Chapter

Processing of Oilseeds in the Tropics: Prospects and Challenges

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Abstract

Oilseeds have been cultivated from antiquity with increasing demand in agricultural industries world trade. Many economies such as Malaysia depend largely on oilseed crops which are grown primarily for the edible oil production; and for additional meal fraction arising from the seed. The meal is rich in protein and used for animal feed. Recent developments in research have posited oilseeds as a viable source for the production of biodiesel. In the tropics, most of the oilseeds are underutilized; and interest in its mass production and utilization are lacking. Some other seed such as neem seeds, pawpaw seeds, Jatropha curcas L. seeds, etc. have not been put to use in tropical countries leading to subsistence production and their applications in other areas. The oilseed crops could be used either for human, animal or for industrial purposes. There is need to increase the volume of production of these oils in tropical countries through improved quality farming techniques that would encourage breeding in other to meet up with increasing demands. Notably, there are many conventional methods that have been used to increase oilseeds yields. However, the adoption of each technology improvement should be sustainable, while other unknown oilseeds should be discovered for increased utilization.

Keywords: oilseed, peroxidation, antioxidant activity, tropical crops

1. Introduction

Oilseeds are seeds grown all over the world and primarily for the production of edible oils. Tropical oilseeds include almonds, avocado, hazelnut, canola, linseed, flaxseed, coconut, peanut, soybean, oils palm, olive and walnut seeds, among other underutilized ones. They are considered important crops due to their high potentials, functional roles, processing needs and economical value. World production of major oilseeds reached 611.48 million metric tons in 2021–2022 and among oilseeds soybean is the leading type (363.86 million metric tons) followed by rapeseed (70.62 million metric tons), sunflower seeds (57.26 million metric tons), groundnut (50.68 million metric tons), cotton seed (43.50 million metric tons) and palm kernel (19.73 million metric tons) [1]. Oilseeds are rich in oleochemicals, phytochemicals such as flavonoids, tocopherols, phenolic compounds, lignans, tocotrienols, protein, fat, ash, fiber, carbohydrate, vitamins, minerals and some antinutritional factors like glucosinolates and phytates [2, 3]. The oilseeds have great potentials in the future both in the economy of the producing nation and in the food value chain. Interestingly, the tropical climate supports diverse species and varieties of oilseed crops production, but is, however, hampered by the traditional processing technologies (**Figure 1**) of the different countries which make its production and processing drudgery and less attractive to young ones. Additionally, absence of adequate conservation technology for the locally sourced oilseeds prior to processing is a major constraint to its export potentials. To avoid postharvest losses of up to 50% of the oilseeds, large-scale industrial processing operations are required to meet the quality criterion in the market [4]. Notably, some tropical countries such as Malaysia, India and Thailand have braced the odds and are ranked among the world oilseed producing nations whose contribution their gross domestic products (GDP) is very high.

Processing of oilseeds is designed to achieve high extraction yields, obtain high quality oil with minimal undesirable components and produce high value meal. Recently, due to increasing world population, demand for high-quality healthy vegetable oils continues to increase for human diet, domestic and industrial applications.

Oilseed processing industry in the tropics has faced some challenges which led to widespread inefficiency which affects domestic markets and export quality such as use of local technologies, the lack of modernization, low oil recoveries, lack of standardization of product quality among small-scale processors [5, 6]. Despite the several challenges, the sector has massive potential for tremendous growth if various governments introduce special investment incentives for investors and for regulators to monitor and enforce environmental controls and standards. This book chapter is aimed at utilization potentials of oilseeds in the tropics, therapeutic considerations, source of vital nutrients for consumers, prospects, and challenges of oilseed production for increased global competitiveness.

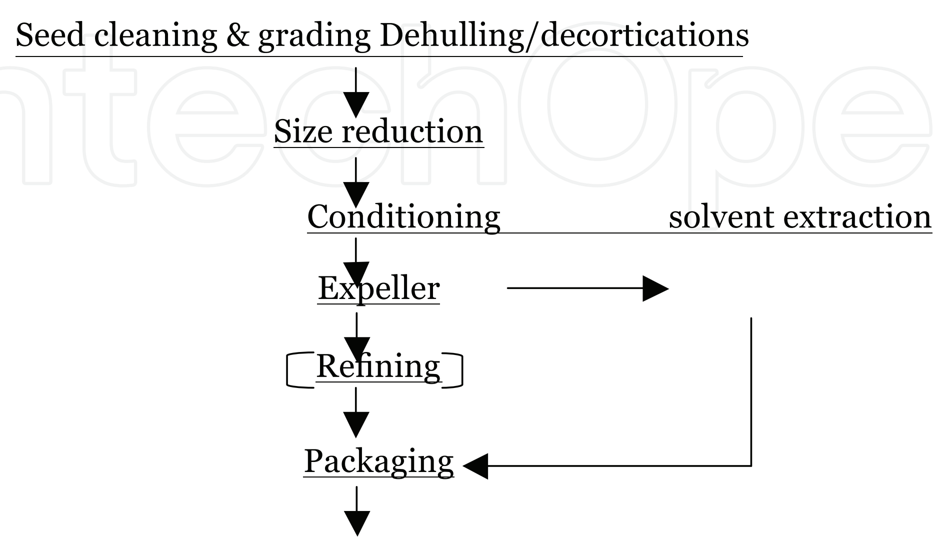

Figure 1.
Traditional oilseed processing technology flowchart.

