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Impact of solvent extraction parameters on oil yield and oil Properties: a review

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ABSTRACT

Oilseeds are rich sources of fatty acids, proteins, fibers, minerals, and vitamins essential for human health. They primarily consist of triglycerides and contain minor components such as phytosterols, phenols, carotenoids, tocopherols, and phospholipids. Oil extraction can be performed using various methods, including traditional mechanical and solvent extraction techniques, as well as advanced methods like supercritical fluid extraction. Literature indicates that solvent extraction generally achieves the highest oil yields. However, the quality of the extracted oil is heavily influenced by process parameters. Key parameters affecting both yield and quality include extraction temperature, time, roasting conditions, solid-to-solvent ratio, and agitation. Temperature is particularly critical; higher temperatures typically increase oil yield, while lower temperatures can reduce yield and extend extraction time. Additionally, larger particle sizes create a temperature gradient within the seeds, leading to lower oil yields. In summary, extraction parameters significantly impact oil yield and quality.

INTRODUCTION

Oil extraction, also known as oil processing, is the process of recovering oil from various plant sources such as seeds, nuts, and fruits (Ibrahim and Onwualu, 2005). These oils are essential in the food, pharmaceutical, and cosmetic industries due to their desirability and nutraceutical properties (Hernandez, 2016). It is a valuable product with global demand. Oil extraction has been used for ages, with early civilizations relying on manual processes for food, lighting, and other reasons (Yara-Varón *et al.*, 2017).

According to archaeological findings, the Egyptians developed the practice of frying food in oils or fats in approximately 2500 BC as a way to preserve meat and vegetables (Yara-Varón *et al.*, 2017). The importance of oil extraction in the food sector cannot be overemphasized. Vegetable oils play an important part in our daily diet, whether eaten directly in refined or virgin forms, or through various food industry products acting as a medium for cooking, adding taste and texture to foods, and supplying the required nutrients. Edible oils are non-polar, lipophilic systems with highly variable and complex compositions depending on their origin, quality, and production methods (Yara-Varón *et al.*, 2017). Vegetable oils are mostly made up of triglycerides, which are 95–98% consisting of three fatty acid molecules esterified to one glycerol molecule. Triglycerides are defined by the kinds, amounts, and locations of fatty acids on the backbone of glycerol (Jadhav and Annapure, 2023).

Due to their biosynthetic processes, even-numbered carbon atoms often dominate the length of fatty acid chains in vegetable oils. Fatty acids can be categorized into saturated, monounsaturated, and polyunsaturated fatty acids based on their saturation degree with varied configurations resulting in different physical and chemical properties (Yara-Varón *et al.*, 2017)

Vegetable oils are usually produced from plant seeds or fruits traditionally by subjecting plant materials to mechanical shear using oil press, expellers, or even mortar and pestle to release the volatiles in virgin state (Gayas and Kaur, 2017) or by solvent extraction using polar solvents (Yara-Varón *et al.,* 2017). Producing a high-quality product requires good manufacturing practices and elective quality assurance. This study aimed to review the impacts of solvent extraction parameters on yield and overall quality of edible oils.

OIL EXTRACTION

The process of extracting triglycerides from oilseeds is known as extraction, and it is accomplished using a variety of chemical, biological, mechanical, and innovative methods. Oilseeds were manually pressed in the past using wooden pestles and stone mortars (Gomez, 2017). Later, mechanical presses, conventional solvent extraction, modern extraction methods, and innovative extraction techniques such as aqueous enzymatic extraction were developed. The technique used to extract the oil is crucial, given that it affects the quality of the finished goods and any potential environmental effects (Souiy, 2023). Oils and fats are currently extracted using both traditional (mechanical, solvent extraction) and innovative methods (supercritical fluid, microwave-assisted, ultrasound-assisted extraction, aqueous enzymatic extraction) either on a large scale or as pilot projects (Yara-Varón *et al.,* 2017). However, the oil extraction industry is dominated by conventional extraction methods including solvent extraction and mechanical expression (Mwaurah *et al.,* 2020).

