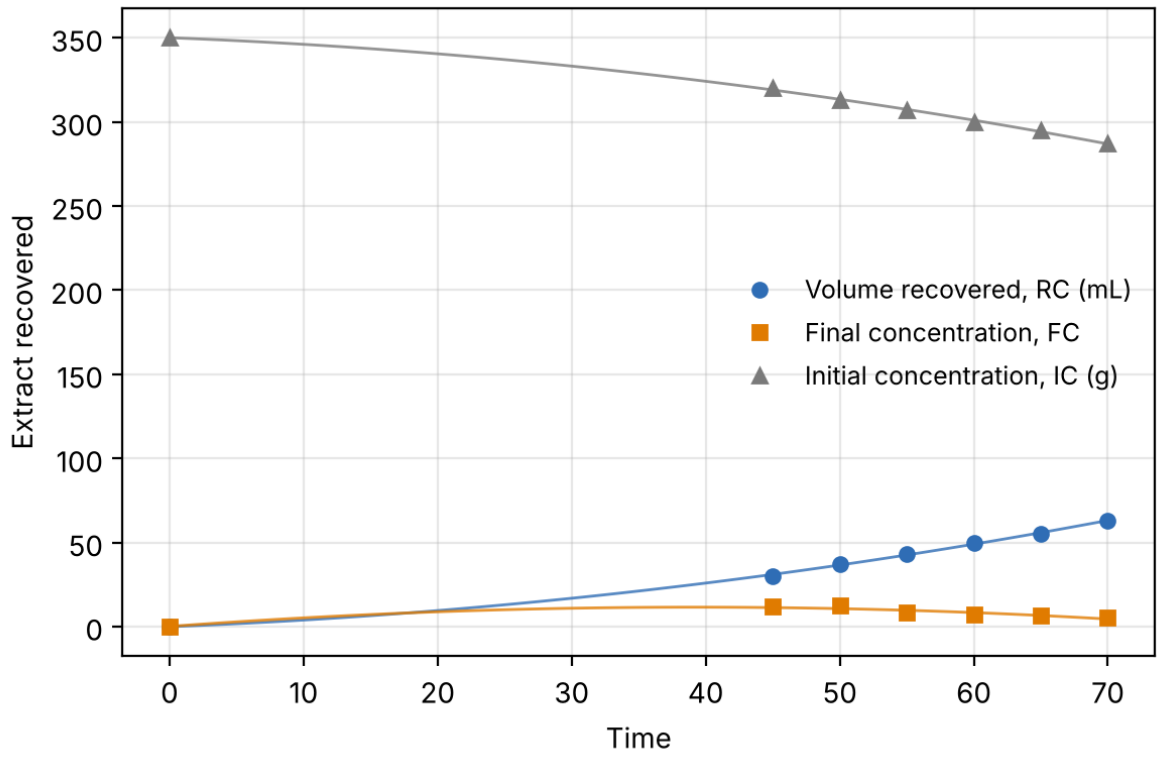


Figure 3. Extraction parameters of the extract recovered from native pear seed oil with respect to the initial concentration of mass, volume recovered and final concentration against time for a 350 g dosage of Eludicote species.

Figure 3 shows the theoretical evaluation of the extract recovered from native pear seed oil of 350 g initial mass (Eludicote species) upon the effect of time. The results demonstrate decrease in the initial feed mass of 350 g of the native pear seed oil with increase in the oil extracted from the process with respect to times. However, the theoretical regression equation of each behaviour is shown in Figure 3 as $Y_{IC} = -0.0085x^2 - 0.3083x + 350.06$ (initial concentration by mass g), $Y_{RC} = 0.0085x^2 + 0.3083x - 0.0561$ (recovered volume in mL) and $Y = -0.0074x^2 + 0.5829x + 0.0892$ (final concentration) in terms of polynomial expression of quadratic equation and the best fit of the square root of the polynomial expression in terms of its reliability are $R^2_{IC} = 0.9988$ (99.88 %), $R^2_{RC} = 0.9998$ (99.98 %) and $R^2_{FC} = 0.9195$ (91.95 %). The above polynomial expression of the quadratic equation defines the rate of initial native pear seed mesh conversion with extracted oil. This has further revealed the significance of the extraction model adopted to monitor the initial concentration, volume of oil recovered and the final concentration using the mechano-thermal approach in oil production for domestic application, pharmaceutical, chemical and industrial utilization.