2. Utilization potentials of tropical oilseeds

Many varieties of oilseeds in the tropics particularly, palm kernels, groundnut, sunflower seed, soybean castor seed etc. are some of the sources of the edible oil. The edible oil is the main source of fat taken in daily meals in different developing countries in the tropics and is used for various purposes. Oilseeds are made up of particles called cells while oil glands are embedded in each of the cells which liberate oil from rupturing. Hence, the essence of oilseed processing is to rupture the gland and cell wall which gives a yield of oil by application of heat and pressure during flaking, followed by extraction. The oil extraction processes are designed to achieve high extraction yields, produce value meal/cake and obtain high-quality oil with minimal undesirable components [7]. There are several techniques for extracting oil from oilseeds. However, mechanical extraction using a screw press and solvent extraction are the two common oilseed extraction processes (**Figure 1**).

2.1 Preparation, handling and storage

The physical properties of the seeds, such as bulk density, shape, size and flowability affect the design of oilseed facilities. Typically, in the tropics oilseeds are cleaned and sorted to remove stones, sand, dust, leaves and other contaminants after harvest and before storage. Proper handling and storage of oil-containing materials are vital so as to minimize deterioration and as well as maintain a good quality of both contained oil and meal. All oil-bearing needs to have correct moisture content to maximize the oil yields as the high moisture content in seeds has an adverse effect on oil and meal quality. Whole and low-moisture oilseeds of about 8–10% may be stored for an extended time under suitable conditions [8].

2.2 Unit operations for oilseeds processing

Although most oilseeds go through pretreatment processes for oil extraction as shown in **Figure 2**, however, the unit operations vary slightly depending on the oil content and physical properties.

Cleaning: Oilseeds may contain certain impurities from the field, during storage and or entered on transit. Such impurities include plant stems, leaves, sticks, infected seeds, dust, stones, foreign material etc. Impurities and foreign materials in the seeds are removed by the use of screens, reels, aspiration or separated by gravity.

Cracking: Most oilseeds are reduced in size to facilitate other downstream processes such as drying, dehulling, tempering and flaking prior to oil extraction. Cracking mills are used for seed size reduction.

Drying: The moisture content of oilseeds is reduced so as to improve the effectiveness of downstream processing particularly, dehulling and tempering.

Dehulling: The husk or shell needs to be separated from the oilseeds prior to oil extraction and the amount of hull on the oilseeds varies significantly. Thus, dehulling increases oil production efficiency and its efficiency is measured by the residual fiber content in the meal and the residual oil content in the hulls.

Tempering: This is done to facilitate oil recovery by heating to about 90°C in order to denature the proteins, release oil from the cells and inactivate enzymes. It is important to maintain the optimum temperature to avoid the formation of undesirable