Mechanical Extraction

Oils can be extracted mechanically, known as "crushing" or "pressing." It is an ancient process that dates back around 6,000 years and is labour-intensive (Dawodu, 2009). It is an early method of separating oil from oil seeds that uses physical pressure to squeeze the oil out. This process preserves the beneficial nutrients that are naturally contained in the seeds or flesh of the fruit and eliminates the possibility of solvent residue in the oil (Masoodi *et al.,* 2022). The mechanical approach is often used to generate traditional oils known as 'extra virgin oils' such as coconut and olive oil, which are preferred by most health food buyers (Gharby, 2022).

The mechanical/hydraulic approach, or the press method, involves applying direct forces on agricultural materials to extract oil from the seed (Roy *et al.,* 2019). There are two types of machines usually employed in mechanical pressing: the hydraulic press machine and the screw press machine. The hydraulic press machine is categorized as a batch mechanical pressing machine, whereas the screw press machine is regarded as a continuous pressing machine (Savoire *et al.,* 2013). It has been claimed to provide oil recoveries of 55% to 75% at operating pressures ranging from 20 to 70 MPa (Subroto *et al.,* 2015). The primary disadvantages of mechanical extraction techniques are that residual oil is present in the cake (Cakaloglu *et al.,* 2018), and the method requires applying high pressure to the oil to escape the solid matrix (López-Ordaz *et al.,* 2019).

Conventional/Solvent Extraction

The solvent extraction process involves the leaching out of oil in the seeds insoluble solid structure using a volatile organic solvent (Johnson and Lusas, 1983) such as n-hexane, isopropanol, butanol, acetone, and so on. Solvent extraction procedures have been reported to have about 90 to 98% recovery rate (Nde and Foncha, 2020). The kind of solvent used, extraction time, temperature, particle size of the solid, and solvent-to-solid ratio all impact oil recovery when utilizing this approach (Ntalikwa, 2021). This process, known as mass transfer, entails moving the solvent into the solid matrix, dissolving the solute (oil) in the solvent phase, and moving the solute and solvent from the solid matrix into the bulk fluid. The determining factor is the solute's concentration gradient between the solid and the bulk fluid. To achieve this, the solvent that can dissolve and carry the solute must be carefully chosen, and the two must be easily separated. The solvent extraction process produces much more oil than mechanical extraction, and it reduces unit operating costs. The facility's high initial capital cost is the primary disadvantage of solvent extraction.

Most oilseed solvent extraction plants employ commercial hexane, a hydrocarbon combination that boils at 63-69 °C (Rani *et al.*, 2021). Because of safety concerns, the solvent extraction process is housed separately from the seed preparation process. The solvent extraction process is made up of five interconnected unit processes: solvent extraction, meal desolventizing, meal drying and cooling, miscella distillation, and solvent recovery (Kemper, 2005). The demand for unique ways originates from standard methods' drawbacks, including more energy, longer time, lower yield, and less environmental friendliness (Sharma *et al.*, 2019).

Only about 80% of the oil in oleaginous material can be recovered by physical oil extraction methods; therefore, alternative technologies must be used to recover the remaining 20% (Puertolas *et al.*, 2016). The ease of use and low cost of solvent extraction make it a popular method. Hexane and n-hexane are the most often used solvents because they produce the highest yields (95%) (Tan *et al.*, 2016). Specifically, n-hexane is favoured because of its exceptional qualities, which include easy recovery, a limited boiling point range (63 to 69 °C), low latent heat of vaporization (330 kJ/kg), high solubility, and non-polarity (Kumar *et al.*, 2017).

In addition to mechanical and hydraulic expression, other methods depend on solvents in which the oil is dissolved before being separated by centrifugation, evaporation, and distillation, or by de-emulsification. Organic solvents such as n-hexane, chloroform, petroleum ether, acetone, ethyl acetate, and hexane are used in conventional procedures.

