Valuable oily seeds / cold pressed seed oils, world market and risk of the contaminants during supply chain

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Oil seed production in Turkey

In oil seeds production; USA, Brazil, China, Argentina and India come to the forefront in the world. Turkey is known as the world's seventh largest agricultural producer, especially cereal crops and oil seeds.

The majority of production of vegetable oils in Turkey is obtained from sunflower. In addition, there are plenty of oil seed crops such as soybean, sunflower, rapeseed, cotton seed, peanut, sesame and safflower seeds, palm, olive and coconut for crude oil production in the world trade (Onat et al., 2017).

Top oilseed producers

- USA
- Brazil
- China
- Argentina
-
-
- Turkey

Soybean

Rapeseed

Cottonseed

Peanut

Sesame

Safflower

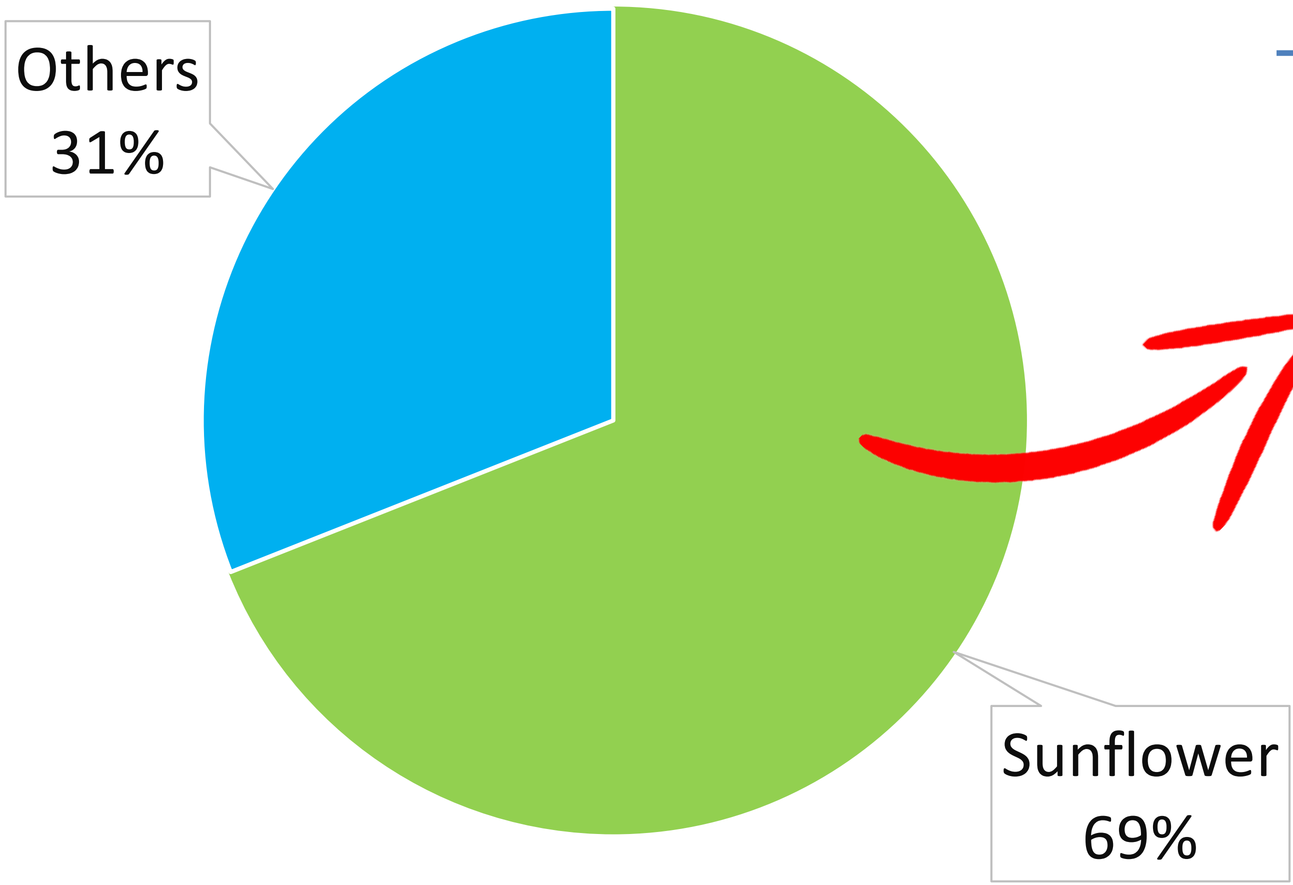
Palm

Olive

Coconut

- Increase from 4.02 million tonnes to 5.40 million tonnes from 2018 to 2023

Vegetable oil production in Turkey



84% of total consumption

32% of total oil use

Table 1: Oil seed Production in Turkey (2010-2020, ton) (TurkStat, 2021)

Years	Soyabean	Peanut	Sunflower (1th)	Sesame	Safflower	Rapeseed (3th)	Cottonseed (2th)	Total
2010	86 450	97 310	1 320 000	23 460	26 000	106 450	1 272 800	2 969 477
2011	102 260	90 416	1 335 000	18 000	18 228	91 239	1 527 360	3 227 588
2012	122 114	122 780	1 370 000	16 221	19 945	110 000	1 373 440	3 138 361
2013	180 000	128 265	1 532 000	15 457	45 000	102 000	1 287 000	3 299 967
2014	150 000	123 600	1 637 900	17 716	62 000	110 000	1 391 200	3 508 640
2015	161 000	147 537	1 680 700	18 530	70 000	120 000	1 213 600	3 442 098
2016	165 000	164 186	1 670 716	19 521	58 000	125 000	1 260 000	3 480 629
2017	140 000	165 330	1 964 385	18 410	50 000	60 000	1 470 000	3 883 370
2018	140 000	173 835	1 949 229	17 437	35 000	125 000	1 542 000	4 009 495
2019	150 000	169 328	2 100 000	16 893	21 883	180 000	1 320 000	3 985 512
2020	155 225	215 927	2 067 004	18 648	21 325	121 542	1 064 189	3 684 675

Table 2: Production of oilseeds crop (TurkStat, 2021)

	Production (Tonnes)		
Yağlı tohumlar - Oil seeds	2020	2021	Change (%)
Mısır (dane) - Maize	6 500 000	6 750 000	3,8
Soya - Soybeans	155 225	182 000	17,2
Aspir - Safflower	21 325	16 200	-24,0
Kolza (kanola) - Rapeseed	121 542	140 000	15,2
Keten (tohum) - Flax (seed)	0	0,5	-
Kenevir (tohum) - Hemp (seed)	273	20	- 92,7
Haşhaş (tohum) - Poppy (seed)	20 542	21 037	2,4
Isırgan otu - Nettle	0,1	0,5	400,0

Turkey has an important potential in oilseed production in terms of its ecology, climate and soil structure. However, it does not make good use of this potential. As a matter of fact, 1 billion 465 million dollars of foreign currency was paid only for oilseed imports in 2017. In addition, 1 billion 270 million dollars was paid for crude oil, which is oilseed derivatives, and 481 million dollars was paid for oilseed meal. In total, 3 billion 216 billion dollars were paid for the import of oilseeds and their derivatives (TurkStat, 2019).

Oilseed Production in the World

Global oilseed production is forecast to grow 8% in 2022/23, primarily on growth in soybean output in South America and the United States, as well as rapeseed production in Canada and the European Union, more than offsetting loses of sunflower seed output in Ukraine and Russia (USDA, 2022).

Global oilseed production is projected to reach 647 million tons, with soybean production forecast to rise 45 million tons to nearly 395 million, up 13% (USDA, 2022).

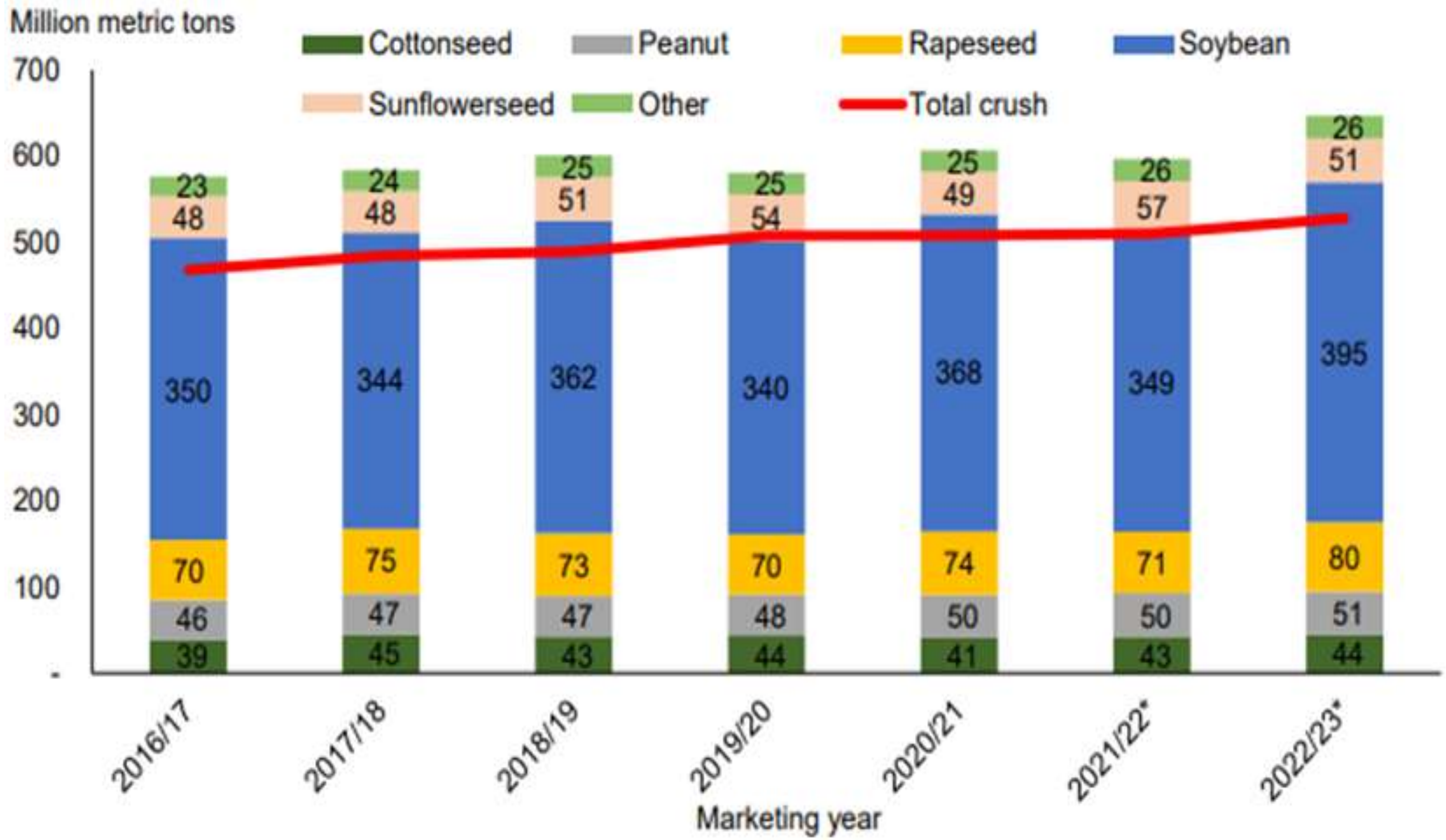
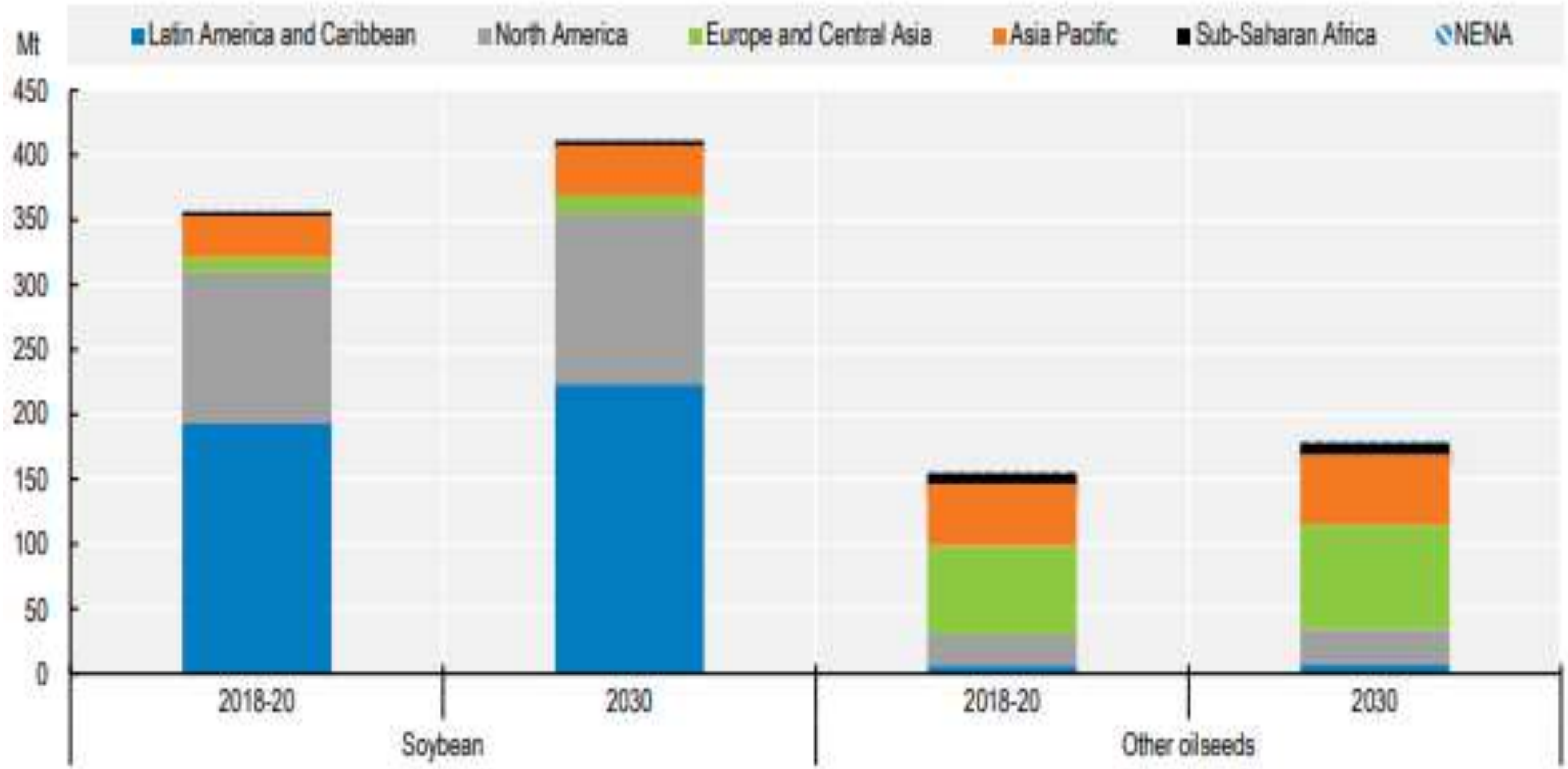


Figure 1: Global major oilseed production and crush (Ates and Bukowski, 2022)

The global oilseed crush volume is expected to increase by 17.74 million tons to 528.05 million tons with soybean accounting for 74 % of that increase (Ates and Bukowski, 2022).