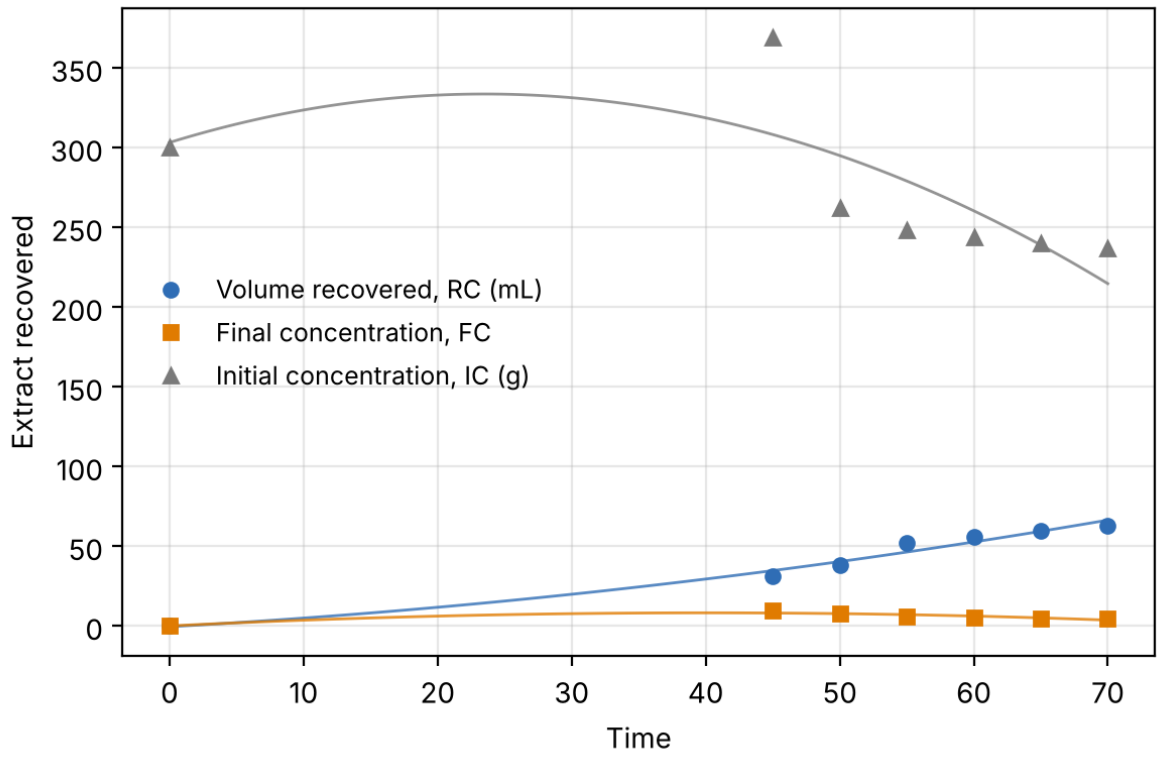


Figure 4. Extraction parameters of the extract recovered from native pear seed oil with respect to the initial concentration of mass, volume recovered and final concentration against time for a 300 g dosage of Eludicote species.