Aqueous Extraction

Aqueous extraction is a traditional technique of extracting oil from oil-bearing materials using water as a solvent (Mwaurah *et al.,* 2020). The process involves heating oliferous material, blending it with or without water, and boiling it to release the oil content. The oil appears on the surface and is collected and heated to remove moisture (Souiy, 2023). One of the advantages of aqueous extraction is that it extracts oil and proteins consecutively due to the insolubility of water in oil (Campbell *et al.,* 2011). Separation and recovery of desired compounds can be done without any damage (Franca-Oliveira, 2021). However, the process could be less effective and result in low yield because water takes longer to damage the cell wall of oil material (Mwaurah *et al.,* 2020).

Novel Extraction Methods

Supercritical Fluid Extraction

Supercritical fluid extraction (SFE) is an extraction technique that has gained popularity recently for obtaining high-value products from plant materials (Herrero *et al.,* 2010). It provides highly pure extracts that are devoid of potentially hazardous solvent residues. It is well-known for its several advantages in selectivity, speed, efficiency, and cleanliness. The extraction and separation process is fast, environmentally beneficial, and safe for thermally sensitive goods (Mercer and Armenta, 2011). Supercritical fluid extraction utilizes the fact that certain compounds exhibit dual-phase behaviour and greater solvating ability when heated above their critical temperature and pressure thresholds, supercritical fluid extraction offers an advantage over other methods of fluid extraction (Sairam *et al.*, 2012)

The comparatively low critical temperature (31.18°C) and pressure (72.9 atm) of carbon dioxide make it a preferred substance (Krishnan *et al.*, 2023). Pressure, temperature, CO_2 flow rate, and extraction time are the four primary parameters that impact the effectiveness of supercritical CO_2 extraction (Duba and Fiori, 2015). The rate of extraction yield in SFE is principally determined by solubility, which is regulated by two major parameters: pressure and temperature. Pressure and temperature are the two fundamental parameters that affect solubility, which in turn affects the extraction yield rate in SFE (Wrona and Buszewski, 2017). Pressure and oil solubility are directly correlated, while solubility and temperature correlate indirectly.

Microwave Assisted Extraction

This method is a quick and volumetric heating process that causes the breakdown of biological cell structures or oil-holding glands by creating a pressure gradient within the cell due to the increased extraction rate (Sangeetha *et al.*, 2023). The foundation of microwave technology is that microwave radiation is extremely selective and emits very little heat into the surrounding space (Veggi *et al.*, 2012). The microwave process can be set up to transport electromagnetic energy to the desired location of the substrate's compounds. Compared to alternative extraction procedures, the energy-saving elements and quick processing times result in lower manufacturing costs, better product yields and homogeneity, and high-quality goods (Sangeetha *et al.*, 2023).

Microwaves have a direct effect on polar liquids and materials. Therefore, even dried plant material can be affected when using them on tiny amounts of moisture in the cells (Veggi *et al.*, 2012). When moisture evaporates, a large amount of pressure is created, which compresses the cell wall of the material and finally causes it to rupture, releasing the desired contents from within (Johnson, 2008). This results in potentially efficient methods for extracting oil; nevertheless, the range of microwave applications is still restricted.

Ultrasound-Assisted Extraction

The ultrasound-aided extraction (UAE) method increases oil yield with faster kinetics since it is a simple, affordable, and efficient extraction process (Sangeetha *et al.*, 2023). This ultrasound-aided extraction approach was utilized to extract thermo-sensitive bioactive chemicals because of its low operating temperatures. The process parameters for ultrasound-assisted extraction process include reactor characteristics, extraction temperature, solvent-sample interaction, applied ultrasonic power, and frequency (Esclapez *et al.*, 2011).