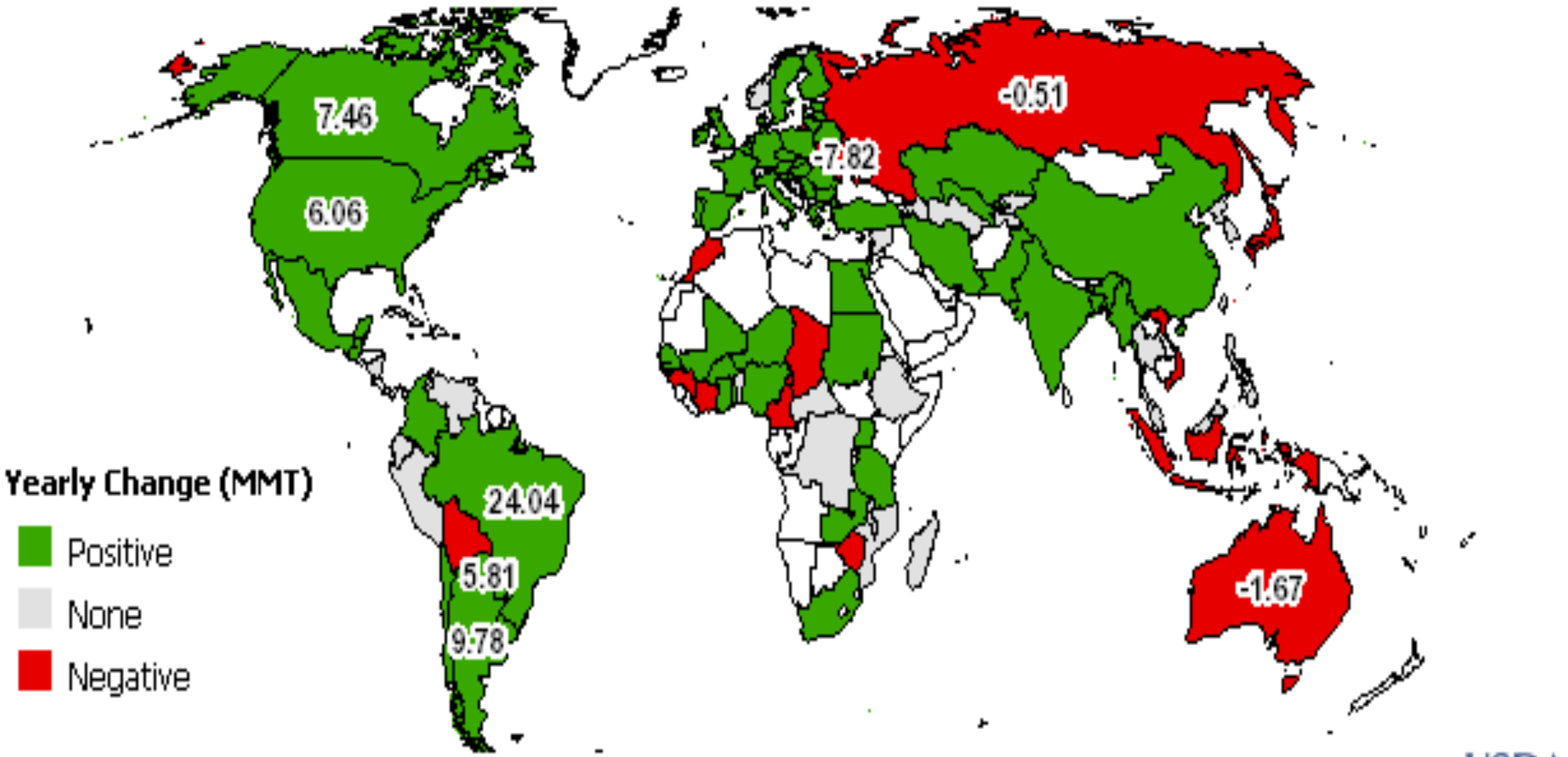
At the same time, due to almost destroyed livestock breeding, domestic enterprises are forced to export raw materials; *sunflower seeds, rapeseeds, soybeans, as well as meal and sunflower cak*e. Export volumes exceed 50% of the gross output of these crops (Slobodianyk et al., 2021)



Note: NENA stands for Near East and North Africa

Figure 2: Oilseed production by region (OECD/FAO 2021)

2022/2023 Total Oilseed Production (Change from Previous Year)



Source: PSD Online (Updated: May 12, 2022)
(https://apps.fas.usda.gov/psdonline)

Sectoral situation of edible vegetable oils

Sectoral situation of edible vegetable oils

On the other hand, due to the low-income levels of the farmers in general, organized structures are needed to improve the living conditions, increase the level of welfare and ensure the development of rural agricultural workers.

Globally, a large part of the problems in the agricultural sector stems from the inability of producers to act together (Aydoğdu et al., 2021).

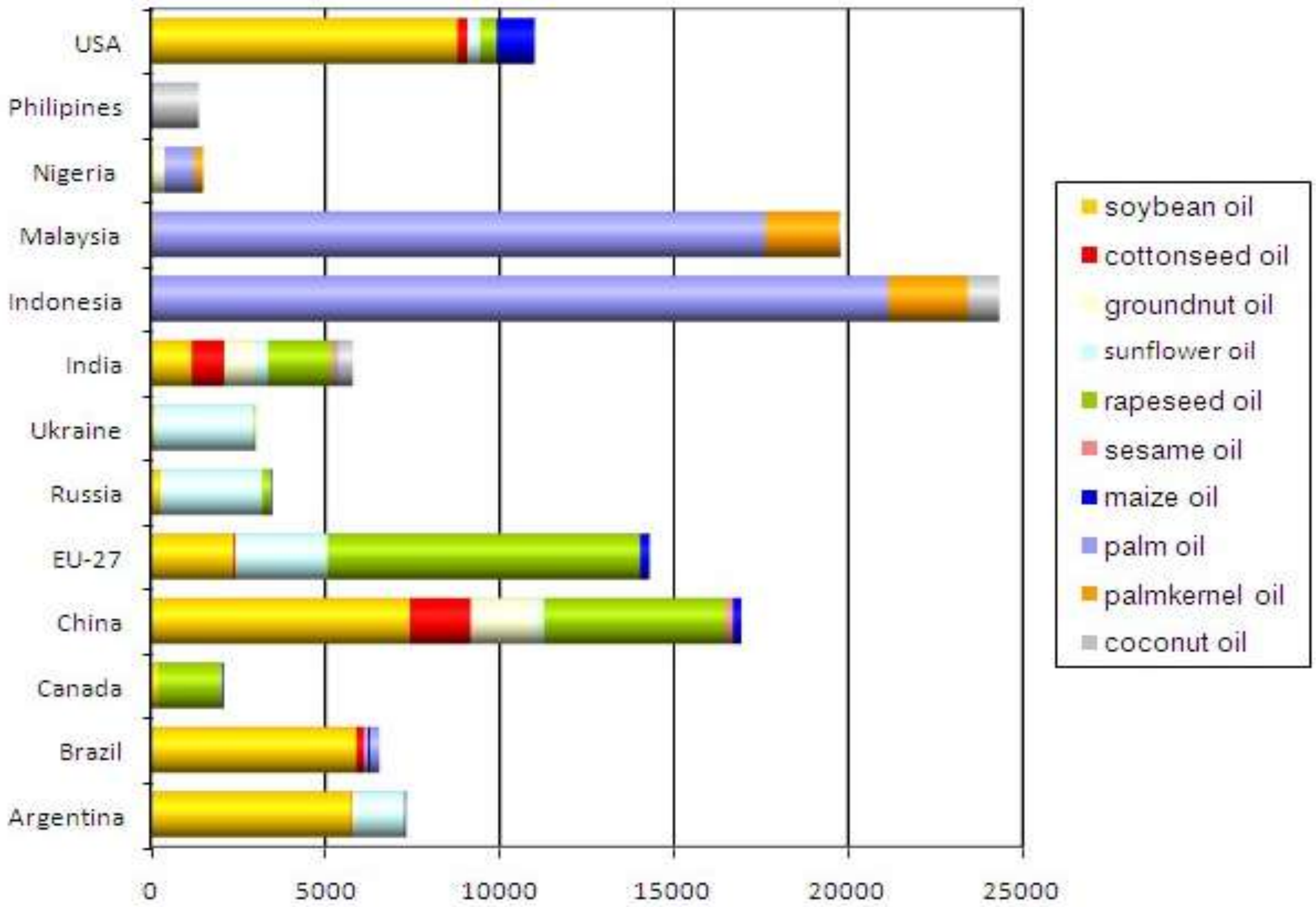
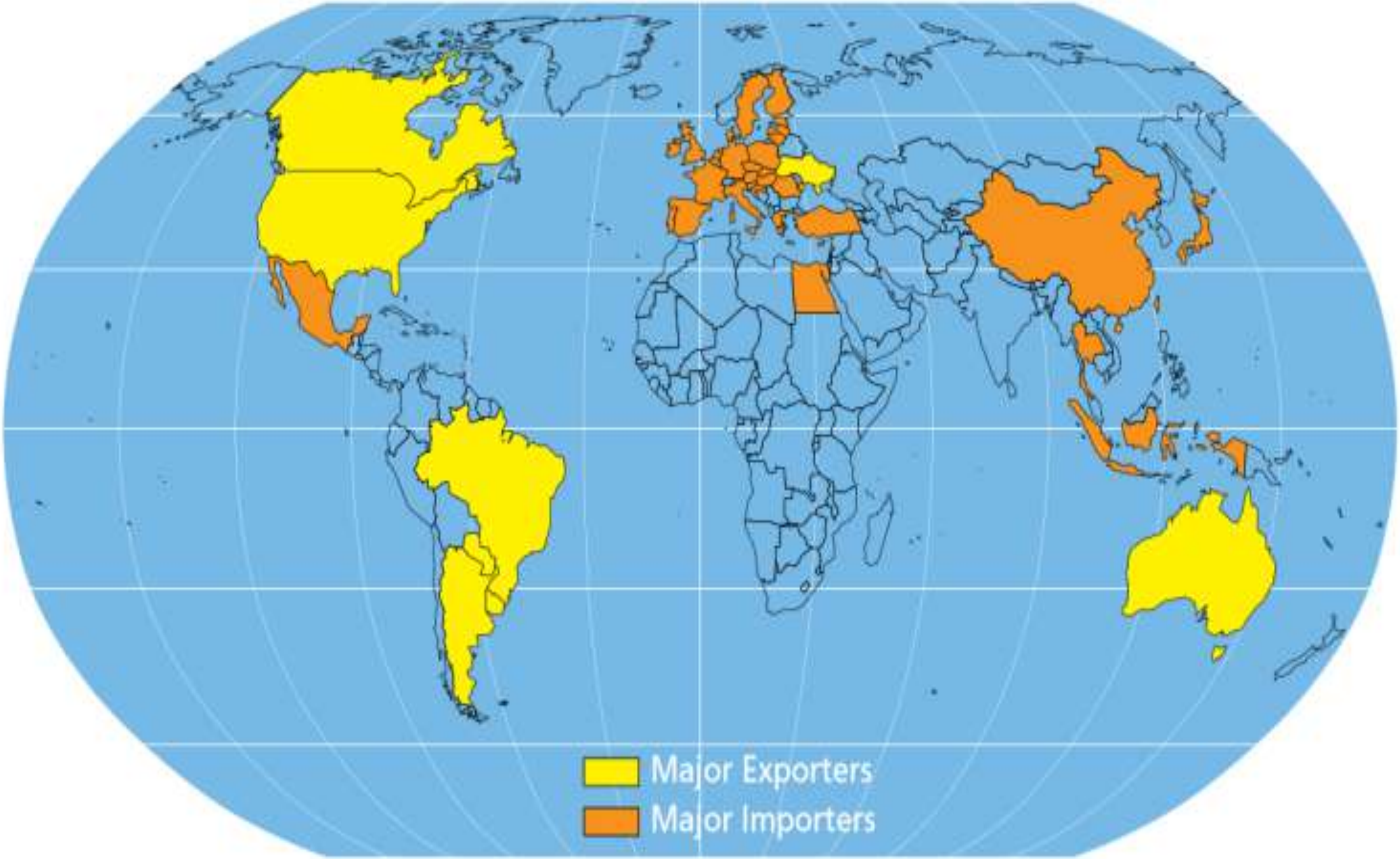


Figure 3: Production of vegetable oils by country (Thousand Tons)

Major Oilseed Exporters and Importers



Sectoral situation of edible vegetable oils

In our country, as in all agricultural products, production of oilseed plants cannot be carried out within a plan. Therefore, production is largely shaped by the product prices of the previous year.

The supply of vegetable oils entirely with domestic production can only be achieved with increases in yields and cultivation areas.