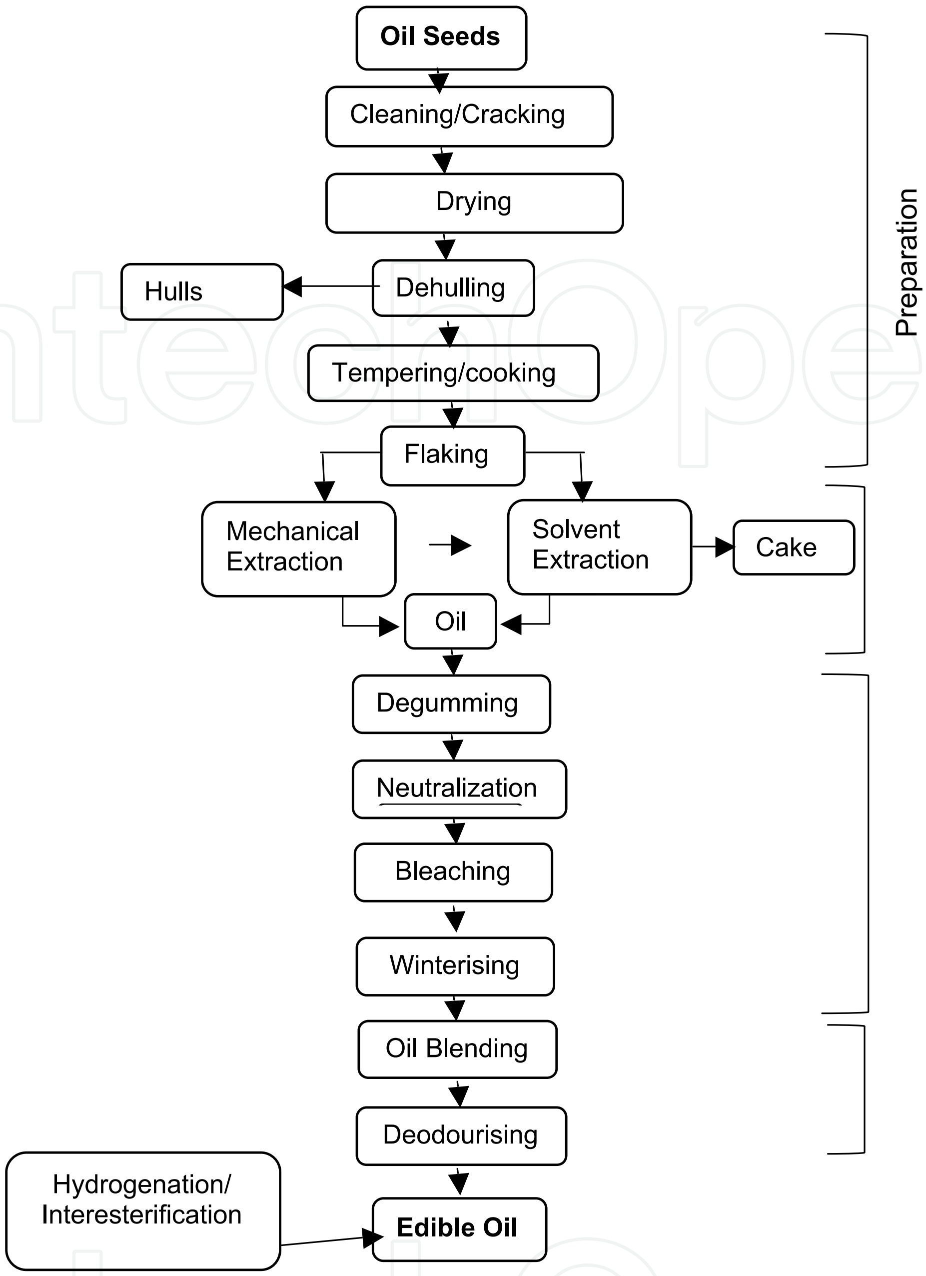

Figure 2.
Processing of oilseeds into edible oil.

aromas and coloring compounds. Tempering improves extraction efficiency and flaking performance. The seeds are then pressed to separate oil.

Flaking: It involves rupturing of the seed cellular structure while increasing the surface area for increased contact between seed and solvent during the solvent extraction process. It is important to note in order to minimize meal and oil quality deterioration, the oil from the flaked seeds should be extracted within 24 hours after flaking.

Extraction: This is the process of separating a liquid from a solid system by either pressing or with the use of a solvent. Although a good percentage of oil is removed by pressing, however, extraction using a low boiling point solvent gives a higher recovery of oil and drier cake than expression. Solvent extraction removes nearly all available oil from oilseed meals. The process provides meals with higher protein qualities and better preservation qualities.

i. **Mechanical Expression:** This is a process of pressing liquid out of liquid containing solids. The oilseeds are compressed in various types of compression devices and the recovery of the oil varies depending upon the sizes and seed being pressed. The oil is removed by pressure from a screw press or an expeller. As the pressure increases, the material is compressed and oil is expelled. It is however more economical to apply lower pressures and then remove the remaining oil by a solvent extraction process.

ii. **Solvent Extraction:** The extraction of the flaked material is performed using non-polar solvents such as food-grade hexane having a boiling point of 65.5°C. The oil is separated from the mixture of oil and hexane called miscella by distillation and stripping under a vacuum. The oil-free flakes are desolventized that is steamed to remove the solvent and dried, cooled and sold as protein-rich feed for cattle. The crude oil obtained contains suspended substances or impurities which are removed by filtration.

iii. **Degumming:** This is a process of removing phosphatides by hydration with water and they vary from one to another and even in the same kind of oils. The phosphatide which makes a gummy residue must be removed to prevent the darkening of the oil during the high temperatures of deodourization and in later applications like frying and to extend oil shelf-life. By mixing the oil with 2–3% water, the hydrated phosphatide can then be removed by settling, filtering or centrifuging. There are two types of phospholipids; hydratable and non-hydratable phospholipids. The non-hydratable phospholipids can be eliminated by the action of strong acids such as citric and phosphoric acids. The strong acids are used to chelate and withdraw the divalent cations and restore phosphatide solubility in water and these can then be eliminated.

iv. **Neutralization:** Any free fatty acids, pigments, waxes and phospholipids in the extracted oil promote fat oxidation and lead to undesirable colors in the final products. These impurities are removed by treating the oil with sodium hydroxide. However, two refining systems are used; short mix process and long mix process. The short mix process is conducted at 90°C using more concentrated sodium hydroxide and a mixing and centrifuging time of less than 1 minute. While the long mix process is conducted at 33°C using lower concentrated sodium hydroxide and mixing and centrifuging time of about 8–15 minutes [9]. The refined oil is lighter in color, less viscous, and more susceptible to oxidation.

v. **Bleaching:** Before the oil is sent for further treatment, various contaminants, pigments, metals and oxidation products are removed. The appearance of the oil can be lightened by bleaching and the types of bleaching material include activated carbon, acid-activated earth and natural earth.

vi. **Winterization:** This is a process of removing glycerides/waxes so as to obtain clarity of oil. In this process, oil is crystallized at a lower temperature, and the glycerides/waxes become solidified and are removed from the oil by filtration.

vii. **Hydrogenation/Interesterification:** The process of adding hydrogen to saturate the carbon-to-carbon double bond is known as hydrogenation. It is used in order to increase the stability against oxidation while raising triglyceride melting points.

On the other hand, interesterification is a technique for positioning or rearranging fatty acids on triglycerides. This technique is followed as a means of obtaining trans-free margarine, spreads, and shortenings since controversies exist about the healthfulness of trans-fatty acids produced during hydrogenation.

viii. **Oil Blending:** This is an optional unit operation in the processing of oilseeds into edible oils. It is used primarily when oils with specific solid temperatures profile are prepared. However, if oil blending does not occur, the oil may go directly from bleaching to deodourisation.

ix. **Deodourization:** This is a process of applying high-temperature steam but at low pressure in order to remove undesirable odorous compounds by sparging process. Odor, flavor and stability are essential compounds of oil. After deodourization, the oil is packaged in polyethene in the form of low-density-polyethene (LDPE) coated paperboard/aluminum foil laminates. Packaging directly influences the quality of the oil by protecting the product from both light and oxygen.