The mechanical energy generated by ultrasound waves is applied to the samples (sonication), resulting in the generation of small voids in the liquid, which implode at the solid sample, resulting in localized high temperatures (about 4500°C) and about 50 MPa pressures. These forces destroy cell membranes and the extraction of intracellular material. Ultrasound-assisted extraction has the advantage of reduced solvent requirements, extraction time, greater solvent penetration, low thermal damage to the final product, and subsequently high yield (Carreira *et al.*, 2021). Conversely, its limitations include high power requirements, scale-up challenges for commercial application, and swelling of plant material resulting in inferior quality of byproducts.

Aqueous Enzymatic Extraction

Aqueous enzymatic extraction (AEE) is a novel extraction technique that employs both water and enzymes to damage the cell wall of oil-bearing materials, thus allowing for the transfer of intercellular contents (Mwaurah *et al.,* 2020). It is complex to carry out and also requires low energy (Nadar *et al.,* 2018). Unlike the solvent extraction technique, this process can be used to extract oil and high-quality proteins (Souza *et al.,* 2019). To improve the yields of oil and protein extraction and to undertake extraction under milder processing conditions, some enzymes or surfactants have been added to the extraction medium (Dunford, 2012).

Conversely, the process still needs to be improved due to the formation of oil in water emulsion, the high cost of enzymes, and the long incubation time if pretreatment is not applied. The unavailability of the enzymes also deters its commercial applicability (Mwaurah *et al.,* 2020).

Solvent Extraction Process Parameters

Pretreatment Operations

Oil seed pretreatment procedures include heating (drying or roasting), size reduction, moisture content adjustment (Ibrahim and Onwualu, 2005), pressure application, seed preparation. Pretreatment of oilseeds prior to processing aids easy and efficient oil extraction (Ibrahim and Onwualu, 2005).

Size reduction is necessary before extracting oil from most oilseeds, except for those extremely small. According to Lebovka *et al.* (2012), important substances in raw food plants are first contained in cells, which must be broken in order to facilitate the recovery of intracellular matter. Most oil seeds and nuts are roasted to liquefy the oil in the seed cells and make it easier to extract (Ogori, 2020).

Particle Size

Increasing the surface area of contact between the substance and the solvent is essential to help release the oil from the cells containing oil (Ibrahim and Onwualu, 2005). As a result, the transfer media can infiltrate more quickly and easily. Size reduction shortens the diffusion path that enzymes and other biological components must travel through and increases the rupture of the cell wall (Kalia *et al.,* 2001). The size reduction is achieved through grinding or milling, and the oilseeds' structural and chemical constituents (Senawong *et al.,* 2023) and moisture content determine whether dry or wet milling is to be carried out.

The wet method is best for oleaginous materials with a high moisture content, such as coconut. In contrast, the dry method is better for oleaginous materials with a low moisture content, such as soybean and rapeseed (Kumar *et al.,* 2017). Smaller particles generally facilitate oil extraction from oleaginous materials (Nde and Foncha, 2020); however, the thin and skeletal parts of the oilseed should be avoided as they decrease the microporosity and thus decrease extraction efficiency (Mwaurah *et al.,* 2020). Sometimes, when there is a high oil content in the oilseed, the small particles tend to stick together, which reduces the effectiveness of oil extraction (Adewale *et al.,* 2022).

Extraction Temperature

The temperature at which oil is extracted affects the pace of oil extraction and the preservation of heat-sensitive components in oil seeds. Temperature control is crucial for the extraction of seed oils since the nutrients and bioactive components are highly sensitive to changes in temperature (Piravi-Vanak *et al.,* 2024). This means that adjusting the temperature can affect the solubility of the oils and reduce oxidation caused by higher temperatures (Ahangari *et al.,* 2021). Studies have shown that greater extraction temperatures often result in more oil yields due to enhanced oil solubility and diffusion from the seed surface (Gaber *et al.,* 2018). Cai *et al.* (2021) noted that temperature increase enhances oil flavour and colour. Nevertheless, very high temperatures may lead to the thermal degradation of heat-sensitive materials such as antioxidants, phytosterols, and tocopherols, endangering the stability and nutritional value of the oil (Cai *et al.,* 2021). The maximum temperature restriction should be established to avoid denaturing the oils in seeds. According to Ahangari *et al.* (2021), the usual temperature ranges for various seed oil extraction processes are 40 ◦C to 80 ◦C.