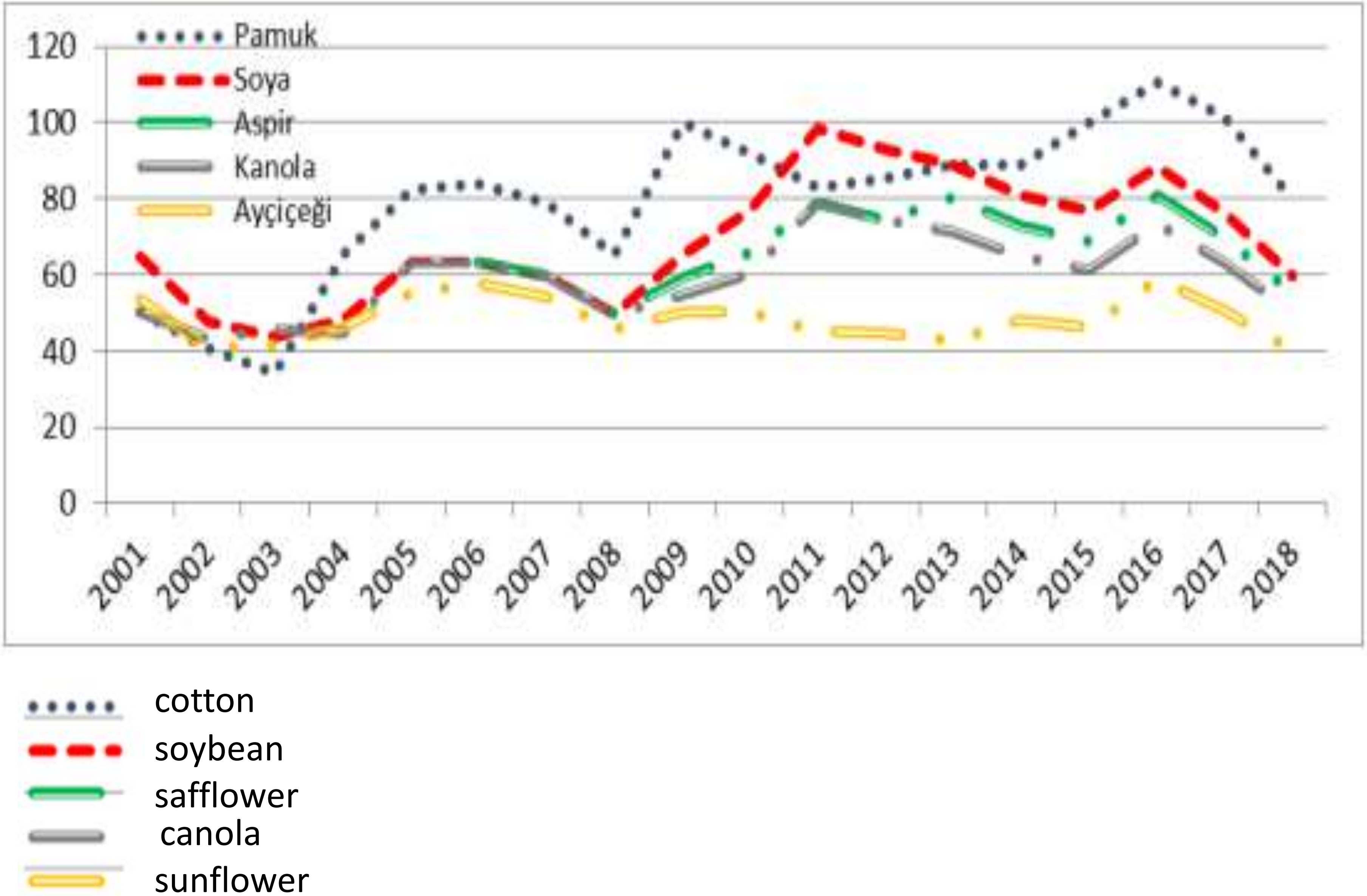
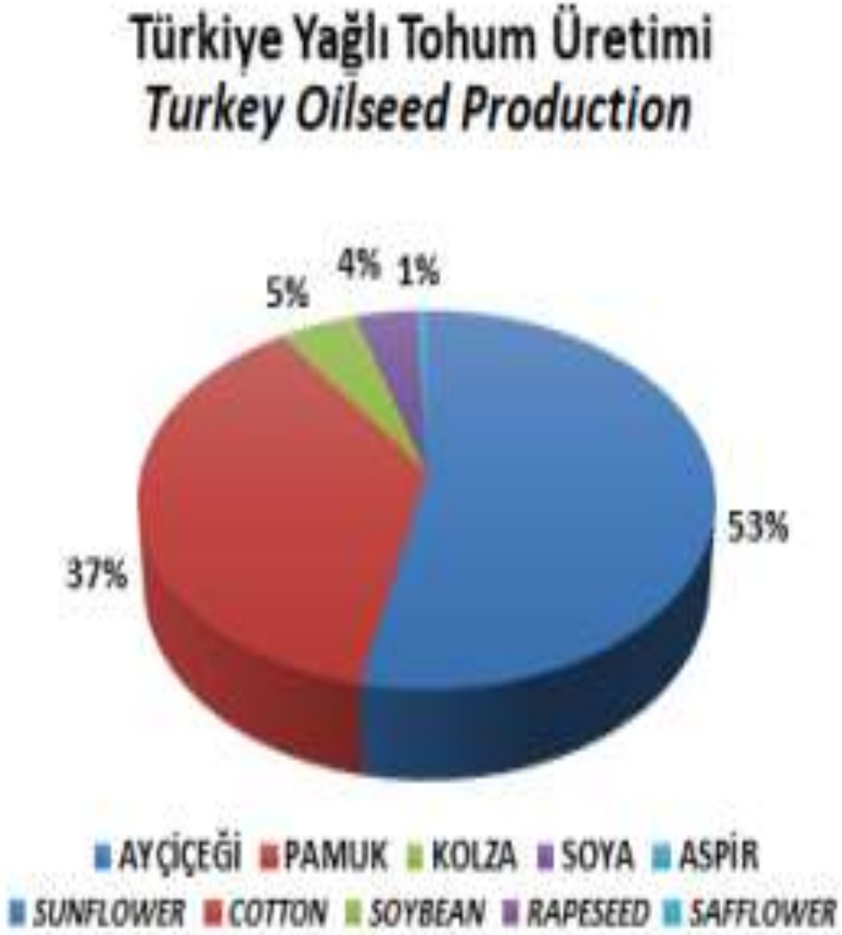


Figure 4: Oilseed premium support in Turkey (kg/krs)

Turkey is literally foreign-dependent country. This situation has provided strategic importance to the production of oil crops (Cançelik, 2021)

In Turkey, the oleaginous oil supply doesn’t meet its demand. Therefore, there have been some subsidies provided (diesel fuel, fertiliser, certificated seed usage, deficiency payments) to increase oleaginous oil production.


Dünya Yağlı Tohum Üretimi
World Oilseed Production
4%
8%
8%
10%
58%
12%
SOYA KOLZA AYÇİÇEĞİ YER FISTIĞI PAMUK DİĞER
SOYBEAN RAPESEED SUNFLOWER PEANUT COTTON OTHER


Türkiye Yağlı Tohum Üretimi
Turkey Oilseed Production
5%
4%
1%
37%
53%
AYÇİÇEĞİ PAMUK KOLZA SOYA ASPİR
SUNFLOWER COTTON SOYBEAN RAPESEED SAFFLOWER

Almost half of the oleaginous oil demand of Turkey is obtained from sunflower and cotton which is the raw material for the textile industry. Therefore, fluctuations and negativities in these two products affect oil production.

However, the importance of canola in oleaginous seed production has increased during recent years (Semerci and Çelik, 2021)

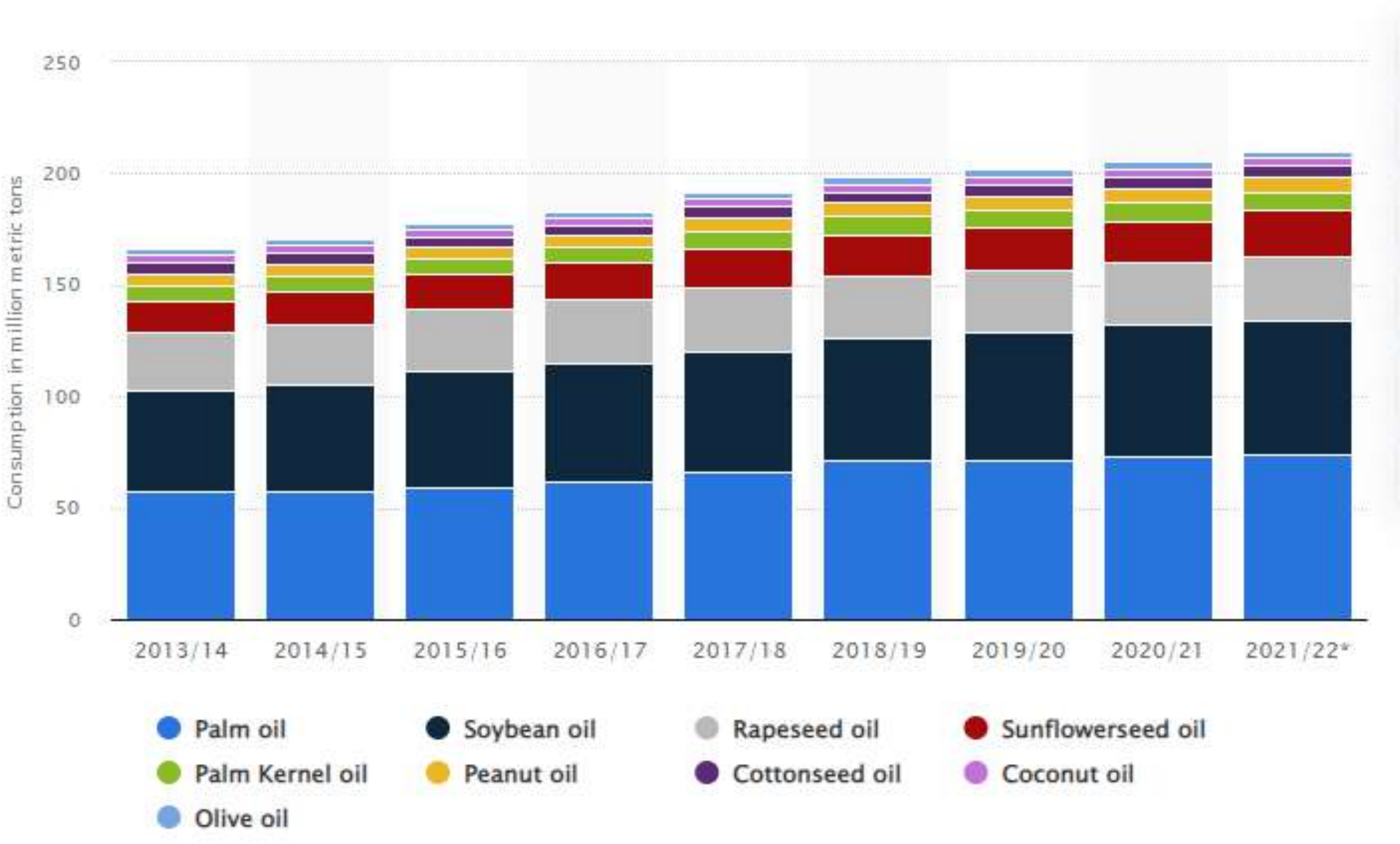


Figure 5: Consumption of vegetable oils worldwide from 2013/14 to 2021/2022, by oil type(in million metric tons)

Alternative oil seed crops

With the increase of population and plant oil consumption, the amount of plant oil produced in our country can not satisfy the demand, and plant oil deficits occur. To meet the required oil demand, plant oil is imported every year, and foreign currency is lost. The fact that vegetable oil consumption per capita in our country is low compared to developed countries is also among the matters to be considered.

To eliminate the vegetable oil deficit, safflower, rapeseed, sesame, camelina, cephalaria, crambe, and flax plants which have the potential of alternative oilseed crops, should be more researched and expanded.

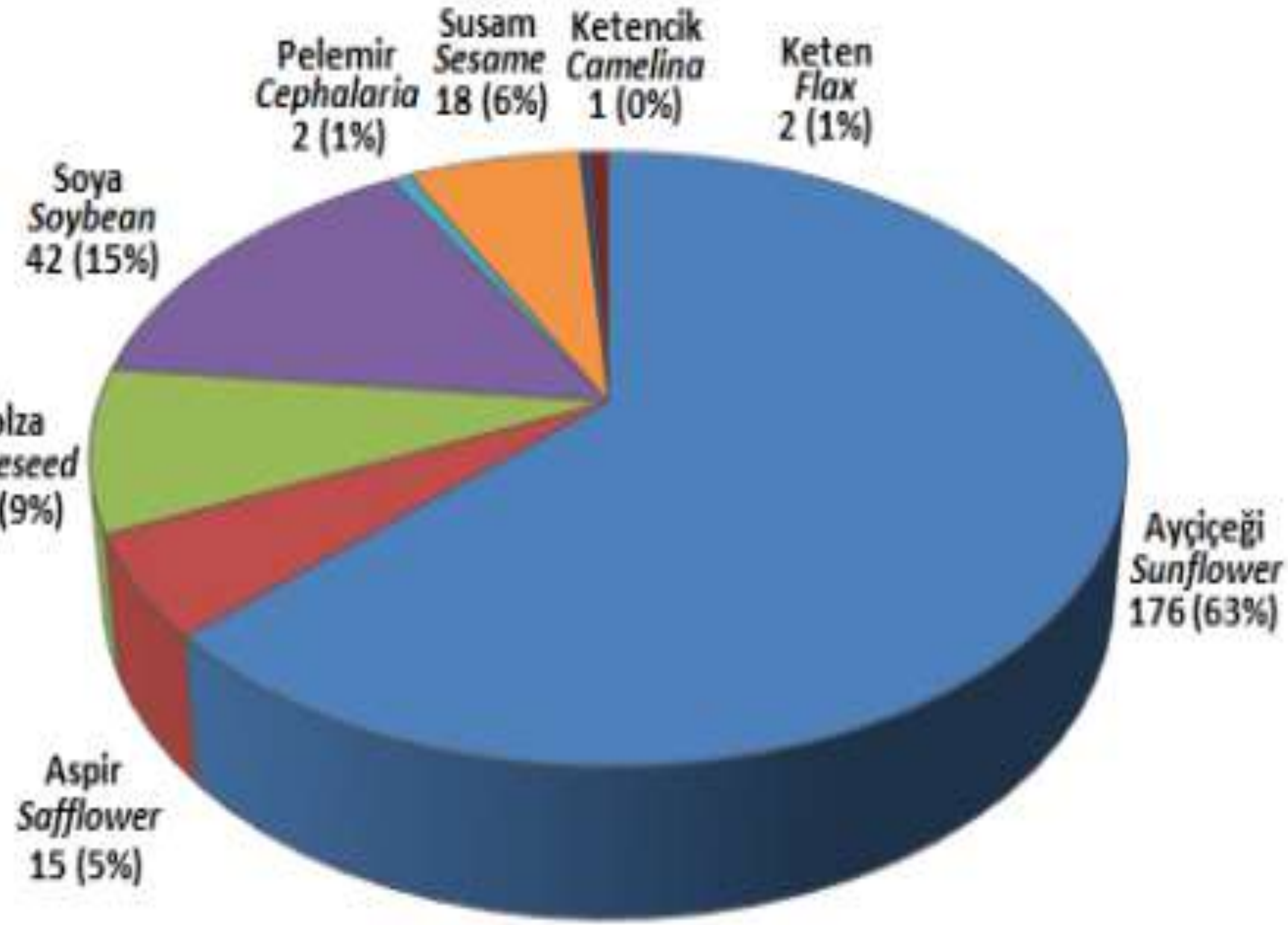


Figure 6: Number of registered varieties of oil crops in Turkey

a) Safflower

b) Camelina sativa

c) Cephalaria seed

d) Flax seed

Alternative oil seed crops

Hemp is also an alternative oilseed plant producing in ten countries such as China, France, Chile, Pakistan, Ukraine, Russia, Hungary, Iran, Romania, and Turkey.

The highest share in hemp seed production belongs to Europe with 61.3% and Asian countries with 37.5%, production in the American continent is 1.2%. It can be cultivated efficiently under various climate conditions (Yılbaşı et al, 2021)

Figure 7: a) Hemp seed crop and b) its seeds (Yılbaşı et al., 2021)

- Recently, an increase in the consumption of cold-pressed edible oils has been observed. In terms of their nutritional values, they are more beneficial than the refined oil (Bartnikowska 2008; Matthaus & Bruhl 2008; Matthaus & Spender 2008; Przysławski & Boleslawska 2006).

- These valuable bioactive components of cold-pressed oils are such as: tocopherols, sterols and carotenoids. They are partially destroyed with phospholipids that have oxidizing properties during the industrial refining (Chandra and Shinde, 2020).

Current comparisons of oil extraction techniques

Conventional methods, namely solvent extraction and mechanical extraction are the well-known and widely practiced methods in oil industry. Most of the seed oils are extracted either by both methods or by combination of the two.