Figure 4 shows the theoretical evaluation of the extract recovered from native pear seed oil of 300 g initial mass (Eludicote species) upon the effect of time. The results demonstrate decrease in the initial feed mass of 300 g of the native pear seed oil with increase in the oil extracted from the process with respect to times. However, the theoretical regression equation of each behaviour is shown in Figure 4 as $Y_{IC} = -0.055x^2 + 2.5867x + 303.28$ (initial concentration by mass g), $Y_{RC} = 0.0069x^2 + 0.4691x - 0.3594$ (recovered volume in mL) and $Y = -0.0051x^2 + 0.4091x + 0.1131$ (final concentration) in terms of polynomial expression of quadratic equation and the best fit of the square root of the polynomial expression in terms of its reliability are $R^2_{IC} = 0.5305$ (53.05 %), $R^2_{RC} = 0.9748$ (97.48 %) and $R^2_{FC} = 0.8871$ (88.71 %). The above polynomial expression of the quadratic equation defines the rate of initial native pear seed mesh conversion with extracted oil. This has further revealed the significance of the extraction model adopted to monitor the initial concentration, volume of oil recovered and the final concentration using the mechano-thermal approach in oil production for domestic application, pharmaceutical, chemical and industrial utilization.

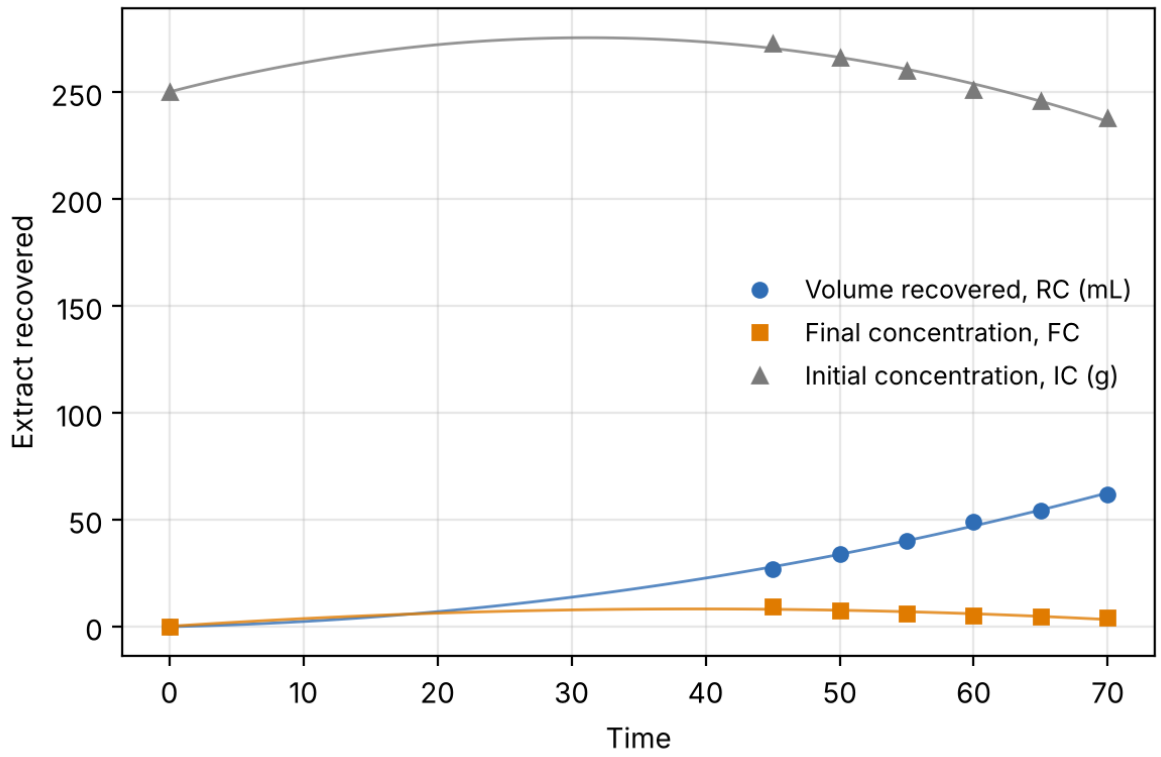


Figure 5. Extraction parameters of the extract recovered from native pear seed oil with respect to the initial concentration of mass, volume recovered and final concentration against time for a 250 g dosage of Eludicote species.