3. Industrial applications of oilseeds

3.1 Soybean oil

The secondary components of soybean oil are valuable commercial products. They include lecithin, phytosterols and tocopherol. Lecithin is produced by degumming soybeans and is the predominant source of food emulsifiers. In the food industries, soybean oil found its application in the following:

1. Shortenings and margarines:

    - Cake making: Soy-based shortenings and margarines used in cake making are very effective in preventing formation of a gluten matrix in cakes, which results in cakes that are pleasingly light, airy and moist. Cakes produced with these shortenings and margarines have very favorable texture characteristics and optimum dome height.

    - Cookies madding: soy-based oils and shortenings produce a favorable spread, height and weight along with a tender mouthfeel in cookies.

    - Icing making: Soy-based oils and shortenings produce icings with an ideal viscosity and specific gravity. High oleic soybean shortening can increase the volume of icing which means more frosting is produced with fewer products.

    - Pies: Soy-based shortenings produce pie crusts with desired characteristics, including evenly browned textured, flaky crust with an ideal finished product height and minimal shrink.

2. Release agent: A blend of soybean oil with soybean lecithin provides excellent release properties, enabling easy removal from baking utensils and conveyors. Reduced sticking makes for easier clean up and better product integrity.

3. Bread making: Less elasticity, better texture, more tender and fluffy breads, are achieved when using soybean oils in dough. Higher levels of soybean oil in specialty breads such as brioche and dinner rolls will reduce chewiness and toughness while contributing to a delectably crispy crust.

4. Deep frying: With lower levels of polymerization, high oleic soybean oil can lead to cost savings due to reduced build-up of polymers on equipment when deep frying. High oleic soybean oil was a top performer on overall likability in a fry taste test which evaluated flavor, aroma, texture and appearance.

5. Packaged foods: High oleic soybean oil offers superior resistance to oxidation, which extends shelf life of packaged products, as well as a desired neutral flavor profile, allowing the natural flavors of ingredients to stand out.

6. Fried snacks: With its neutral flavor profile and high level of oxidative stability, high oleic soybean oil is the ideal frying medium for snacks of all types. Because of its high stability, longer fry life and better frying efficiency will result when using high oleic soybean oil.

3.1.1 Non-food industrial application of soybean oil

These include manufacture of caulks and mastics useful as adhesives or sealants. These adhesives and sealants are commonly used in a variety of high moisture applications including bathroom and basement waterproofing. The use of soybean oil in these sealants ensures they are pliable and flexible enough for bonding and repairs. Soybean oil is also valuable in soap and candle making, especially as a mold release agent. In soap making, soybean oil produces neutral effects and poses no potential skin problems. It's also an inexpensive release agent that does not compromise quality or consistency. According to studies by the USDA-ARS Oil Chemical Research Unit, soybean oil can serve as a significant substitute for the petroleum-based resin needed to make parts for automobiles and other types of equipment.

3.2 Sesame seeds oil

The antioxidant properties of refined sesame seed oil allows for greater shelf life with improved flavor and taste for use in the food industry. Roasted sesame oil resists rancidity due to the antioxidants formed during seed roasting and the particular roasted sesame add flavorand improves taste of fried products. Extra virgin sesame seed oil is used for salad dressing and cooking. Refined sesame seed oil is used for food frying, confections such as candy, margarine and baking. Toasted sesame seed oil is used for frying because it burns easily instead added as a flavoring agent in the last stage of cooking. Food products such as sauces and pickles use sesame oil as a preservative to increase their shelf life.

3.2.1 Non-food industrial uses of sesames seed oil

Refined Sesame oil is used as a solvent, oleaginous vehicle for drugs, skin softener, and hair oil; and used in the manufacture of soap [10]. While, Extra virgin sesame seed oil is used for therapeutical massage.

3.3 Canola seed oil

Heart-healthy consumers' value cholesterol-free canola oil for its high percentage of unsaturated fat; the polyunsaturated fats in canola oil are healthy omega-3 and omega-6 fatty acids. It is used for cooking and its high-smoke point is advantageous when deep frying or cooking over extreme temperatures. Canola oil is a traditional ingredient in many salad dressings, shortenings and margarine, cooking sprays, coffee creamers and whiteners, and breads and crackers.

3.3.1 Non-food industrial application of canola oil

It is used to produce fertilizer, pesticides, cosmetics (Lip glosses and lipsticks, creams and lotions (including suntan lotion), toothpastes, soaps, and shampoos frequently contain canola oil as an ingredient to allow products to flow easily as the natural vitamin E in canola oil protects and repairs damaged cells), essential oil (massage oil), biodiesel and lubricants.

3.4 Coconut seed oil

Studies are also being conducted on the feasibility of using coconut oil to synthesize edible packaging material as an additive for starch-based films in food packaging as an improved edible film, for cooking, Confectioners and bakers use refined coconut oil in products that may stand for a time after manufacturing. The oil also has a high smoke point, which allows foods to be fried or sauteed at high heat. Coconut oil is used as a component of infant milk powders because of its easy digestibility and stable flavor. Coconut oil is extensively used in the food industries as a confectionery fat particularly in the preparation of ice creams. In imitation chocolates coconut oil is used in place of cocoa butter along with cocoa powder.