Oil extraction applications have some basic and unalterable rules such as not damaging the oil during operation, least impurity, minimum oil content in the cake, and maximum oil yield (Çelenk et al., 2018)

The basic methods for oil extraction are schematized in Fig. 8

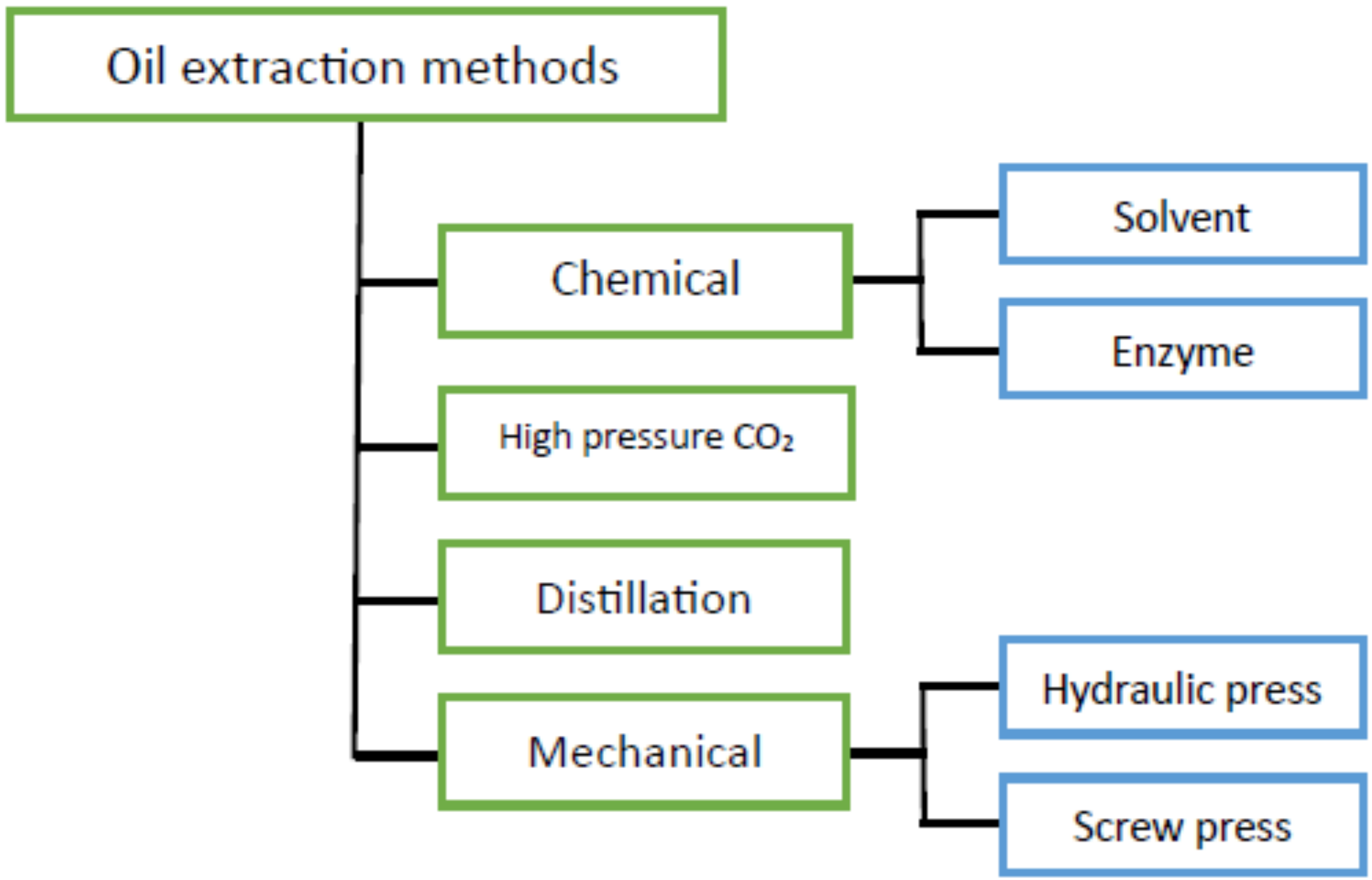


Figure 8: Oil extraction methods (Celenk et al., 2020)

Table 3: Advantages and disadvantages of the extraction techniques (Çelenk et al., 2020; Zhou et al., 2020)

	Advantages	Disadvantages
Solvent extraction	✓ high oil yield	✓ toxicity, ✓ high-cost solvents, and ✓ harmful to the environment
Mechanical extraction (eco-friendly methods)	✓ Simple usage, ✓ rapid realization, ✓ short duration of the process, and ✓ high-quality oils	✓ low yield is the biggest disadvantage (but it could be optimized by preheating the seeds, to increase the yield)

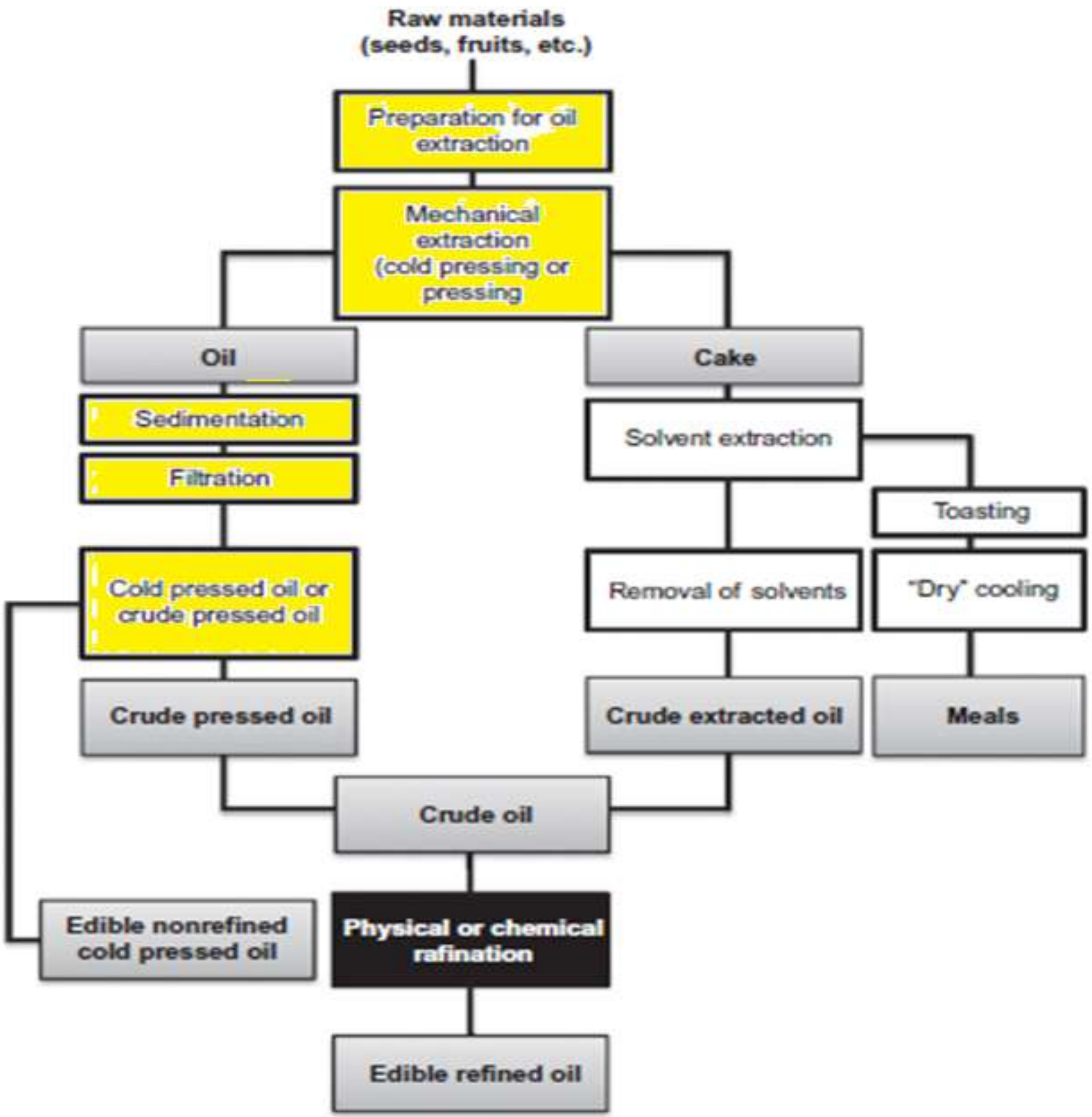


Figure 9: Flow diagram of nonrefined and refined edible oils production (Popovic et al, 2021)

The quality requirements imposed both by the oil industry and more health-conscious consumers continue to increasing trends force the oil producers to improve their technology.

It is achieved through the application of the most advanced technologies in different fields in order to obtain fats with the best health, nutritional and utilitarian attributes.

Thereby, the demand for cold pressed oils has been increased in recent years due to their well-preserved nutrients and bioactives contents (Öztürk, 2020).

What is cold pressing technique?

Pressing extraction of edible oil can be divided into hot pressed and cold-pressed. Cold-pressed is a method of producing oil by low-temperature pressing the oil grains with force through an oil mill. The oil plants are not heated, nor are they are stir-fried at low temperature before pressing.

It's processed at lower temperature (≤40°C) does not alter the properties of the oil which contains a higher phenolic content, flavour, aroma and nutritional value. Cold pressed oil does not contain trans fatty acids and are naturally cholesterol, it has great importance for cooking and skin care requirements (Zhou et al., 2020; Mondor and Alvarez, 2021)

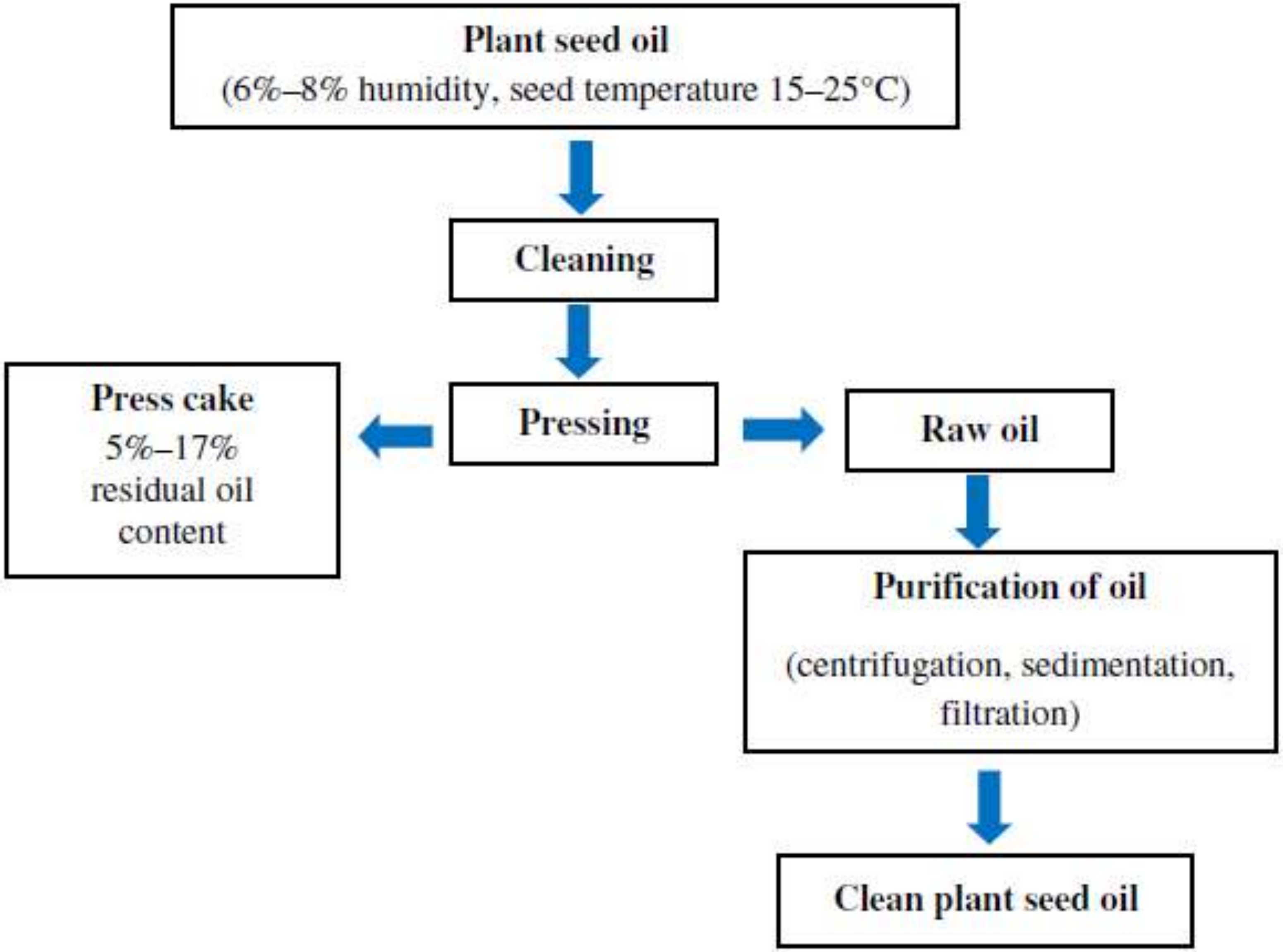


Figure 10: The flow diagram of cold pressed plant seed oil (Rezig et al., 2020)

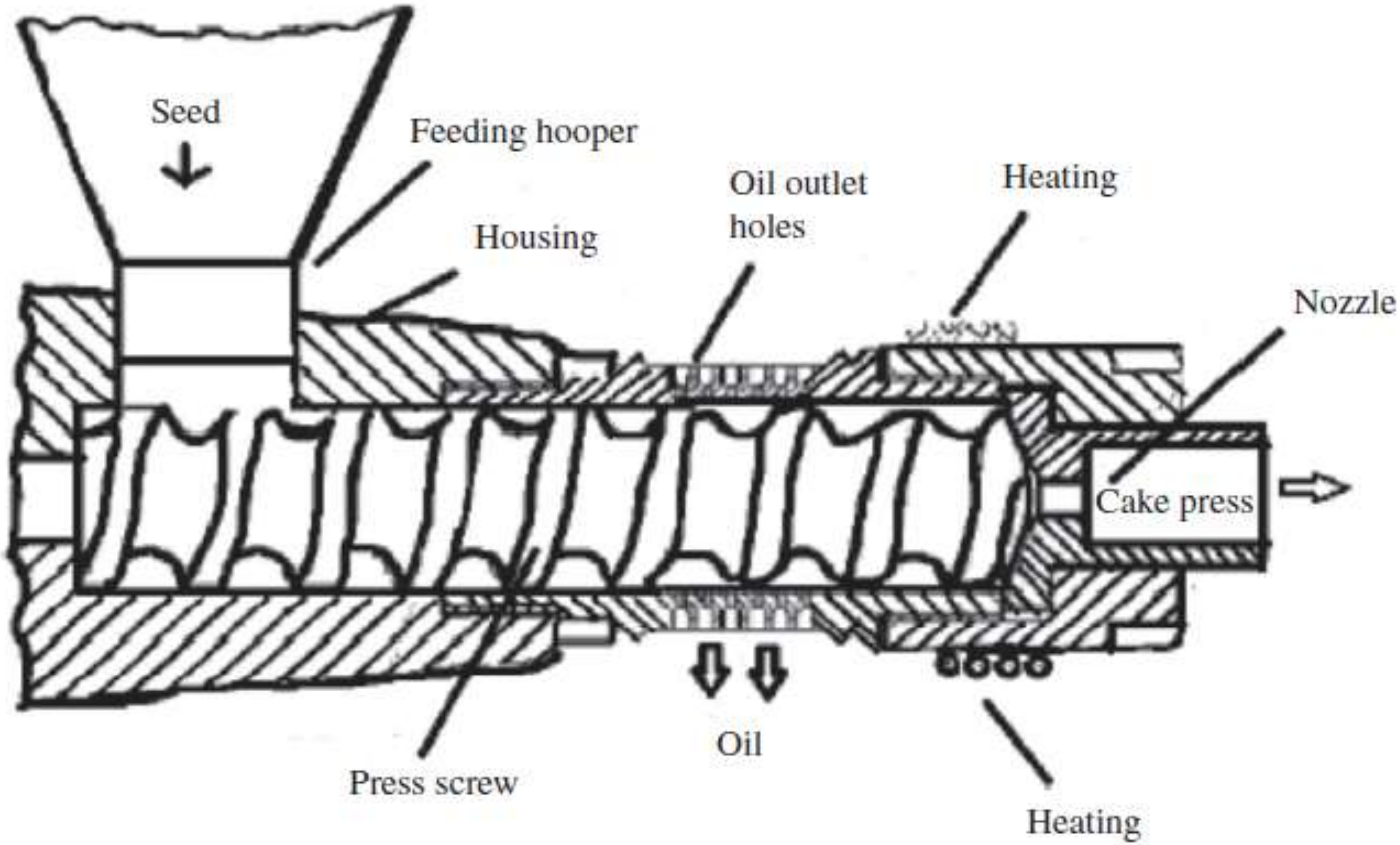


Figure 11: Screw press machine (Rezig et al., 2020)

Figure 12: A view from our research on cold pressed pumpkin seed oil

Hot pressing;

- is the opposite method of cold pressing,
- the oil pressing process occurs at a continuous high temperature environment,
- high temperature may lead to loss of many nutrients and flavor substances in EPOs. For example, high temperature caused vitamin E damage and loss. *Research showed that the content of vitamin E in cold-pressed and hot-pressed sunflower seed oil was 45.7 mg/100 g and 13.2 mg/100 g, respectively*. This indicates that vitamin E decomposed to a certain extent during the baking process, thus resulting in a decrease in the vitamin E content (Siger et al.,2017).