Figure 5 shows the theoretical evaluation of the extract recovered from native pear seed oil of 250 g initial mass (Eludicote species) upon the effect of time. The results demonstrate decrease in the initial feed mass of 250 g of the native pear seed oil with increase in the oil extracted from the process with respect to times. However, the theoretical regression equation of each behaviour is shown in Figure 5 as $Y_{IC} = -0.0261x^2 + 1.626x + 250.18$ (initial concentration of mass), $Y_{RC} = 0.0109x^2 + 0.1328x - 0.0734$ (recovered volume) and $Y = -0.0053x^2 + 0.4137x + 0.0847$ (final concentration) in terms of polynomial expression of quadratic equation and the best fit of the square root of the polynomial expression in terms of its reliability are $R^2_{IC} = 0.9795$ (97.95 %), $R^2_{RC} = 0.9979$ (99.79 %) and $R^2_{FC} = 0.9342$ (93.42 %). The above polynomial expression of the quadratic equation defines the rate of initial native pear seed mesh conversion with extracted oil. This has further revealed the significance of the extraction model adopted to monitor the initial concentration, volume of oil recovered and the final concentration using the mechano-thermal approach in oil production for domestic application, pharmaceutical, chemical and industrial utilization.

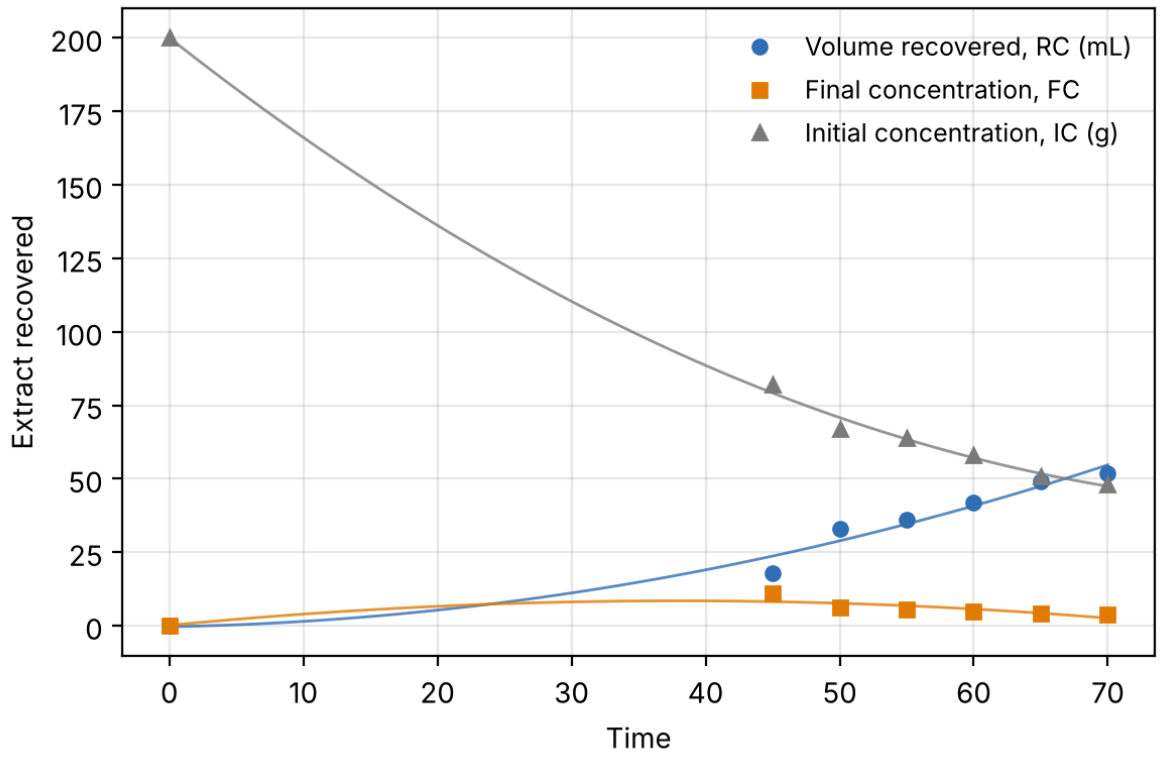