Solvent Type and Ratio

A solvent is defined as a liquid that can dissolve, dilute, or extract other materials without causing chemical changes to these substances or to itself (Yara-Varón *et al.,* 2017). The effectiveness and selectivity of seed oil extraction are highly influenced by the solvent selection (Zhang *et al.,* 2018). Solvents that are commonly used include non-polar solvents like hexane, polar solvents like ethanol, and environmentally friendly substitutes such as supercritical carbon dioxide (CO_2) (Winterton, 2021). Larger oil yields are produced by non-polar solvents, which are also very soluble and selective.

Since the majority of solvents currently on the market are volatile organic compounds (VOCs) derived from the petrochemical industry, like hexane, the issue with most commonly used solvents is their detrimental effects on health, safety, and the environment (HSE) (Cravotto *et al.,* 2022). Substituting one solvent for another does not always guarantee that all risks and problems associated with a process's execution will be resolved. New hazards are usually involved when a process is modified. Thus, care should be taken when choosing a substitute solvent, considering factors such as physicochemical, environmental, or sanitary requirements, process eco-compatibility, solvent cost, and techno-economic factors about the solvent's characteristics like dissolving power and energy consumption (Yara-Varón *et al.,* 2017; Almohasin *et al.,* 2023).

In summary, an optimal substitute solvent should meet the following criteria: (a) it should have low toxicity (Hikmawanti *et al.,* 2021); (b) it should have minimal environmental impact (Claux *et al.,* 2021); (c) it should be derived from renewable resources; (d) it should have a high dissolving power (Chemat *et al.,* 2019); (e) it should be simple to recover (Hikmawanti *et al.,* 2021); (f) it shouldn't drastically alter the process setup; and (g) it should be economical (Hikmawanti *et al.,* 2021). In light of this, novel technologies including aqueous formulations, solvent-free techniques, and substitute solvents seem like excellent choices. A significant alternate route for substituting petrochemical solvents among these solutions is using greener solvents, such as bio-based solvents (Yara-Varón *et al*, 2017).

Proper solvent selection is crucial for preventing volatiles and obtaining a decent extraction yield (Gayas and Kaur, 2017). The ideal solvent is highly selective and has a low enough viscosity to allow for free circulation. Additionally, the liquid should preferably be pure and devoid of contaminants. According to Li *et al.* (2004), the performance of the extraction process is determined by the molecular affinity of the solvent and solute in agreement.

Extraction Time

Extraction time is a significant component that affects seed oil output during extraction (Ishak *et al.,* 2020). Extended solvent-seed matrix interaction times usually result in greater oil yield since the solid and solvent are in contact for a longer period (Rani *et al.*, 2021). However, overly long extraction durations may lead to over-extraction, increased loss of solvent via evaporation, decrease in antioxidant effectiveness (Ishak *et al.*, 2020), and the extraction of undesirable materials, which may reduce the quality of the extracted oil. It is essential to adjust the extraction duration carefully, considering factors like solvent type, extraction temperature, and seed particle size, to balance oil yield with the preservation of desired quality qualities. Table 1 shows an overview of the effects of process parameters on oil yield and oil properties.