Therefore, cold-pressed method becomes more popular (Zhou et al.,2020).

Cold pressing

- This method is generally recognized as safe **(GRAS)** since no solvents are used.
- Based on type of raw material and botanic classification oils can be obtained from **seeds** (e.g. canola, flax, poppy, borage, hippophae or sea-buckthorns, pumpkin, blackcurrant, grapes), **fruit** (e.g. plums, hippophae or sea-buckthorns), nuts or kernels (e.g. hazel, walnuts, argan) or sprouted **grains** (e.g. wheat germs) (Chandra et al., 2020)
- However, cold press extraction results in a low extraction yield, which outweighs its better quality (Mondor and Alvarez, 2021). After pressing , the remaining cake contains about 5 to 15 % of oil. But it could be optimized by pre-treatment methods such as microwave heating, roasting, ultrasonic exposure and pulsed electric fields.

- Cold-pressed oils provide a wide range of bioactive substances, such as tocopherols and tocotrienols, free and esterified sterols, hydrocarbons (squalene), triterpene alcohols, carotenoids and chlorophylls along with colourants being valuable nutrients are called functional food.

- It contains n-3 and n-6 PUFA or sterols having biologically active effects (Chandra et al., 2020)

Uses of cold pressed oils

Due to all these favourable and beneficial features, cold pressed oils have a wide range of applications as a flavor or basic natural perfume agent in

cosmetic,

pharmacology,

aromatherapy,

personal care,

manufacturing, and the food industry

(Matthaus & Ozcan, 2012; Aydeniz-Guneser & Yilmaz, 2017).

How big is the Cold Pressed Oil market?

- Cold pressed oil market is primarily driven by increased usage of cold pressed oil in the preparation of various cuisines. Additionally, upsurge in internet penetration and accessibility of smart gadgets is increasing awareness about the benefits of cold pressed oil such as its high nutritional value and enhanced flavor (Anon., 2022a).

- The global cold-pressed oil market size was valued at \$24.62 billion in 2018, and is expected to reach \$ 44.78 billion by 2030 (Anon., 2022a) (Fig.13)

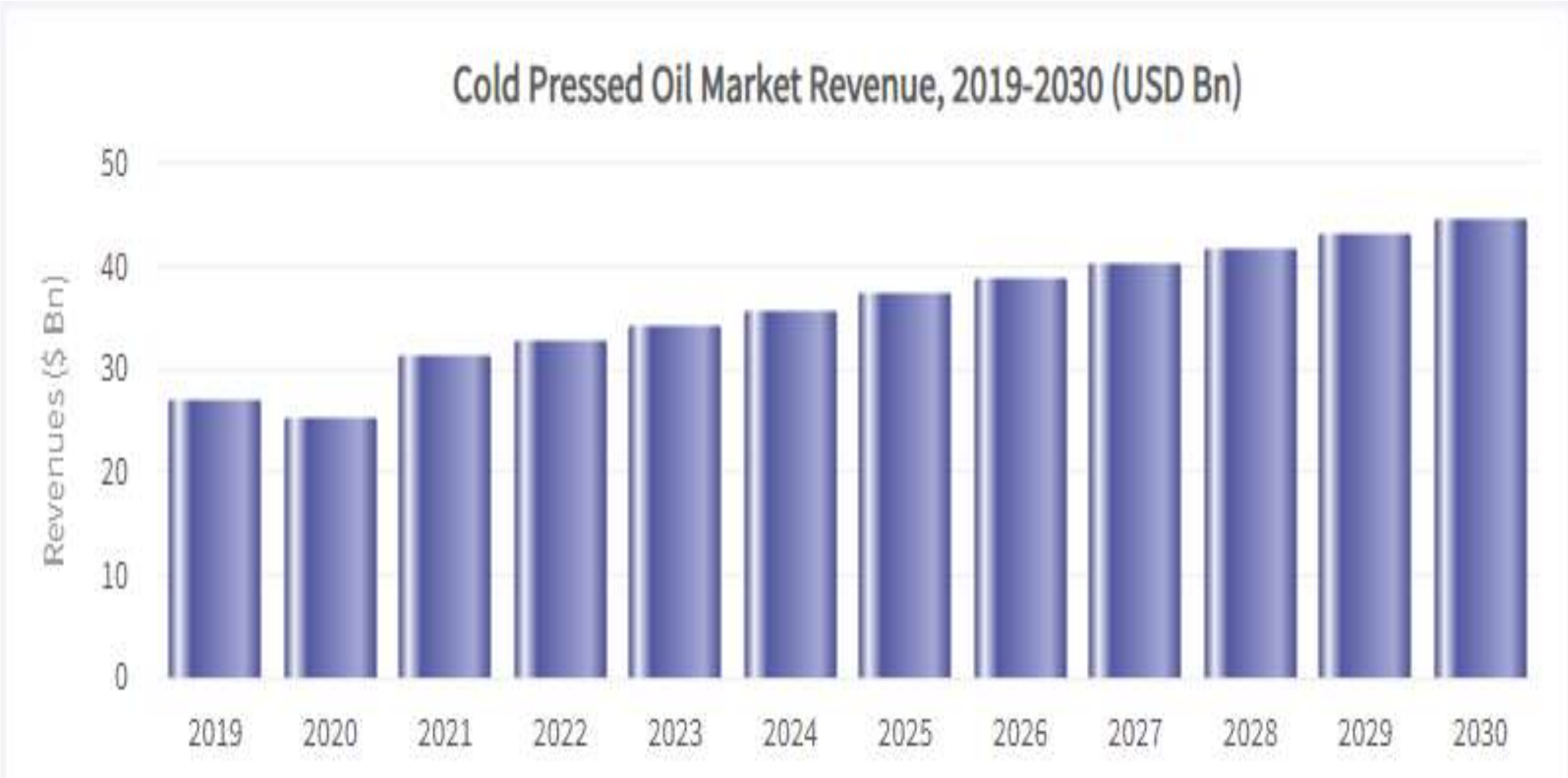


Figure 13: Estimated cold pressed oil market income (2019-2030)

The market is divided into several categories as;

Type

Coconut oil
Cottonseed oil
Olive oil
Palm oil
Palm kernel oil
Peanut oil
Rapeseed oil
Soybean oil
Sunflower seed oil

Application

Food industry
Agriculture
Cosmetics
Personal care

Distribution

Convenience stores
Departmental stores
Modern trade units
Online retail

(Anon., 2022b)

They are gaining more popularity day by day among consumers who prefer natural, traditional and low processed food.

In certain European Countries like Poland, Germany, Switzerland, Austria, UK and Great Britain, cold-pressed rapeseed oil has grown in popularity as it possesses characteristic taste with a hint of nuts, distinct aroma and intensive colour. This oil is available across many temperate regions in the world including Northern Europe where its popularity is growing (Öztürk, 2020).

- North America is expected to hold the highest market share in the global market because of its health benefits and environment friendly characteristics (Anon., 2022a).

- *European market is estimated to show consistent growth due to the development in its food industry.*

- Moreover, the market of Asia Pacific is estimated to show rapid growth with consistent increase in market share due to high nutritional value of cold pressed oil, coupled with enhanced taste & aroma (Anon., 2022a).

Comparisons of cold pressed and solvent extracted oils in terms of oil yield and quality

- Lower oil yield compared to solvent extraction is considered the most significant disadvantage of the cold pressing technique.

- Studies reported that some pretreatments such as heating, roasting, steaming microwave irradiation, and enzyme addition applied on oily material could enhance the oil yield (Aydeniz et al.,2014).

Table 4: Comparison of different oil extraction technologies in terms of oil yield from various oilseeds (Rani et al., 2021)

Seeds	Extraction method	Oil yield (%)
Canola	UAE	47
	Solvent	39
Flaxseed	Screw press	25.5
	Solvent extraction	38.8
	SFE	35.3
Niger	Mechanical	39.34
	Solvent	29.23
Sesame	Cold pressing	9.19
	Cold pressing + solvent	59.52
	Cold pressing + SFE	57.15
Soybean	SFE	19.9
	Solvent	20.0
	SFE	19.5
	Solvent	25
Sunflower	UAE	49.41 (nonhulled) 28.53 (hulled)
	SFE	54.37

Table 5: Lipid yield and some chemical , qualitative parameters of walnut oils depending on extraction methods (Gao et al., 2021)

	Cold pressed	Roast pressing	Hexane extraction	Supercritical CO2 extraction
Lipid yield (%)	47.04	45.10	58.11	44.46
Acid value (mg KOH/g)	0.41	0.51	0.39	0.11
Peroxide value (mmol/kg)	1.39	1.57	1.12	1.18
α-Tocopherol (mg/ kg)	43.1	115.9	45.9	43.9
β-Tocopherol (mg/ kg)	27.5	23.3	23.6	12.1
γ-Tocopherol (mg/ kg)	168.9	99.6	191.9	207.2
δ-Tocopherol (mg/ kg)	80.5	64.4	85.7	57.5
Polyphenol (mg/ kg)	29.7	35.2	45.4	28.0
DPPH (µmol TE/kg)	356	324	479	370

Table 6: Chemical characteristics of argan oils obtained by different extraction methods (Mechqoq et al., 2021)

			Supercritical fluid extraction		
	Cold pressed	Soxhlet extraction	20 MPa	30 MPa	40 MPa
Lipid yield (%)	49.83	57.12	22.03	37.22	48.50
Acid value (mg KOH/g)	0.3	0.4	0.4	0.6	0.5
Peroxide value (meq/kg)	0.7	1.2	0.8	0.6	0.7
Iodine value (g/100 g)	103.5	94.3	98.2	99.5	90.0
K_{232}	2.00	1.90	1.53	1.30	1.49
K_{270}	0.25	0.18	0.24	0.17	0.15

Table 7: Effect of different extraction techniques on coconut oil yields (Aytaç, 2022)

Techniques	Yield (%)
Cold press	20.75 ± 0.32
Soxhlet	30.23 ± 0.25
SFE-I	25.44 ± 0.10
SFE-II	28.84 ± 0.15
SFE-III	24.35 ± 0.13
SFE-IV	22.66 ± 0.11

SFE-I: 50 °C, 300 Bar, 1 h, SFE-II: 60 °C, 300 Bar, 1 h, SFE-III: 40 °C, 200 Bar, 1.5 hrs, SFE-IV: 30 °C, 200 Bar, 1.5 hrs

Table 8: Analysis results of cold pressed seed oils obtained by conventional and enzyme pre-treatment methods (Candan and Arslan, 2021)

	Flaxseed oil		Apricot seed oil		Grape seed oil	
Analysis	**Conventional**	**Enzyme**	**Conventional**	**Enzyme**	**Conventional**	**Enzyme**
Oil yield (%)	37.82±1.09*a	30.85±1.94b†	31.16±4.13b	38.25±1.76a	10.43±0.92	11.05±0.65
Free fatty acids (%)	1.91±0.09b	2.04±0.47a	0.37±0.03b	0.52±0.02a	0.94±0.05b	0.99±0.07a
Peroxide value (meq O_2/kg_{oil})	2.05±0.15a	1.73±0.17b	1.89±0.17a	1.34±0.40b	18.93±1.56	20.59±1.18
p-Anisidine value	1.40±0.59	1.31±0.15	2.28±0.75a	1.97±0.23b	5.30±1.14	4.46±1.08
Total carotenoids (mg/kg)	0.297±0.03	0.295±	0.376±0.026b	0.731±0.08a	1.237±0.168a	0.719±0.037b
Total phenolics (mg/kg)	62.32±12.94	56.27±7.15	18.44±2.67b	31.08±4.41a	154.13±23.29	127.92±15.03
Antioxidant capacity %						
hydrophilic	29.72±1.14a	16.34±3.65b	17.81±3.90b	33.55±4.24a	40.46±4.51	33.68±1.48
lipophilic	40.37±1.26a	35.61±5.22b	20.59±4.02b	42.93±3.44a	42.12±6.84	31.30±2.48
total	31.85±2.73	28.89±3.17	34.10±4.18	38.31±5.21	42.13±2.17	38.54±3.05
Tocopherols (mg/L)						
α-tocopherol	112.43±24.8	111.60±12.5	119.09±17.6	119.65±9.53	181.49±18.72a	156.59±17.5b
β-tocopherol	186.22±21.17a	154.29±25.9b	0.157±0.05a	0.147±0.04b	95.09±12.4b	117.89±14.6a
γ-tocopherol	416.62±26.8	444.09±31.17	638.84±30.86	619.04±22.46	418.11±46.65	413.00±29.34
δ-tocopherol	146.21±13.06	147.12±10.66	154.12±12.38	150.97±26.67	0.140±0.03	0.147±0.05
Oil color indices						
L*	31.13±3.7	31.88±4.0	31.15±2.9	30.88±1.67	27.44±4.5	27.57±1.53
a*	-1.95±0.7	-1.97±0.31	-1.66±0.8	-1.52±0.6	1.07±0.4a	0.76±0.21b
b*	7.15±0.48	6.82±0.62	3.98±0.25	3.63±0.21	-1.94±0.09b	-0.87±0.06a

Contrary of apricot and grape seed oils, enzyme pre-treatment reduced oil yield of cold pressed flaxseed. It's thought that the applied enzyme mixture is not suitable for the flaxseed cell membrane structure and also created a negative result by affecting the moisture ratio (Table 8).