Figure 6. Extraction parameters of the extract recovered from native pear seed oil with respect to the initial concentration of mass, volume recovered and final concentration against time for a 200 g dosage of Eludicote species.

Figure 6 shows the theoretical evaluation of the extract recovered from native pear seed oil of 200 g initial mass (Eludicote species) upon the effect of time. The results demonstrate decrease in the initial feed mass of 200 g of the native pear seed oil with increase in the oil extracted from the process with respect to times. However, the theoretical regression equation of each behaviour is shown in Figure 6 as $Y_{RC} = 0.0101x^2 + 0.0793x - 0.2997$ (recovered volume), $Y_{IC} = 0.0202x^2 - 3.5968x + 200.08$ (initial concentration of mass) and $Y = -0.0058x^2 + 0.438x + 0.162$ (final concentration) in terms of polynomial expression of quadratic equation and the best fit of the square root of the polynomial expression in terms of its reliability are $R^2_{RC} = 0.9691$ (96.91 %), $R^2_{IC} = 0.9986$ (99.86 %) and $R^2_{FC} = 0.7707$ (77.07 %). The above polynomial expression of the quadratic equation defines the rate of initial native pear seed mesh conversion with extracted oil. This has further revealed the significance of the extraction model adopted to monitor the initial concentration, volume of oil recovered and the final concentration using the mechano-thermal approach in oil production for domestic application, pharmaceutical, chemical and industrial utilization.