3.4.1 Non-food industrial application of coconut oil

Coconut oil has found application as a health care product for preterm infants in their skin maturation development. Results of studies conducted on many new-borns under randomized controlled conditions showed that coconut oil has beneficial effects on new-born health and has no undesirable side effects. Coconut oil also has antibacterial properties. Researchers have reported that the antibacterial properties of detergents could be greatly improved by replacing the surfactant used in the manufacture of detergents with new surfactants derived from coconut oil.

Coconut oil can be a potential feedstock for biodiesel production. With the help of cellulose-Zn/SiO_2 nanocomposites, biodiesel methyl esters of coconut oil can be formed more efficiently, which further promises that coconut oil could also be used in the fuel industry. Also, coconut oil could be combined with soot to develop a strain sensor. This strain sensor can be used for various applications such as human activity detection, health advice, as well as soft robotics. Coconut oil is also used in industry to make cutting fluids and lubricants. However, this application is limited by its poor thermal stability due to its poor thermal stability.

3.5 Corn seed oil

Corn oil is used as a salad oil, for frying and margarine making because it contains little cholesterol.

3.5.1 Non-food industrial application of Corn oil

It is used for making soaps, paints, insecticides, biodiesel and inks.

3.6 Olive seed oil

Pure olive oil is used mainly for culinary purposes and in the preservation of foods, mostly canned fish.

3.6.1 Non-food industrial application of olive seed oil

It is also used in the textile industry for wool combing, for toilet preparations and cosmetics, in the production of high-quality castile soap, and as a lubricant.

3.7 Walnut seed oil

It is used for various cooking purposes because it has rich, nutty taste and been proved to reduce high blood sugar and cholesterol level.

3.7.1 Non-food industrial application of walnut seed oil

It is used in the manufacturing of skin care products, hair oil and wood finishing oil.

3.8 Hempseed oil

It is used for cooking and topping salads because of its high nutritious and nutty flavor attributes.

3.9 Non-food industrial application

Hemp is used to make rope, textiles, clothing, shoes, paper, bioplastics, insulators, and biofuel.

3.10 Palm oil

For edible applications, Palm oil is currently used extensively in food preparation and manufacturing around the world. When refined, palm oil is used in the food industry as margarine, shortening, vanaspati, sugar confectionary, frying fat and special fat. Recently, it has been used in emulsion based, powdered and convenience food products. Palm oil and palm kernel oil have been used to replace butterfat in ice cream and in milk preparation to make filled milk. Infant formulas as well as salad oils are now being made with palm oil as it has a low melting point. Palm oil has also been used in the pharmaceutical industry as many important oil fractions such as natural carotenes, vitamin E, sterols, squalene, coenzymes and phenolic compounds are used for many pharmaceutical applications.

3.10.1 Non-edible applications of palm oil

This is mainly found in the soap and oleochemical industries, where it is applied in the manufacture of soap, diesel substitute, epoxidized palm oil, polyols, polyurethanes, polyacrylates and raw materials for oleochemicals such as oleochemicals or derivatives based on C12-C14 and C16-C18 chain lengths with a variety of applications. Palm oil has also been used to make rubber, glycerine, soap, candles, and cosmetics.

3.11 Cottonseed oil

Cottonseed oil is used as liquid oil and in the manufacture of shortening and margarine in food industries.

3.11.1 Non-food industrial application of cotton seed oil

It can also be used in the manufacture of soap, sulfonated lubricating oil, pharmaceuticals, rubber, as a carrier for nickel catalysts, and to a lesser extent in the manufacture of leather, textiles, printing ink, polishes, synthetic plastics, and resins. Cottonseed oil has been used in the synthesis of sucrose polyesters as a noncaloric fat substitute, bearing the trade name Olean or a common name Olestra, suitable for human consumption.

4. Nutritional composition and consumption of tropical oilseeds

The oilseeds have great potentials in human nutritional requirements in diets due to its array of proteins, minerals and oils (essential and non essential oils) with huge functional benefits. The nutritional composition of each oilseed, and amino profile differ according to the maturity, type, variety, specie, breeding condition, environment as well as the management objectives [11–13]. It has been reported that oilseeds are currently used essentially for oil extraction for vegetable oils whose characteristic quality is dependent on the composition of the fatty acids. Researchers [14, 15] have identified ome-6 fatty acids in corn, nuts, soybean, safflower, sunflower, among other oilseeds, which have scientifically proven to impact human health and prevent cardiovascular ailments. Apart from human uses, wastes from oilseeds called meals or press-cakes could be utilized for the production of animal feeds. In the traditional society, oilseeds are mainly consumed as intact food grains, or processed into cakes, e.g. groundnut cakes, chifko, etc. [16] (**Table 1**).

The nutritional composition of oilseeds ex-rays the different compositional values of oilseeds in terms of the proximate, fatty acid, amino acid profile, vitamin, steroids, and mineral contents; including such properties of the oils like melting point, refractive index, iodine value, peroxide value, p-anisidine value, acid value, saponification value, and the oxidative stability of the oils (**Table 2**, **Figure 3**).