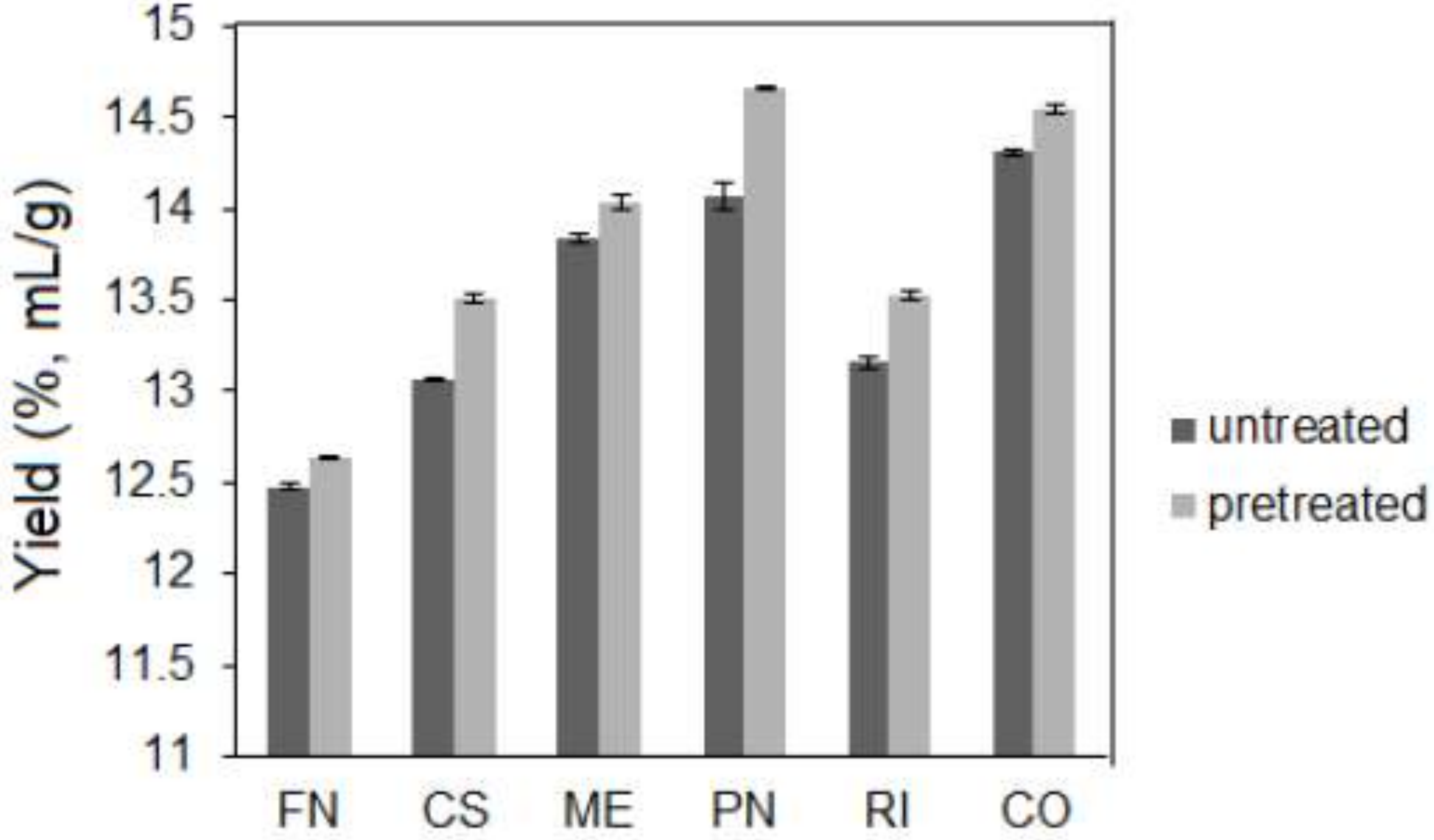


Figure 14: The oil amount (mL/100 g seeds) obtained by cold pressing from untreated and enzyme pre-treated grape seeds (Tociu et al., 2021)

- The enzymatic treatment seems appropriate due to the progress in the industrial production of enzymes as well as their numerous industrial applications derived from their properties, namely: low toxicity, energy saving due to mild work conditions, biodegradability, etc.. An improvement in oil quantity and/or quality was predicted (Tociu et al., 2021).

Why pre-processing techniques?

- Pre-processing techniques are becoming increasingly studied because they offer multiple advantages including; increasing oil yield, increasing concentration of beneficial minor compounds, formation of new beneficial minor compounds, and increasing of oxidative stability (McDowell et al., 2017)

- The reason for an increased oil yield after preprocessing is claimed to be the disruption of the internal structure of the seeds. The retention of the oil within the seed is reduced and therefore easier to extract during cold pressing. When seeds have been either microwaved or thermally roasted, the tocopherol and phenolic concentration in cold pressed oils has been shown to increase (McDowell et al., 2017)

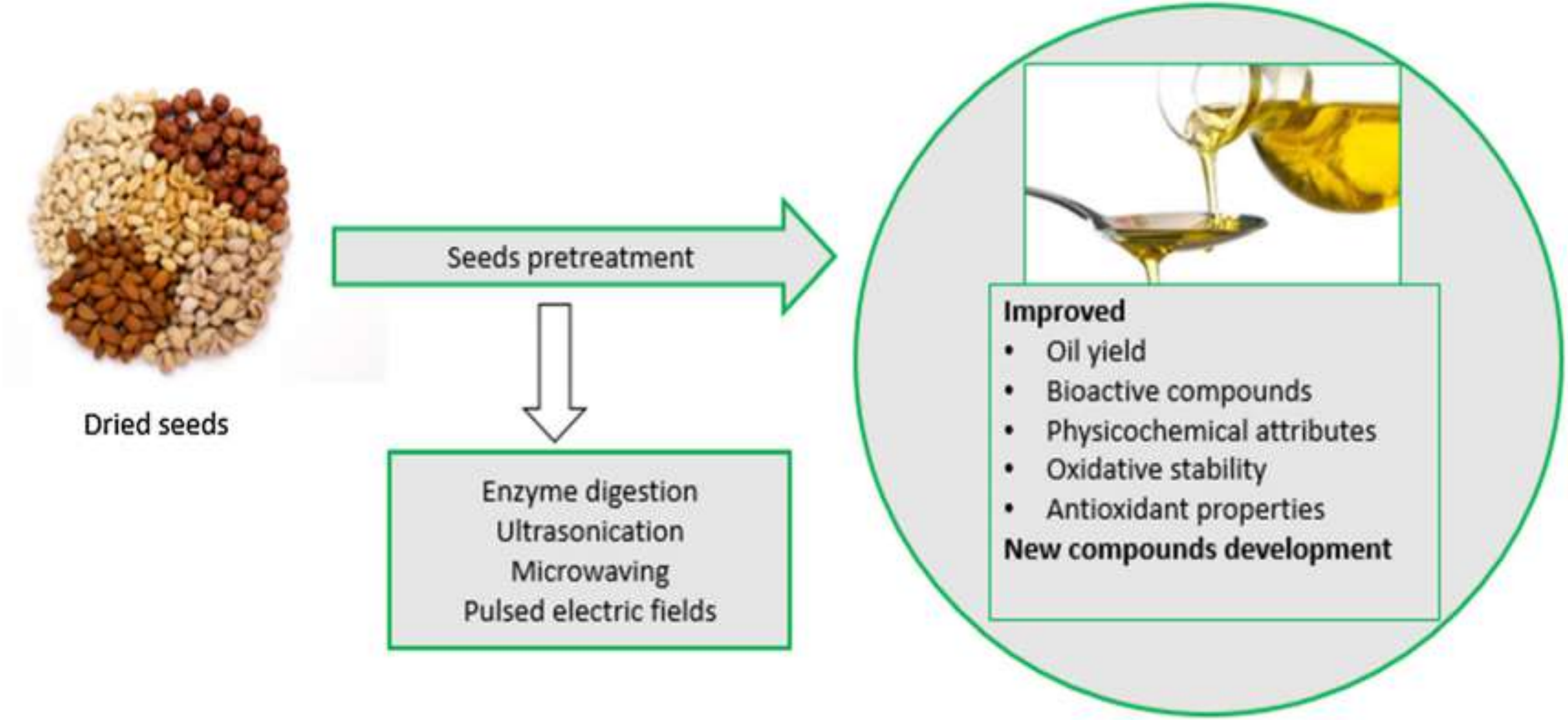


Figure 15: Summary of the effect of novel seeds pretreatment techniques on oil quality and antioxidant properties (Kaseke et al., 2021)

*The yield of oil from **rapeseeds** is an important parameter for any producer, as extracting the maximum amount of oil from the seed means more of the end product can be sold. Previous research studies have reported an increase in cold pressed rapeseed oil yield when seeds have been preprocessed.*

Table 9: Changes in the yield of cold pressed rapessed oils depending to the pre-treatments methods (McDowell et al., 2017)

	Microwave treatment		
	Untreated sample	800 W/2 min	800 W/4 min
Azadmard-Damirchi et al. (2010)	15 %	18 %	25 %
	Untreated sample	**Ultrasound treatment**	
Turkay and Gurbuz (2013)	44 %	73 %	

Table 10: Rice bran oil extractability under different extraction processes (Phan et al., 2019)

Extraction method	**Condition**	**Oil extractability (%)**
Hexane extraction	-	100
Cold press extraction	-	84.97
ultrasonic pretreatment combined with cold press extraction	2.25 W/g, 10 min	86.42
	4.50 W/g, 10 min	89.89
	6.75 W/g, 10 min	94.78
	2.25 W/g, 25 min	92.52
	4.50 W/g, 25 min	93.93
	6.75 W/g, 25 min	**95.07**
	2.25 W/g, 40 min	92.54
	4.50 W/g, 40 min	93.91
	6.75 W/g, 40 min	**95.11**
cooking process combined with cold press extraction	100°C, 5 min	93.59
	100°C, 15 min	**96.81**
	100°C, 25 min	**97.73**
	100°C, 35 min	**97.93**

Table 11: Proximate composition and antioxidative properties of roasted and unroasted hemp seeds (roasted at 160°C) (Babiker et al., 2021)

Quality attribute	Roasting time (min)			
	0	7	14	21
Proximate composition (%)				
Moisture	3.79 ± 0.57[cd]	4.20 ± 0.00[b]	4.29 ± 0.14[a]	3.89 ± 0.14[c]
Oil	27.80 ± 1.41[d]	29.40 ± 0.57[b]	28.70 ± 1.56[c]	31.90 ± 3.25[a]
Protein	15.91 ± 0.05[c]	19.34 ± 1.02[b]	23.66 ± 0.63[a]	19.93 ± 0.79[b]
Colour parameters				
L*	45.60 ± 1.69[a]	45.43 ± 1.41[b]	45.17 ± 1.56[c]	41.26 ± 0.46[d]
a*	2.99 ± 0.61[b]	2.97 ± 0.17b[c]	2.78 ± 0.42[c]	3.65 ± 0.30[a]
b*	15.55 ± 0.90[b]	16.26 ± 0.97[a]	15.60 ± 1.11[b]	14.61 ± 0.74[c]
Antioxidative properties				
Total phenolics (mg GAE/100 g)	16.67 ± 0.01[d]	28.75 ± 0.00[c]	42.50 ± 0.01[a]	27.60 ± 0.01[b]
Total flavonoids (mg CA/100 g)	29.00 ± 0.01[c]	28.83 ± 0.00[c]	74.67 ± 0.00[a]	34.00 ± 0.00[b]
Antioxidant activity (%, as DPPH)	18.37 ± 0.01[b]	6.65 ± 0.02[d]	10.99 ± 0.00[c]	33.08 ± 0.01[a]

Roasting at higher temperature rises destroyed the molecular bonds in the cell-matrix and the solubility of the molecules increases, resulting in higher yields of bioactive compounds and consequent increase in antioxidant activity.

14 min could be considered as the most suitable duration to process hemp seeds

Table 12: Some physicochemical properties of the lemon seed oils obtained by different extraction techniques (Yılmaz and Güneşer, 2017)

Property	Lemon seed oil	
	Cold pressed	Solvent extracted
Specific gravity (g/ml) (25 °C)	0.94 ± 0.01^{A}	0.94 ± 0.01^{A}
Refractive index (25 °C)	1.47 ± 0.01^{A}	1.47 ± 0.01^{A}
Viscosity (25 °C, cP)	56.55 ± 1.16^{A}	54.57 ± 0.16^{A}
Turbidity (25 °C, NTU)	19.50 ± 4.99^{A}	1.00 ± 0.01^{B}
Color L	28.09 ± 0.99^{B}	33.71 ± 0.55^{A}
a*	0.40 ± 0.21^{B}	1.88 ± 0.25^{A}
b*	4.38 ± 0.46^{B}	17.48 ± 2.12^{A}
Sediment content (%)	5.93 ± 0.27^{A}	7.50 ± 0.56^{A}
Free fatty acid (%, linoleic acid)	0.64 ± 0.01^{B}	1.05 ± 0.01^{A}
Acid value (mg KOH/g oil)	1.27 ± 0.01^{B}	2.11 ± 0.09^{A}
Peroxide value (meq O_2/kg oil)	9.49 ± 1.35^{B}	39.11 ± 6.65^{A}
p-anisidine value	1.12 ± 0.50^{B}	3.39 ± 0.85^{A}
Iodine number (g I/100 g oil)	117.49 ± 2.92^{B}	129.11 ± 0.52^{A}
Saponification number (mg KOH/g oil)	199.96 ± 1.78^{A}	200.33 ± 1.31^{A}
Unsaponifiable matter (%)	1.08 ± 0.23^{A}	1.17 ± 0.01^{A}
Total phenolics (µg GA/100 g)	4916.0 ± 326.0^{A}	3863.0 ± 59.70^{B}
TEAC (µmol Trolox/100 g oil)	11,669.0 ± 36.20^{A}	7311.0 ± 662.0^{B}

- As seen in Table 12, both the acid and peroxide values are quite low and acceptable for the cold pressed and solvent extracted lemon seed oils according to the Turkish codex for named vegetable oils

- The codex (Codex 1999) permits maximum 15 meq O_2/kg oil peroxide value for virgin oils. Therefore, the peroxide value of the solvent extracted lemon seed oil sample exceeds the legal limit and must be refined. This again highlights the advantage of cold press oil processing, if the lower oil yield is considered (Yılmaz and Güneşer, 2017).

- The total phenolic content and antioxidant capacity values of cold pressed lemon seed oil were higher than that of the solvent extracted lemon seed.

- These results indicate that phenolic and antioxidant compounds leach more into the lemon seed oil by the cold pressing technique.

- There is no refining step after cold pressing; therefore, the phenolic and other antioxidant compounds remain in the oil, providing more health benefits and extending the shelf life of the oils (Yılmaz and Güneşer, 2017).

Chemical contaminants

- Agricultural use of pesticides may lead to food contamination by polycyclic aromatic hydrocarbons (PAHs), polychlorinated-biphenyls (PCBs), and polybrominated biphenyl-ethers (PBDEs) (Meeker, Johnson, Camann, & Hauser, 2009).

- PAHs, PCBs, and PBDEs bioaccumulate in the food chain and affect both the environment and human health. Chemical contaminants with PAHs, PCBs, and PBDEs are reported in CPSSO at various levels of occurrence (Roszko, Szterk, Szymczyk, & Waszkiewicz-Robak, 2012).