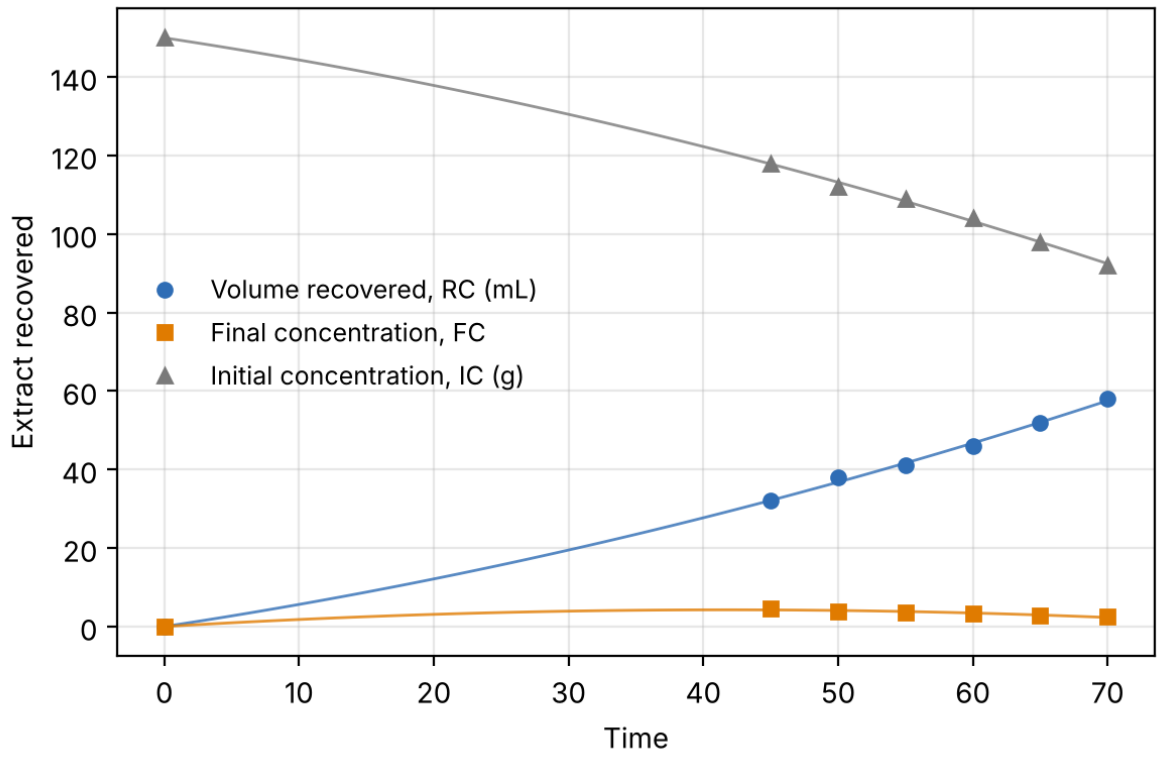


Figure 7. Extraction parameters of the extract recovered from native pear seed oil with respect to the initial concentration of mass, volume recovered and final concentration against time for a 150 g dosage of Eludicote species.

Figure 7 shows the theoretical evaluation of the extract recovered from native pear seed oil of 150 g initial mass (Eludicote species) upon the effect of time. The results demonstrate decrease in the initial feed mass of 150 g of the native pear seed oil with increase in the oil extracted from the process with respect to times. However, the theoretical regression equation of each behaviour is shown in Figure 7 as Y_{IC} = -0.0043x^2 − 0.5202x + 149.97 (initial concentration of mass), Y_{RC} = 0.0043x^2 + 0.5202x + 0.0308 (recovered volume) and Y = -0.0024x^2 + 0.2041x + 0.0271 (final concentration) in terms of polynomial expression of quadratic equation and the best fit of the square root of the polynomial expression in terms of its reliability are R^2_{IC} = 0.9988 (99.88 %), R^2_{RC} = 0.9988 (99.88 %) and R^2_{FC} = 0.9729 (97.29 %). The above polynomial expression of the quadratic equation defines the rate of initial native pear seed mesh conversion with extracted oil. This has further revealed the significance of the extraction model adopted to monitor the initial concentration, volume of oil recovered and the final concentration using the mechano-thermal approach in oil production for domestic application, pharmaceutical, chemical and industrial utilization.

The experimental data of C_s against extraction time are given in Table 1, and the plot of ln C_s against time is shown in Figure 8.

Table 1. Experimental data of Cs against extraction time.

$C_{s\,(g)}$	t (min)	$ln\ C_s$
150	40	5.011
142	50	4.956
132	60	4.883

$C_{s(g)}$	t (min)	$ln\ C_s$
128	70	4.852
123	80	4.812
118	90	4.771

From the plot of ln C_s against time (t), the slope is:

$$-\frac{KA}{Vb} = -0.0047$$

Also, ln C = 5.18928, so that:

$$C = e^{5.18928} = 179.339$$

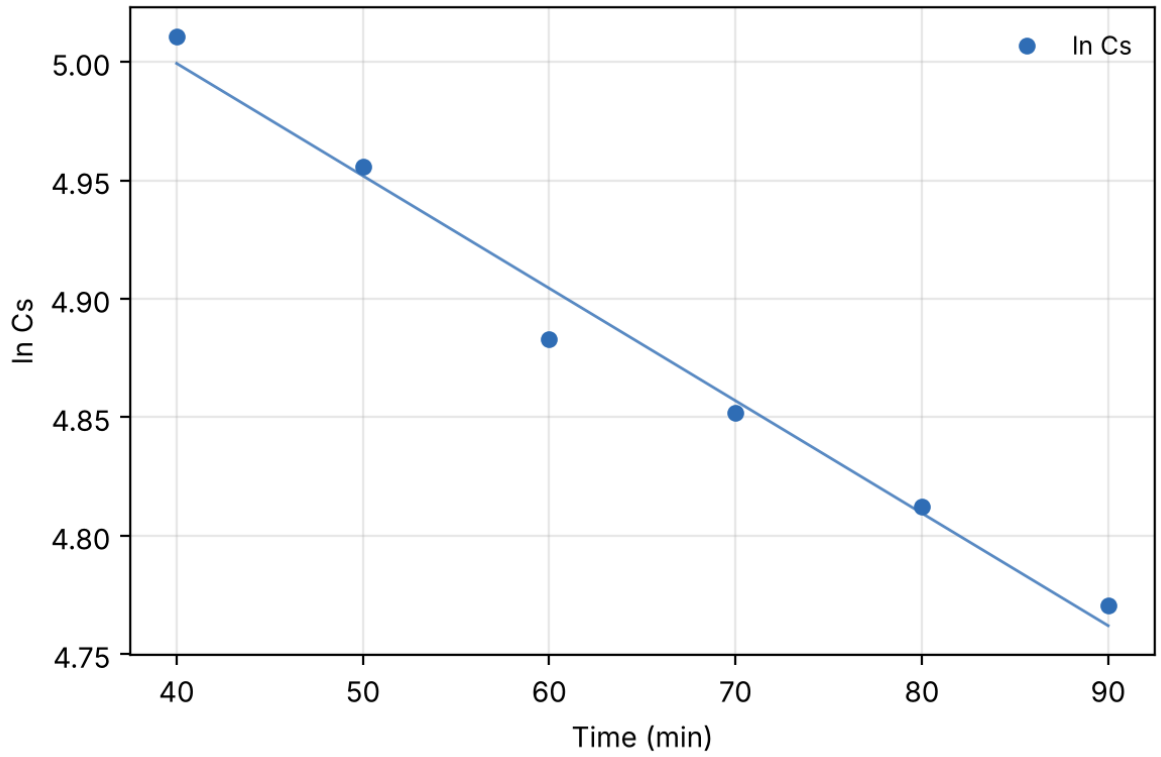


Figure 8. Plot of ln Cs of the extracted oil recovered versus time.

Figure 8 shows the theoretical evaluation of the extract recovered from native pear seed oil of initial mass (Eludicote species) upon the effect of time. The results demonstrate decrease in the initial concentration of the native pear seed oil with increase in the oil extracted from the process with respect to times. However, the theoretical regression equation of each behaviour is shown in Figure 8 as Y = −0.0047x + 5.1892, with a coefficient of determination of R^2 = 0.9821 (98.21%). The above linear expression defines the rate of initial native pear seed mesh conversion with extracted oil. This has further revealed the significance of the extraction model adopted to monitor the initial concentration, volume of oil recovered and the final concentration using the mechano-thermal approach in oil production for domestic application, pharmaceutical, chemical and industrial utilization.

4 Conclusion

Different types of extraction processes have been in use, such as steam extraction, solvent extraction, enzyme-assisted aqueous extraction, ultrasound-assisted solvent extraction, high hydrostatic pressure-assisted solvent extraction, extrusion-expelling extraction, microwave-assisted extraction and supercritical fluid extraction, which have been yielding oil with traceable contaminants. The mechano-thermal extraction/distillation method of this research has:

1. introduced a new method of extraction/distillation whose product is pure and free of any trace of contaminant;
2. used native pear seeds only, and the effect of different concentrations was monitored to ascertain the production characteristics in terms of yield;
3. shown, through physicochemical and HPLC/GC-MS analyses, properties that can serve as raw materials in the chemical, pharmaceutical and food industries;
4. shown that the oil obtained from the agro-seeds will be useful to many industries, such as the chemical, pharmaceutical and food industries, by producing vital raw materials locally instead of depending on conventional ones, thereby promoting local content; and
5. shown that the oil recovered from this process does not need any other treatment, such as preservatives, demoisturising, deodorising, decolourising or dewaxing, as it is natural and pure and lasts for a longer period without becoming rancid.

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