Increased demand for oilseed crops both for domestic and industrial applications has increased recently partly due to the functional roles played by the oilseed, livestock needs and in part, due to population increase and processing needs [18]. According to World Population Review [19], the current world population of estimate as of 2019 is 7.9 billion and is projected to reach about 9.9 billion in 2050. To meet the demand of the growing population, high yielding varieties are been produced through genetic engineering, especially in the area of soybean and oil palm seedlings, not only for the oils they supplies, but also for their cake [20]. Although temperate regions constitutes the major oilseed producers, the tropical regions such as parts of USA, Africa, Malaysia, Indonesia, among other countries contributes about 6% of

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Oilseeds/Proximate composition	Moisture (g/100 g)	Protein (g/100 g)	Crude fat (g/100 g)	Carbohydrate (g/100 g)	Ash (g/100 g)	fiber (g/100 g) NSP	Energy (Kcal/KJ)
Lanneakerstingii seeds*	3.61	26.39	57.85	10.07	2.08		
Cotton seed kernel**		32.6	36.3	21.9		5.5	506/2117
Lin seed/flax seed**		19.5	34.0	34.3		27.9	492/2059
Peanut (plain)**		25.6	46.0	12.5		6.2	563/2337
Rape seed**		22.0	N	8.3		7.2 (Crude fiber)	452/1900
Sesameseed**		18.2	58.0	0.9		7.9	598/2470
Soya (boiled in unsalted water)**		14.0	7.3	5.1		6.1	141/590
Safflower seed**		16.2	38.5	34.3		N	517/2163
Sunflowerseed**		19.8	47.5	18.6		6.0	581/2410
Olives (in brine)**		0.9	11	Tr		2.9	103/422

*Ouilly et al. [17].
**McKevith [18].

Table 1.
Proximate compositions of oilseeds.

Oilseeds/Minerals	K (mg)	Mg (mg)	Ca (mg)	Zn	Fe	Na (mg)	Folate (µg)	Ph (mg)
Lanneakerstingii seeds (mg/kg)*	674.18	317.15	78.33	6.34	4.46	2.48	ND	ND
Cotton seed kernel**	1350	440	100	6	5.4	25	233	800
Lin seed/flax seed**	681	362	199	4.2	6.2	34	278	498
Peanut(plain)**	670	210	60	3.5	2.5	2	110	430
Rape seed**	800	250	400	ND	ND	5	ND	800
Sesameseed**	570	370	670	5.3	10.4	20	97	720
Soya (boiled in unsalted water)**	510	63	83	0.9	3.0	1	54	250
Safflower seed	687	353	78	5.1	4.9	3	160	644

**Ouilly et al. [17].*
***McKevith [18].*

Table 2.
Mineral compositions of oilseeds.

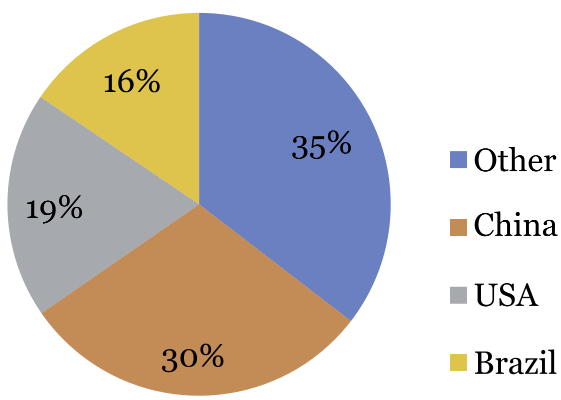

Figure 3.
Global major producers of soybean oil. Source: Shahbandeh [1].

the production, with Malaysia, China and Indonesia as the highest world suppliers of oil palm [16, 21] (**Figure 4**). Other important tropical oilseed crops are groundnut oil, coconut, cotton, neem seed, paw paw seed, etc. Most of the tropical oilseeds are underexploited but very important in traditional folk medicine, especially the oilseeds from the family Anacardiacea, e.g. *Anacardium excelsum*, *Anacardium giganteum*, *Anacardium spruceanum*, *Anacardium humile*, *Anacardium occidentale* as well as other lesser known oilseeds such as *Lannea microcarpa, Pistacia vera* L. and *Sclerocaryabirrea* (A. Rich.) Hochst [22] (**Figure 5**).

Indonesia and Malaysia produced 85% of the world palm oil supply in 2017 with Indonesia supplying about 53% while Malaysia supplied 32%. China majored mainly on the rapeseed and groundnuts and was also the major producer of soybean oil in 2017 with about 30% contribution to the global supply chain [24]. Three tropical countries (Indonesia, Malaysia and Thailand) accounted for approximately 87% of the global palm oil supply in 2017. With the trend in global oilseed supply, it is expected that sunflower oil supply will decline in 2022 due to the Russian-Ukrainian war. Unfortunately, the three major producers of sunflower oil (Ukraine, Russia and Argentina) lies entirely on the temperate region, which will put a heavy demand on