Environmental risk factors from farm to fork

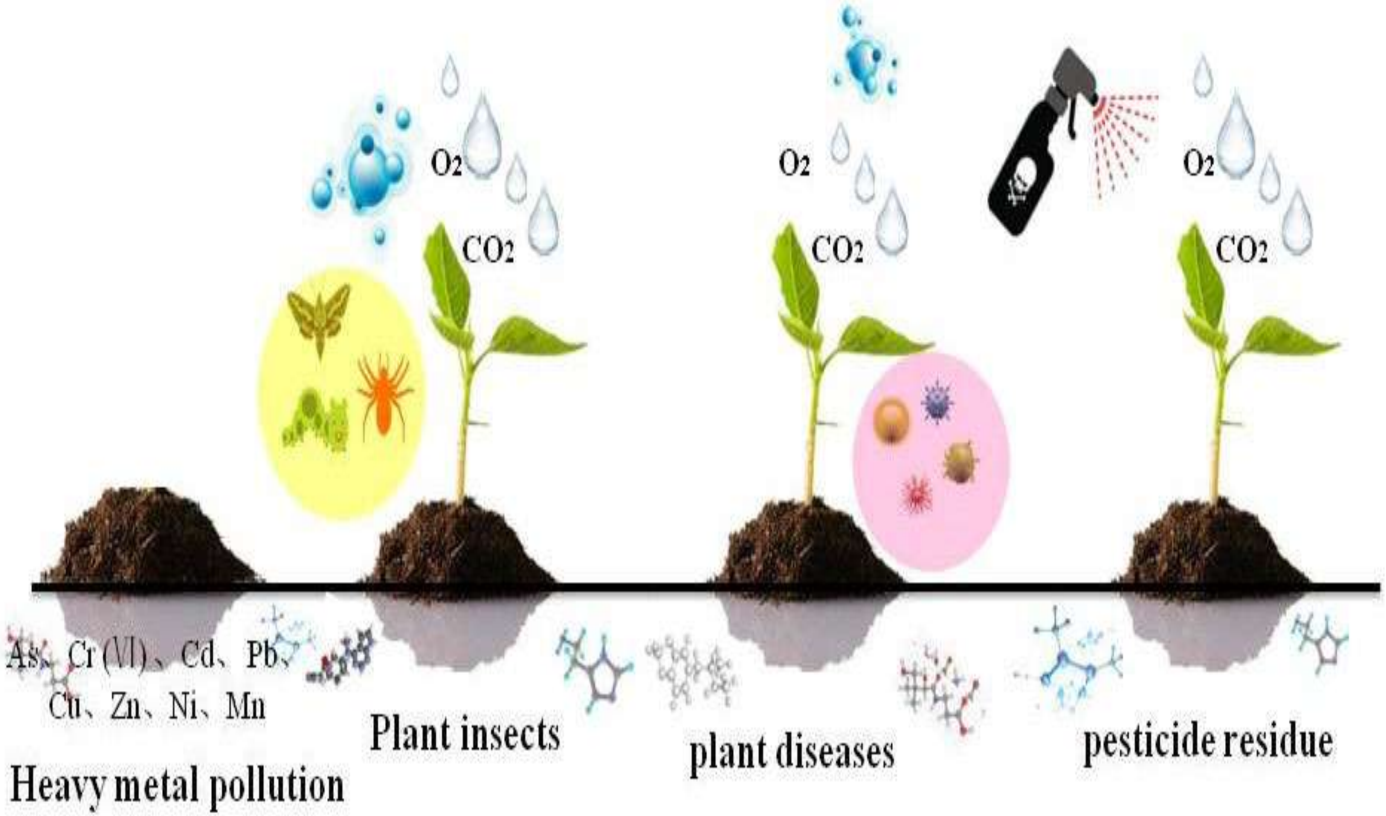


Figure 16: Environmental risks in oil-bearing plant cultivation (Zhou et al., 2020)

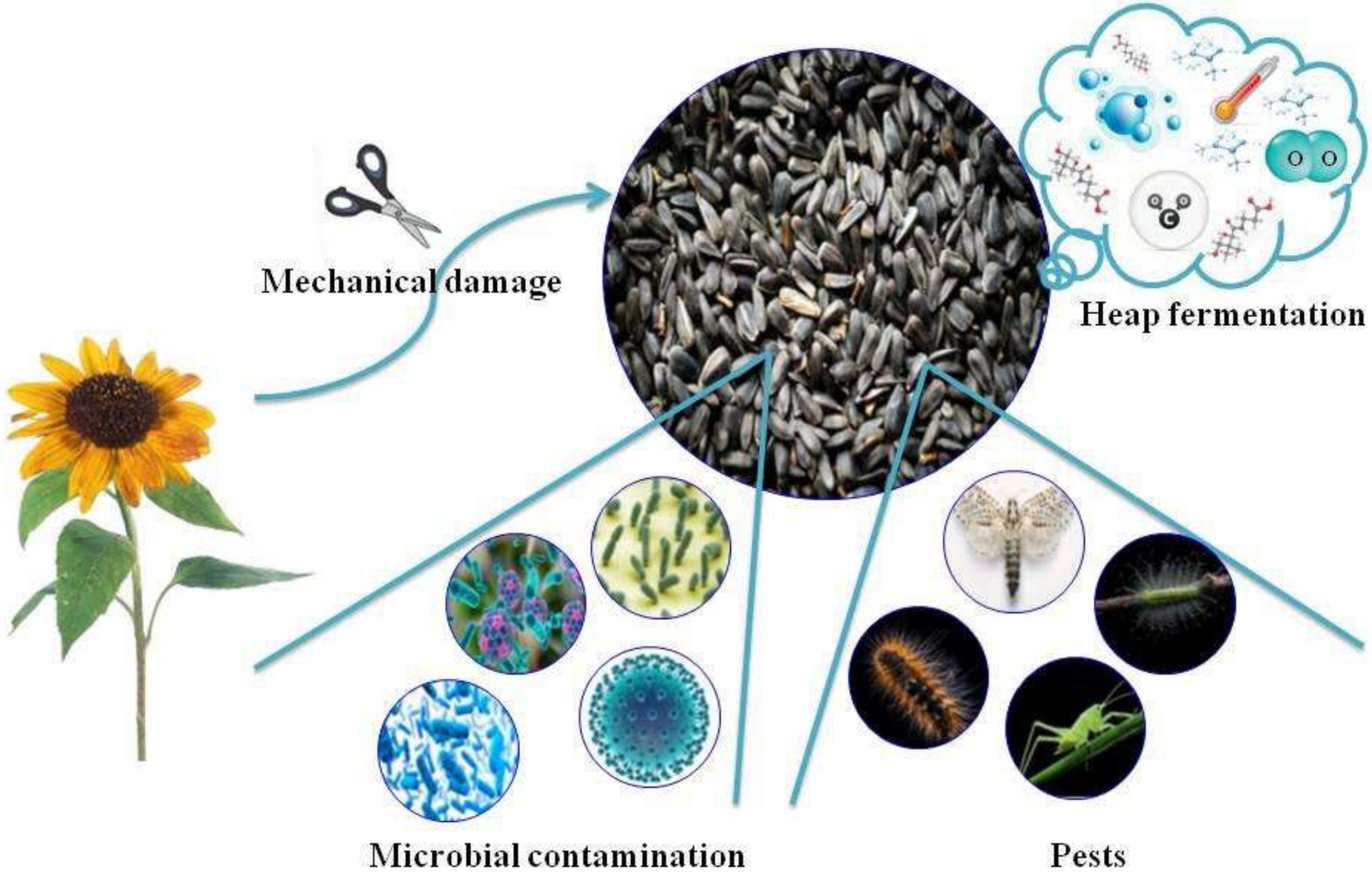


Figure 17: The risk during harvesting and post-harvest process of oily seeds (Zhou et al., 2020)

Chemical contaminants

- No matter which oil pressing method, it is hard to obtain complete-pesticide-free oil, and trace amount of pesticide residues may be still detectable in extracted edible oils.

- To remove as more as possible the pesticide residue in oil, different counties have made different criterion for limiting the pesticides. Among them, the European Union is the organization with the strictest detection criteria. Therefore, the EU standards can be used to evaluate pesticide residues after processing (Zhou et al., 2020).

- Apart from the intentional adulteration, cross contamination may occur throughout the production of several vegetable oils.

- In Latvia, the presence of sesamolin (7.17mg/100g in 2011 and 2.49mg/100 g in 2012) and sesamin (20.54mg/100g in 2011 and 7.22mg/100g in 2012) lignans in cold pressed pumpkin seed oil were revealed (Gornas, Siger, Pugajeva, & Seglina, 2014). These results indicated the improper and inadequate cleaning procedures carried out in plants.

- Contamination of oils with any allergic substances is a serious health concern (Özbek and Ergönül, 2020)

✓ *Polycyclyc aromatic hydrocarbons*

The most widely distributed environmental carcinogens are polycyclic aromatic hydrocarbons (PAH) (Harrison, 2001).

Cold pressed vegetable oils may be contaminated through atmospheric deposition onto plant material, combustion of fossil fuels such as coal, oil, wood, or car exhaust emissions, directly use of combustion smoke in the drying of oilseeds, and/or cultivation of oilseed plants in contaminated soils (Park & Penning, 2009). So, chemical risk assessment of foods is crucial in order to ensure food safety (Pandey, Mishra, Khanna, & Das, 2004).

✓ *Polycyclyc aromatic hydrocarbons*

Due to their lipophilic character, vegetable oils are one of the most important source of PAHs (Shibamoto & Bjeldanes, 2009).

Phenanthrene (13.6mg/kg), fluoranthene (7.32mg/kg), naphtalene (3.98mg/kg), pyrene (3.91mg/kg), fluorine (3.19mg/kg), acenapthylene and acenaphtene (0.88mg/kg), anthracene (0.70mg/kg), benzo(b)fluoranthene (0.67mg/kg), benzo(a)anthracene (0.44mg/kg), benzo(a) pyrene (0.42mg/kg), benzo[g,h,i]perylene (0.40mg/kg), dibenz[a,h]anthracene (0.35mg/kg), benzo(k)fluoranthene (0.28mg/kg), and indeno[1,2,3-cd]pyrene (0.06mg/kg) are the detected PAHs in cold pressed pumpkin seed oil (Roszko, Szterk, Szymczyk, & Waszkiewicz-Robak, 2012)

✓ *Polycyclyc aromatic hydrocarbons*

Cold pressed poppy seed oil was characterized by its comparatively lower total PAHs content *(23.4mg/kg)* than cold pressed oils of amaranth *(101.6mg/kg*), linseed *(115mg/kg),* common flax *(170.8mg/kg),* camelina *(41.3mg/kg*), pumpkin seed *(234.3mg/kg),* sesame *(30.09mg/kg),* mustard *(35.04mg/kg*), safflower *(53.7mg/kg),* blackseed *(221.2mg/kg*), walnut *(45.9mg/kg*), borage *(66.2mg/kg*), and evening primrose *(68.9mg/kg).*

The sum of heavy PAHs in cold pressed poppy seed oil as benzo[a]pyrene, chrysene, benzo[a]anthracene, and benzo[b]fluoranthene (1.71mg/kg) **was found below the maximum tolerable limit of 10 mg/kg set by Commission Regulation (EU) No 835/2011** (Ciecierska & Obiedzinski, 2013).

✓ *Polycyclyc aromatic hydrocarbons*

On the other hand, naphthalene, chrysenes, fluorene, acenaphtene, acenapthylene, benzo[g,h,i]perylene, and dibenz[a,h]anthracene were also detected in the oil (Roszko, Szterk, Szymczyk, & Waszkiewicz-Robak, 2012).

In addition to these PAHs, benz[a]acridine, dibenz[a,j]acridine, and dibenz[a,c]acridine were the identified polycyclic aromatic nitrogen hydrocarbons (PANHs) in cold pressed poppy seed oil (Özbek and Ergonul, 2020).

✓ *Pesticide residues*

A working group on contaminants by BAH (German Medicines Manufacturers' Association) reported a remarkable finding on the pesticide content of citrus essential oils.

The researchers claimed that citrus essential oils obtained from cold pressing were more likely to contain pesticides than the steam-distilled essential oils. It was observed that high temperatures at steam distillation could cause the degradation of thermolabile pesticides. In the analyzed 600 essential oil samples, more than 50% of the analyzed oils having positive results for pesticide residues (Klier et al., 2015).

✓ *Pesticide residues*

Similarly, Saitta, Di Bella, Salvo, Lo Curto, and Dugo (2000) explained the presence of organochlorines in lemon, orange, mandarin, and bergamot essential oils produced by cold pressing grown in Italy (Klier et al., 2015).

Roszko et al. (2012) detected the presence of some insecticides, DDT (0.02 mg/kg) and trifluralin (0.137mg/kg) in cold pressed pumpkin seed oil. In a recent study, the existence of chlorpyrifos in the range of 0.01–0.018mg/kg in cold pressed oils of Turkish pumpkin seed varieties was confirmed (Arslan et al., 2017).

✓ *Pesticide residues*

The Codex Alimentarius Commission (CAC) has established maximum residue limits (MRLs) for pesticides in various plant and animal origin food commodities. *The group of vegetable oils was divided into two subgroups by the CAC: crude vegetable oils and edible (refined) vegetable oils.*

However, data for crude vegetable oils are extremely limited. Only the MRLs of some pesticides has been determined in virgin olive oil, crude rapeseed oil, crude soybean oil, crude maize oil, crude cotton seed oil, crude linseed oil, crude peanut oil, and crude sunflower seed oil. Moreover, MRLs of different pesticides have been established in many edible (refined) oils (Özbek and Ergönül, 2020)

✓ *Polychlorinated biphenyls*

Polychlorinated biphenyls (PCB), including 209 congeners, are synthetic chemical pollutants distributed in the environment by human activity. Their high thermal and chemical stability turn the PCBs into a severe environmental concern (Arnold & Feeley, 2003; Schrenk & Chopra, 2017). PCBs are regarded as a probable carcinogen.

Six nondioxin-like PCBs, namely congeners 28 (59.2 pg/g), 52 (25.9 pg/g), 101 (9.90 pg/g), 138 (21.1 pg/g), 153 (6.40 pg/g), and 180 (4.60pg/g), and one dioxin-like PCB, namely congener 77 (1 pg/g), were identified in cold pressed pumpkin seed oil (Roszko et al., 2012).

- ✓ *Heavy metals*

Heavy metals are also an important factor for the assessment of seed oil quality since they affect several properties such as the rate of oil oxidation, its nutritional value, and storability (Chouaibi et al., 2020)

Table 13: The average contents of some heavy metals in the cold pressed oils (İmer and Taşan, 2018)

Soğuk pres yağı/ cold press oil	elementler/elements										
	Pb	Hg	Ni	Sn	S	As	Cd	Co	Cr	Cu	Mn
ayçiçek/sunflower	0,58±0,13a	10,65±1,60a	0,03±0,01b	3,90±0,43a	4,61±0,30bc	TEDB	TEDB	TEDB	TEDB	TEDB	TEDB
aspir/safflower	TEDB	0,06±0,03b	TEDB	0,96±0,23b	5,79±0,69bc	TEDB	TEDB	TEDB	TEDB	TEDB	TEDB
keten/flaxseed	TEDB	0,13±0,07b	0,05±0,02a	0,67±0,20bc	24,41±0,82a	TEDB	TEDB	TEDB	TEDB	TEDB	TEDB
fındık/hazelnut	TEDB	0,21±0,07b	TEDB	0,83±0,21bc	7,96±1,26bc	TEDB	TEDB	TEDB	TEDB	TEDB	TEDB
susam/sesame	TEDB	TEDB	TEDB	0,26±0,06c	3,94±0,58c	TEDB	TEDB	TEDB	TEDB	TEDB	TEDB
ceviz/walnut	TEDB	0,03±0,02b	TEDB	0,65±0,09bc	4,65±0,34bc	TEDB	TEDB	TEDB	TEDB	TEDB	TEDB
badem/almond	TEDB	TEDB	TEDB	0,21±0,07c	4,72±0,35bc	TEDB	TEDB	TEDB	TEDB	TEDB	TEDB
kabak çek./pumpkin	TEDB	TEDB	TEDB	0,52±0,15bc	6,07±0,55bcd	TEDB	TEDB	TEDB	TEDB	TEDB	TEDB
yerfıstığı/peanut	TEDB	TEDB	TEDB	0,19±0,06c	6,75±0,19bc	TEDB	TEDB	TEDB	TEDB	TEDB	TEDB

- When the results are evaluated in terms of heavy metals, Ni, Tin (Sn) and Zinc (Zn) values are below the legal limits in all cold pressed oil samples. However, the values of lead (Pb), Mercury (Hg), İron (Fe) and Al exceeded the legal limits in some cold press oil samples.