Table 1: Overview of the effects of process parameters on oil yield and properties

S/N	Oilseed	Extraction parameters	Experimental Findings	References
1	Moringa Oleifera	Extraction temperature: 100-150 ^oC; extraction time: 30 min	The oil yield, saponification value, free fatty acid, acid value, peroxide value and iodine value decrease with an increase in heating temperature, while heating temperature has no significant effect on the specific gravity of the oil	Adejumo *et al.* (2013)
2	Jatropha curcas	Extraction temperature: 24–80 °C, extraction time: 2-8 h, solvent to solid ratio 4 :1 - 7 :1,	Oil yield increases with an increase in extraction temperature, time and solid-solvent ratio.	Ntalikwa (2021)
3	Fish	Extraction temperature (70-90 °C), extraction time (5-7 h) and solvent (hexane: isopropanol) (1:2, 1:1, 3:2)	Maximum oil yield was observed at 90 ^oC, for 6h with solvent ratio 0.5 affirming that oil yield increased as extraction temperature and time increased.	Shahi *et al*. (2018)
4	Freshwater microalgae species	Extraction temperature: 40-120 °C, Extraction time: 30 - 210	The effect of extraction temperature and time on oil yield was significant.	Asoiro *et al.* (2019)
5	Ginger	Extraction temperature (85.14-90 °C), extraction time (5-7 h) and solvent ratio (hexane: isopropanol) (1:2, 1:1, 3:2)	It was found that the yield of ginger generally increased with an increase in extraction time, slightly increased with an increase in diluent volume, but decreased when the temperature was above 86 ^oC.	Uwadiae *et al.* (2019)
6	Tamarind	Extraction temperature: 70-90 ^oC, extraction time: 2-8h, Solid-solvent ratio: 1:2-1:8w/v.	Oil yield increased with about 3% while an increase of 8% was observed at the solvent's boiling point.	Balaji *et al.* (2013)
7.	Mango seed kernel	Extraction temperature: 40-58 ^oC, extraction time: 0-360 mins, solid-liquid ratio: 0.0033-0.0267g/Ml	Oil yield increased as extraction temperature increased. Increasing the solid-liquid ratio lead to an increase in oil yield. However, an increment beyond the saturation point led to a reduction in surface area resulting in	Ohale *et al.* (2022)

			diffusion difficulties and a corresponding decline in the yield of mango seed kernel oil.	
8.	Coconut fruit	Roasting temperature: 60-120 °C and roasting duration 5-30 min	The effect of roasting temperature and time on oil yield, FFA,pH, colour, and refractive index of coconut oil were significant.	Adeyanju *et al.,* (2016)
9.	Sandbox seed	Extraction temperature: (90-100 °C), extraction time: (90-150 mins),	The oil yield increased with an increase in extraction temperature from 60ºC up to 75 ºC, 60 min up to 120 min after which the oil yield decreased.	Onwe and Bamgboye (2023)
10	Vateria Indica Seeds	Solvent/seed ratio 1 - 1.5 ml/gm, extraction temperature 60-70 ºC, and extraction time 3-5 h	The highest extraction yield was observed at reflux for processing parameters and a corresponding decrease in oil yield was recorded at 70 ºC.	Gowda *et al.* (2019)
11	*Ofada* Rice Bran	Roasting temperature: 160-200 °C and roasting duration 5-35 min	It was observed that the treatments have significant effects on oil yield, free fatty acid, peroxide values, and colour at $p<0.05$	Akinoso and Adeyanju, (2012)
12.	Moringa seeds	Extraction time (1–3 h), solid/solvent ratio (0.050–0.200 g/ml) and type of solvent (ethyl acetate, ethanol and n-hexane)	A directly proportional relationship was observed in the extraction parameters and their interactions.	Oladipo and Betiku. (2019)

Effects of process parameters

Particle size is a critical element influencing the rate of solvent extraction of oil, or crude lipids, from oil-bearing materials. Yunus *et al.* (2013) used Accelerated Solvent Extraction to examine how particle size affected the oil extracted from *Areca catechu* L. seeds. Seeds of *Areca catechu* L. were ground into particles ranging from 75 µm to 500 µm. The extraction parameters of temperature, pressure, flush volume, and duration were set at 140 ºC, 1500 psi, 60%, and 10 minutes respectively. With the same set of process conditions, a higher percentage oil production of 30.00% was produced at 125 µm, whereas 24.75% of oil was yielded by a particle size of 500 µm and 5.50% by a particle size of 75 µm. When in contact with the solvent at high pressure and temperature, it was found that the sample with finer particle size compacted and formed hard lumps.