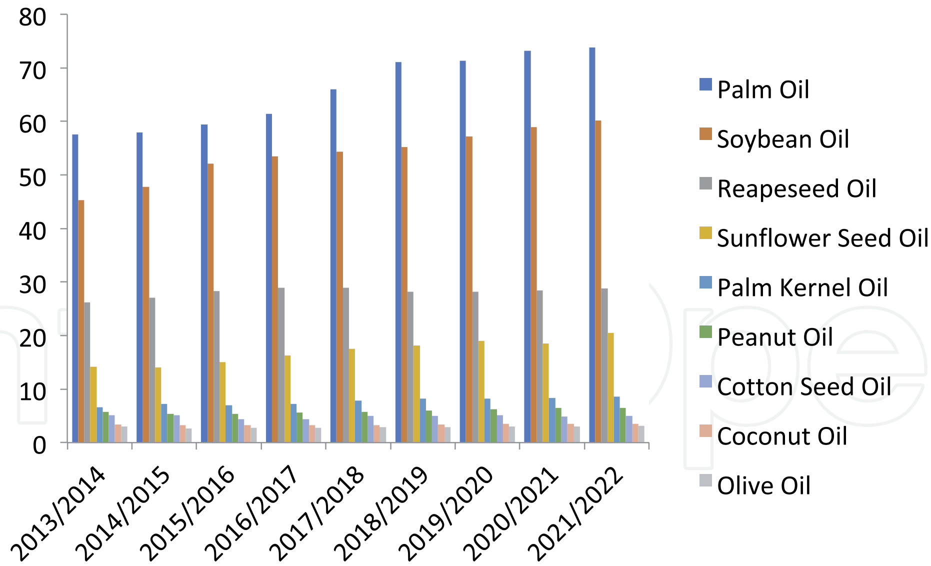

Figure 4.
Consumption of vegetable oils worldwide from 2013 to 2022 (in million metric tons). Source: Shahbandeh [1]. https://www.statista.com/statistics/263978/global-vegetable-oil-production-since-2000-2001/.

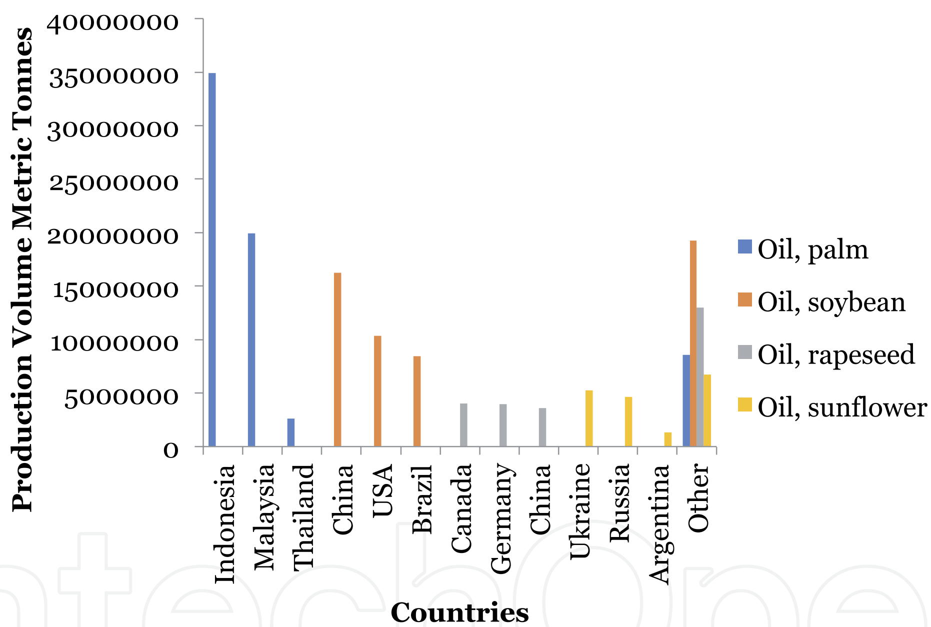

Figure 5.
Source: USDA [23].

sunflower oil from the temperate region. Therefore, the tropical countries could take up this opportunity to improve on their production capacities for increased market demand (**Figure 6**).

4.1 Health implication of oilseed crops

Oilseeds are sources of vegetable oils and fats that provide vital nutritional function in diets, both as a store of energy and as vital component in body nutrition. The oilseeds are sources of vitamin E, fiber, niacin, foliate, iron, phosphorous, and magnesium. The peanuts provide monounsaturated fatty acids, while sunflower and soybean are source of polyunsaturated fatty acids, among others. According to [13], fats and oils contribute more than 39% of the body's calories [17]. The fat may act as

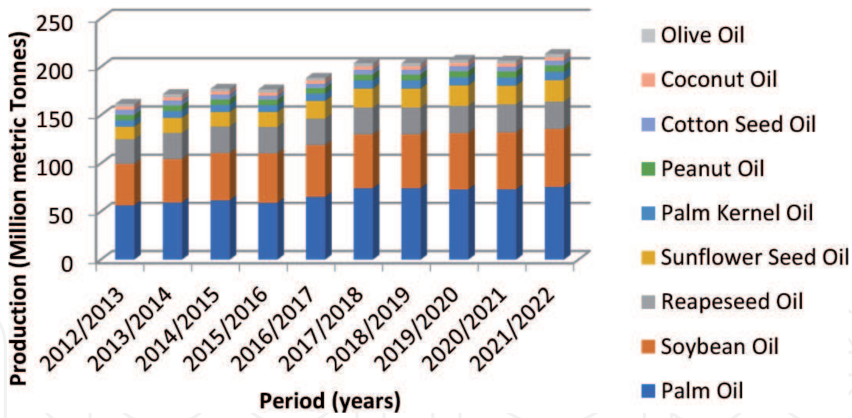

Figure 6.
World production of main vegetable oils by main producers (2012–2022). Source: Shahbandeh [1].

co-factors in vitamin biosynthesis, especially the fat-soluble vitamins, in the supply of essential fatty acids (EFA – our body do not synthesize them but must be obtained from other sources) important in the formation of eicosanoids that serves as signaling substances. It has been established that essential fatty acids, with its associated log-chain derivatives, is important in new tissue formation in the membrane [12]. Essential fatty acids have been associated with brain development, retinal function and nervous system function. Particularly, body fats is an endocrine gland that is involved in the production of signaling molecules for the prevention of fat accumulation in heart, muscles, pancrease, and any other body tissues [25].