- The exceeding limits of Pb and Hg elements in cold pressed sunflower oil, is a critical index.

- The maximum amount of Hg that can be found in foods has been determined by FAO/WHO as 0.05 ppm. The sale of foodstuffs containing Hg residues from pesticides is prohibited in Germany (İmer and Taşan , 2018).

- The UK has a residual Hg concentration from pesticides of 0.1 ppm; Sweden has set it to 1 ppm. Countries such as Canada, New Zealand, Spain and the USA are 0.5 ppm for fish as determined by the FAO/WTJO; Italy and France apply the 0.7 ppm limit for their export products (İmer and Taşan , 2018).

- The lead (Pb limit value determined for "fat and liquid oils" in the Turkish Food Codex Contaminants Regulation No. 28157 (Anonymous, 2011) is 0.1 ppm. It is seen that the cold pressed sunflower oil samples exceed the legal limit (İmer and Taşan , 2018).

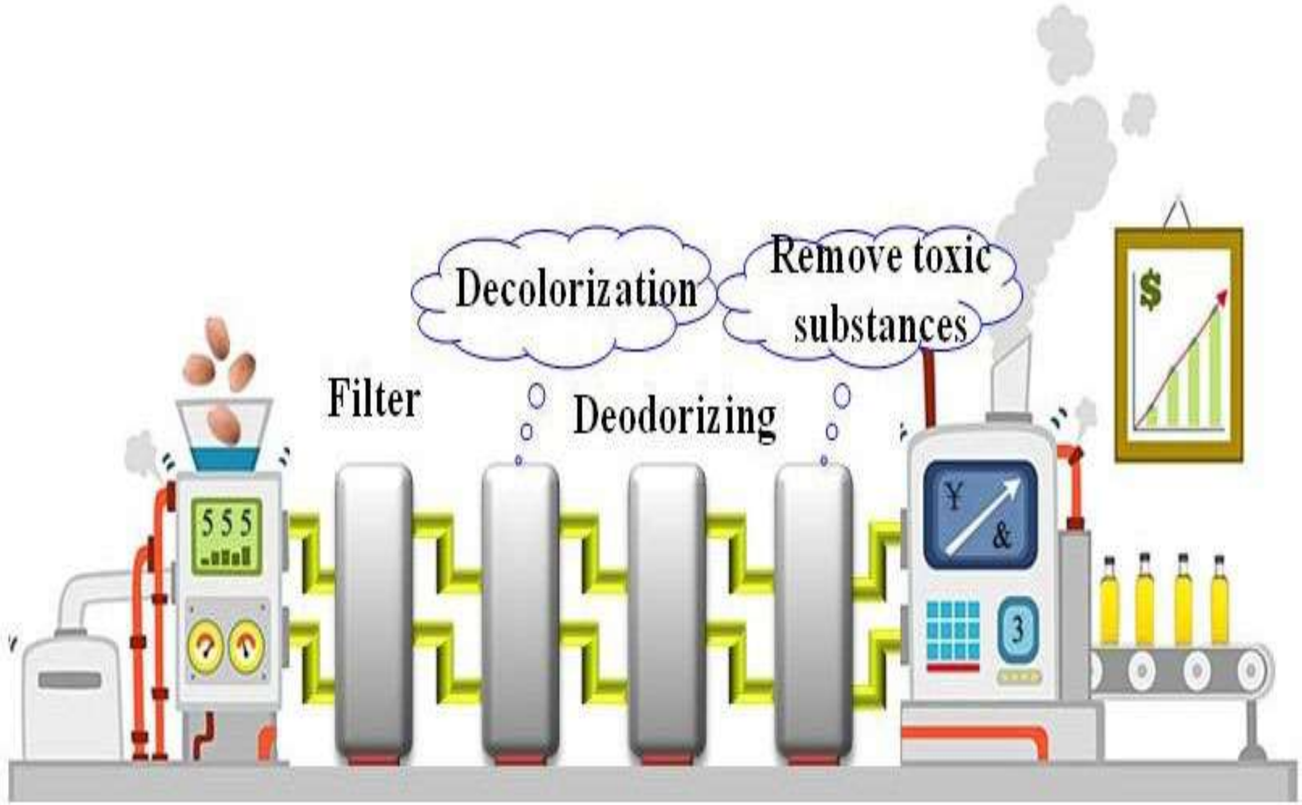


Figure 18: Removing stages of toxic substances during edible oil refining processing (Zhou et al., 2020)

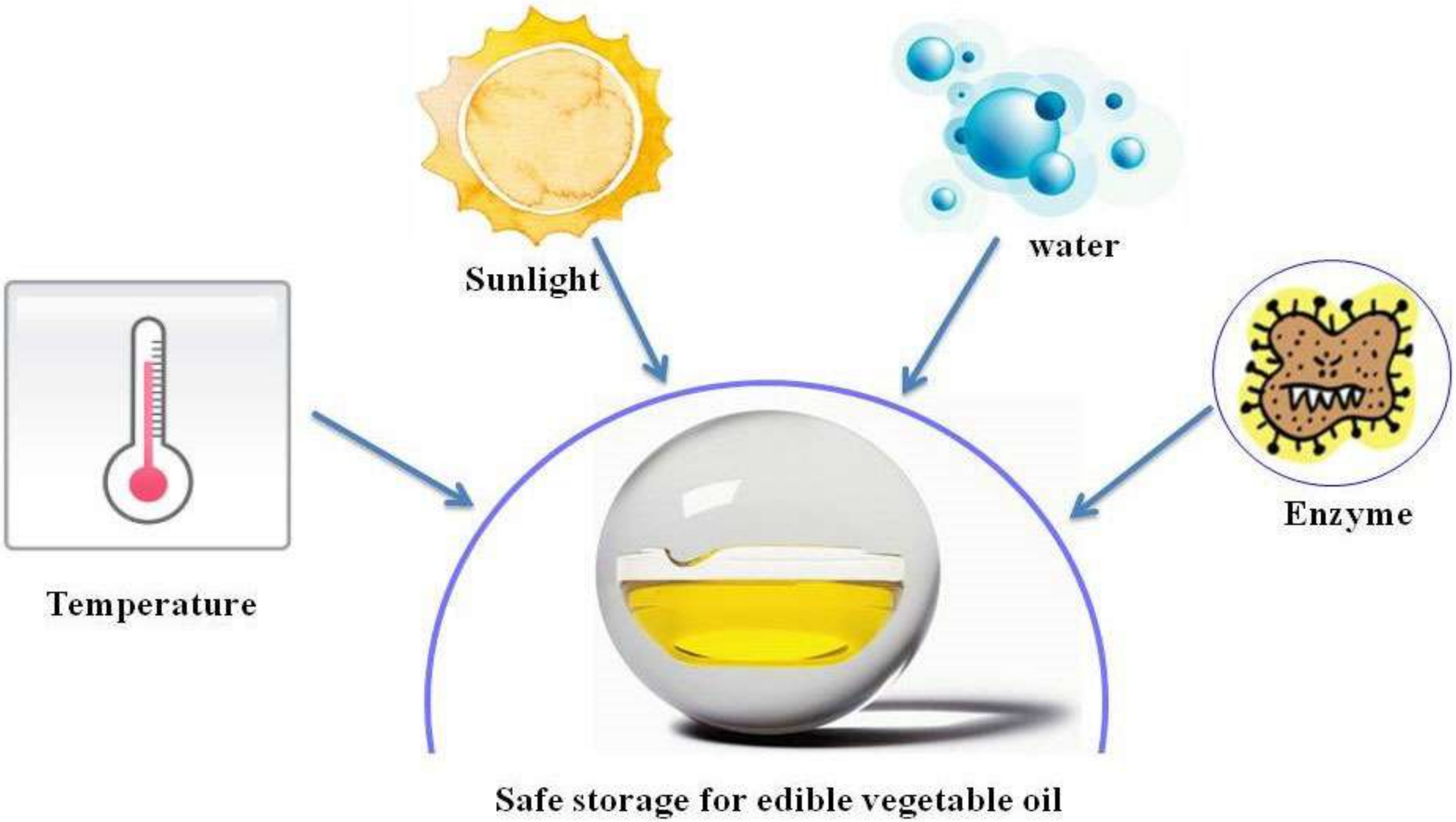


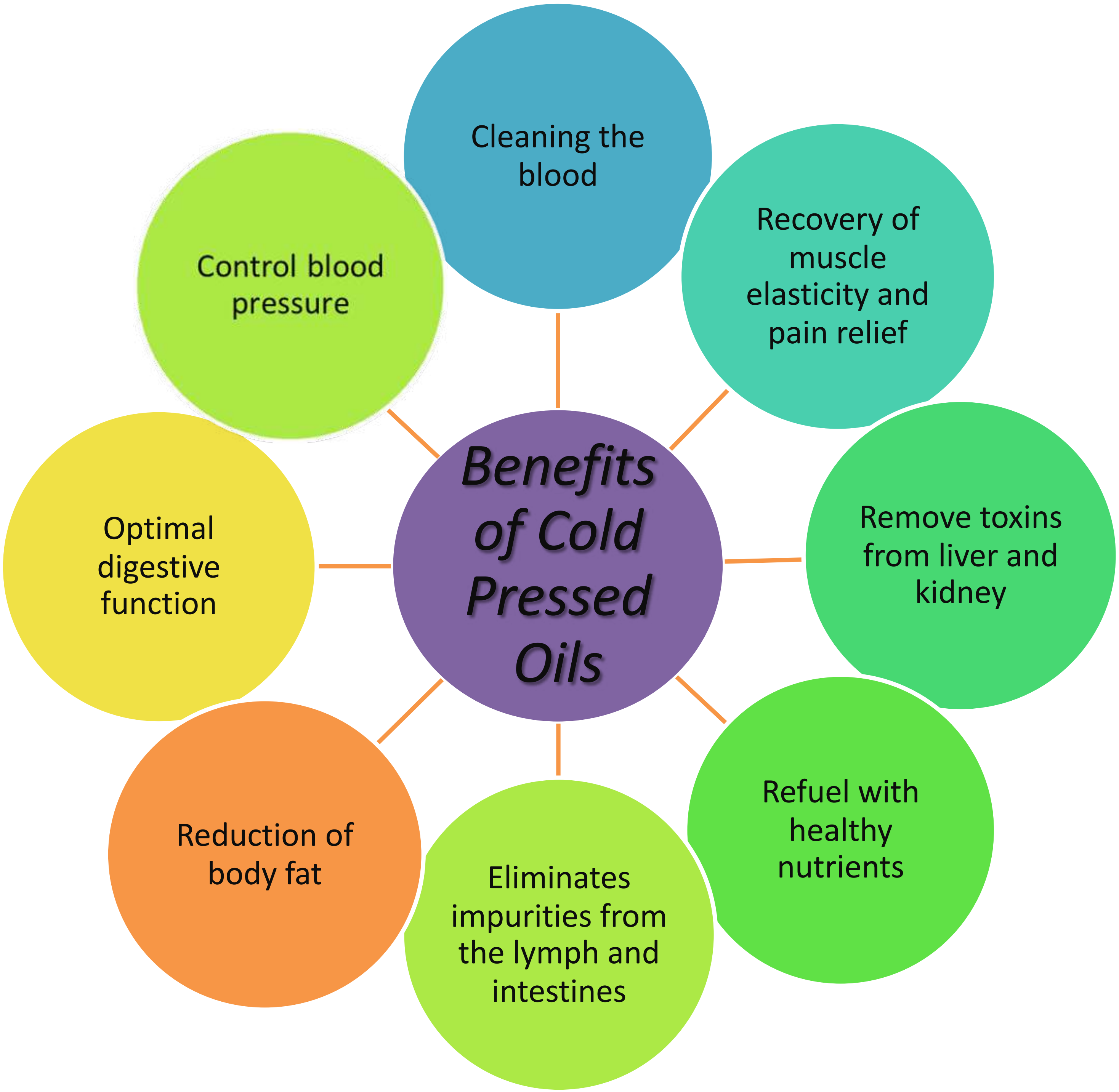
Figure 19: Safety during edible vegetable oil storage (Zhou et al., 2020)

Approaches to ensure the safety and quality of edible oil production

- ✓ The quality and safety of edible oil depends on different testing data, testing depends on instruments and advanced scientific instruments are the material basis to promote more accurate testing.
- ✓ At present, compared with developed countries, developing countries' technology and means of detecting pesticide residues and harmful substances in EPOs remain slightly inferior
- ✓ Recently, a new method, the quick, easy, cheap, effective, rugged, and safe (QuEchERS) procedure using high performance liquid chromatography-tandem mass spectrometry (HPLC-MS/MS), has been applied in the detection of pesticide residues (Song et al., 2018).
- ✓ In the future, with the continuous development of science and technology, more advanced instruments can be used for detection and a multi-stage evaluation system will be established (Figure 20) to deal with the deteriorating environment, which will help to improve the safety and quality of EPOs.
- ✓ For this, it requires the joint efforts of all countries in the world.

Figure 20: The quality and safety of EPOs monitored during the whole industrial chain (Zhou et al., 2020).


Health Benefits
of
Cold Pressed
Oils


Cleaning the blood
Recovery of muscle elasticity and pain relief
Remove toxins from liver and kidney
Refuel with healthy nutrients
Eliminates impurities from the lymph and intestines
Reduction of body fat
Optimal digestive function
Control blood pressure
Benefits of Cold Pressed Oils

ORGANIC
100%

Why Organic
Cold-Pressed Mustard Oil?

- Lowers risk ischemic heart disease & Cancer

- Whitens Teeth & Treats Dental Problems
- Boosts Brain Function & Hair Growth
- Removes Tan & Dark Spots
- Relieves Cold & Cough

Orgpick™
keeps healthy

BENEFITS & USES
OF WALNUT OIL

Great anti inflammatory properties

Rich in Omega-3 ALA and Omega-6 LA, which are essential for healthy skin

Rich in unsaturated fatty acids

Helps in regulating blood pressure and keeping a healthy heart

Has anticancer properties


HEALTH BENEFITS OF PURE PEANUT OIL
Boosts Immune System
Help to Prevent Cancer
Maintains Cholesterol Levels
Helps to Lower Blood Pressure
Reduces risk of Heart Diseases
Protects against symptoms of Aging

Conclusion

- Cold-pressed oils have been accepted as a functional food due to the presence of bioactive substances. The content of EFAs, sterols or tocopherols may prevent or retard the lifestyle diseases *such as cardiovascular diseases, cancer, and obesity or have anti-ageing properties*

- Additionally, residues and heavy metal contaminants which cause important health problems, should be handled in more details in national and international legal regulations for cold pressed oils

- Further studies should be carried out to determine the toxicity, bioavailability, and bioaccessibility properties of these cold pressed oils.

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