In a subsequent study to investigate the effects of solvent-to-solid ratio, particle size, extraction time, and temperature on the extraction of Jatropha oil, Ntalikwa (2021) varied the parameters in the following ranges: extraction temperature of 24-80 °C, extraction time of 2-8 h, solvent-to-solid ratio of 4:1 - 7:1, and particle size of 0.5-0.8 mm. It was discovered that oil yield from large particles (greater than 0.8 mm) was low, which was attributed to the smaller surface area of large particles providing less contact area. This makes it difficult for the solvent to permeate into the interior section of the particle, allowing less oil to be leached into the surrounding solution. In agreement with Yunus *et al.* (2013), Ntalikwa (2021) affirmed the cluster of fine particles, which limits the available surface area accessible for the free flow of solvent to the solid, and so recommended particle sizes in the range of 0.5-0.8 mm for Jatropha solvent extraction.

The impact of extraction temperature on oil production was investigated, and it was discovered that extraction temperature significantly influences the rate at which crude oils are extracted from vegetable oil seeds using solvents. High extraction temperatures denature protein complexes, allowing for the recovery of components bound by these molecules. However, caution should be exercised because extremely high temperatures alter the nutritional and sensory properties of the finished product. Ntalikwa (2021) noticed that oil yield increases with increasing extraction temperature and appears to have a maximum value at the solvent's boiling point, after which the oil yield drops. The thermal impact caused by a high extraction temperature promotes solvent diffusion rates. Conversely, lower temperatures promote cavitation and thus yield. The temperature should be kept within an appropriate range so avoid process damage (Wen *et al.,* 2018).

Equally, increasing the extraction period increases the oil production. While extended time increases yield, it also causes unfavorable nutritional and sensory alterations in the extracted product. While validating the rise in oil yield with increasing temperature, Navin *et al.* (2017) discovered that increasing temperature induces a comparable increase in solvent dissolving power, resulting in increased oil yields. Extraction time is critical in the oil extraction process. Initially, it has a good impact by increasing yield, but it soon becomes detrimental. Beyond a certain value, oil yield either decreases or stabilizes due to heat deterioration and oil oxidation.

Besides the quantity of oil extracted, processing parameters also have a significant effect on oil quality/ properties. For instance, oil colour intensity increased with temperature and extraction time. In oilseeds, the breakdown of cells initiates the production of free fatty acids. However, acid production is restricted to the fragmented cells that result from size reduction. Thus, increasing heating temperature and time increased the oil's free fatty acid levels. Raising the heating temperature boosted lipase activity, raising free fatty acid levels. Oil’s peroxide value of oil was also reported to increase when extraction temperature and time were increased. This suggests that the oil became rancid due to extended heat treatment at a high temperature, which decreased the oil's oxidative stability. The oxidative stability of the oil was not significantly affected by variations in particle size.

SUMMARY AND CONCLUSION

Oilseeds are critical to the nutritional security of the global population. Hydraulic pressing and solvent extraction are the typical methods for extracting oil from oilseeds. In solvent extraction, n-hexane is utilized as a solvent due to its simple recovery, non-polar nature, high selectivity, and low latent heat of vaporization (330 kJ/kg). However, the quality and quantity of extracted oil depends on the process parameters.

Among many process parameters, temperature and time are the main factors that controls yield and quality. Temperature range depends upon the nature and type of oilseed. High temperature increases yield, while relatively low temperature results in low oil yield and longer extraction time. This in turn results in higher solvent loss due to evaporation, increase loss of the effectiveness of antioxidant components of the oil, and extraction of undesired components. The large particle size of the solid creates a temperature gradient between the inner and outer surface of the seeds which in turn lowers oil yield.

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