The amount of different fatty acids as well as the fat total amount in our food intake greatly influences our health. The emphases on the ratio of the intake of Omega-6 and Omega-3 fatty acids have advocated to be more important than levels of intake of individual fatty acids, although Omega-6 fatty acids have proven to be more vogue due to changing dietary lifestyles [12]. Dietary reference value (DRV) has been recommended for average age brackets in United Kingdom (UK). However, since 1986/87, average intakes of saturated fatty acids has continued to decline in the UK, for men (16.5% food energy) and women (17.17.0% food energy), it was observed vey that intakes still exceeded the Daily Reference Value (DRV) of 11% between 2000 and 2001 survey, suggesting the need for further decrease in the consumption of saturated fatty acids in the UK population. The DRV of fatty acids in developing worlds is still a mirage due to paucity of information in that regard.

It is important to note that excessive consumption of foods with saturated fatty acids and trans fatty acids have been corroborated with increased blood cholesterol levels, a risk factor associated with cardiovascular diseases (CVD). Conversely, the mono unsaturated fatty acids (MUFA) decrease the cholesterol levels responsible for CVD, e.g. low-density-lipoprotein cholesterol (LDL-C). The poly unsaturated fatty acids (PUFA) likewise decrease the LDL-C [1].

The meals from rapeseed, peanut, flaxseed, and soybean are known to provide complete amino acids in diets as they are mixed with other food sources such as cereal grains [17]. Hemp seed oil provides EFA as a cofactor in vitamin assimilation; mustard seed oil could be vital in rheumatoid and arthritic pains (muscle pain). Sawar et al. [17] asserted that the application of mustard oil to scalp enhances hair growth. The health implication of the deficiencies of Omega 3 and Omega 6 fatty acids and the derivatives (prostaglandins) are common and is related to dysfunctional enzyme systems (or genetic disorder) that are immune-system related, as the ratio of consumption of essential fatty acids confers strong immune system and healthy smooth skin. Most of the oilseed crops, tropical oilseeds inclusive, provide adequate supply of vitamin E (antioxidant) carotene, phytosterols, phospholipids, and some minerals such as magnesium, calcium sulfur, potassium, and moderate amounts of zinc, and iron [17]. Rapeseed with about 43% oil and a meal of more than 41% crude protein is therefore an essential oilseed crop due to the array of function performed by protein-rich foods from fatty acid substrates as they acts as hormones, enzymes, tissue structural components, antibodies and as a blood protein [17]. Rapeseed oil are mainly mono unsaturated fatty acids and have been genetically modified to produce cooking oils for food processing applications [26, 27].

Other oilseed crops have been solely used for medicinal purposes, in addition to serving as a traditional culinary spice for ages, e.g. mustard seed (*Brassica juncea*), *cucmeropsismannii, Cucurbita maxima, Cucurbita moschata, Lagenariasicer* aria *and Cucumissativus*. Mustard seeds provide peridoxine (B_6-vitamin), pantothenic acid, thiamin, folates, etc. The vitamin B-complex synthesizes enzymes, aids nervous system function and regulates metabolism in the body [19]. Most oilseeds serve in the development of functional foods and nutraceuticals. Thus, biotechnological research approach through breeding and genetics have been applied in the production of sitostanol enriched soy and canola oils [22].

5. Challenges and prospects

The state of oilseed processing in the tropics leaves much to be desired due to several challenges and large technological gaps which continue to hinder the rapid commercialization of the oilseed processing sector in terms of scale and technology. Although a variety of local technologies are being used in the industry, low utilization of its installed capacity is a challenge. Other challenges include; the lack of modernization in the oilseed processing industry due to inefficient capital machinery, low oil recoveries due to lack of integration between expelling and solvent extraction techniques, lack of standardization of product quality among small-scale processors as most processors produce under non-hygienic conditions without proper monitoring of the quality parameters etc. All this has led to widespread inefficiency in the oilseed processing industry in the tropics which affects domestic markets and export quality.

Furthermore, going by the sustainable development goals of the United Nations, the use of solvent extraction processes in the oilseed processing industry has to take into consideration the health and environmental issues. This in itself is a challenge as alternative and greener solvents have to be used and optimized in the processing of oilseeds while keeping the oil quality intact [28]. Moreover, a sustainable processing methodology and system that has an efficient recovery of the oil fraction from the oilseeds by preserving the quality in an efficient way [29] while eliminating undesirable compounds ought to be adopted.

Nonetheless, despite the several challenges, the sector has massive potential for tremendous growth if various governments introduce special investment incentives for investors and for regulators to monitor and enforce environmental controls and standards. This will lead to the mechanization of bulk handling facilities for enhancing the efficiency of oilseed extractions, development of new value-added products, from the by-products of oilseeds and possibly scientific investigations to machine learning predictive modeling algorithms and simulations for optimization of key parameters necessary to improve oil yield.

6. Conclusion

Processing of oilseeds in the tropics is inevitable because of its high potentials as processed products fetch higher price on sale as compared to the raw materials. There is a need for countries in the tropics to adopt policy reforms and investment strategies that will help oilseed processing in the rural areas particularly, small-scale processors to attain technological advancements, connect to markets and take advantage of any trade opportunities that arise. Thus, sustainable investments in human capital are required so as to scale up to higher-productivity activities in the manufacturing and service sectors.

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