PM Formalisation of
Micro Food Processing Enterprises Scheme

Processing of Olive Oil

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CHAPTER 1

INTRODUCTION

1.1. Origin

The olive, known by the botanical name _Olea europaea_, meaning "European olive", is a species of small tree in the family Oleaceae, found in the Mediterranean Basin from Portugal to the Levant, the Arabian Peninsula, and southern Asia as far east as China, as well as the Canary Islands and Reunion. The species is cultivated in many places and considered naturalized in all the countries of the Mediterranean coast, as well as in Argentina, Saudi Arabia, Java, Norfolk Island, California, and Bermuda. The Origins of the Olive Tree Revealed. Olives, like the Salonika variety pictured here, were likely first domesticated in the Levant around 6,000 years ago, new research suggests. The olive was first domesticated in the Eastern Mediterranean between 8,000 and 6,000 years ago, according to new research. Modern olive cultivars descend from multiple wild ancestors, however, the detailed history of domestication is not known yet. Olive production mainly occurs in countries like Italy, Spain, Greece, Turkey, Tunisia, Syrian Arab Republic, Morocco, Egypt, Portugal, Lebanon, Libyan, Arab Jamahiriya, Algeria, Palestine, United States of America, Argentina, Jordan, Israel, Peru, Islamic Republic of Iran and Croatia.

1.2. Distribution of crop across the country

Olive crop although grown wild or scattered in some parts of India long back but its commercial cultivation to India is new. It is being grown in some parts of Jammu and Kashmir like Ramban, Uri, and Srinagar etc. Recently Rajasthan state had started cultivation of olive plants. In Rajasthan, Olive farms are basically situated in 7 districts - Bikaner, Sriganganagar, Nagaur, Jhunjhunu, Alwar, Jaipur & Jalore. It is also grown in some parts of UP and Himachal Pradesh.

1.3. Olive oil

Olive oil is the oily juice of the olive, separated from the other components of the fruit. Properly extracted from fresh, mature fruit of good quality, the oil has a characteristic sensory profile. Its fatty-acid composition is characterized by a good balance between saturated, monounsaturated, and polyunsaturated acids. It is also unique among common vegetable oils in that it can be consumed in the crude form, thus conserving vitamin content and phenolic compounds of nutritional importance. According to the Codex Alimentarius, IOOC, and EC regulations: Virgin olive oil is the oil obtained from the fruit of the olive tree solely by mechanical or other physical means under conditions that do not lead to alteration in the oil, which has not undergone any treatment other than washing, decantation, centrifugation, or filtration, to the exclusion of oils obtained using solvents or using adjuvants having a chemical or biochemical action. The ideal objective of any extraction method is to extract the largest possible amount of oil without altering its original quality. However, if the quality is not to be modified, it is essential to use only mechanical or physical methods for extracting the oil, avoiding chemical and enzymatic reactions that might change its natural composition.

When treating the olive as prime material, one must consider two groups of phases: the solid elements of the skin, pulp, and kernel, and the liquid phases made up of the oil and the vegetable water. The preparation of olive oil is an industrial process, the purpose of which is to separate one of the liquid phases—the oil—from the other constituents of the fruit. Thus, beginning with healthy, whole, clean fruit, harvested at the moment of optimum maturity, it is necessary to make a paste preparation by means of breaking the vegetal structure; to liberate the oil from the cells and finally achieve the formation of solid and liquid phases. By means of pressure, percolation, or centrifugation, the solid and liquid phases are then separated. Finally, the liquid phases are separated into oil and vegetable water by decantation and/or vertical centrifugation. The separation between the solid and the liquid phases is not complete: the mass of solids with varying percentages of humidity and oil content form the sub-product called olive pomace and the liquids with varying percentages of fine solid material constitute the oily must. Extraction methods became more effective with the use of hydraulic presses and transmission mechanisms. Over the years they became more and more mechanized, driven by the need to spare labor expenses in order to lower costs, but the whole process was discontinuous. The first tests conducted on continuous-flow facilities date back to the second half of the 1960s by Alpha Laval. Improvements enabled the oil to be extracted through the centrifugal effect produced by devices rotating at high speed; the use of stainless steel instead of ordinary steel raised the quality and hygiene standards of the oils produced. These facilities exploit the effect of centrifugal force, which operates by drawing off the liquids. When they came into use after years of testing, they helped to lower labor costs and raise processing capacity. The extraction of olive oil commences from the olive tree and ends with the storage of the product. There are limitations in a series of factors prior to the extraction process which influence the quantity and quality of the oils.

1.4. Status and market size

Olive oil, edible oil is being increasingly consumed by people from across the globe. Considering its nutritional value and the taste, olive oil is being consumed by a big pool of the global population. The market offers various types of olive oils such as extra virgin olive oil, light olive oil, pure olive oil, virgin olive oil, olive pomace oil, and refined olive oil. At present, the extra virgin olive oil is the highest quality olive oil, consumed by a majority of health-conscious people. As the extra olive oil carries less than 1% acidity, it has gained popularity across the globe. By region, the global olive oil market is divided into Europe, Asia Pacific, North America, and Rest of the World. Nations such as the United States and Australia are on the verge of standardization of olive oil on an international level. This would support the consistently rising demand for olive oil. The rising demand for olive oil in Europe and North America is expected to make these two regions two of the most promising markets for olive oil. Currently, the production of olive oil in countries such as Brazil and India is low. However, consistent efforts are being made by emerging nations to propel their production so as to meet the rising demand. The report on the global olive oil market highlights key factors driving the growth and factors challenging the market. Factors such as market structure, the feasibility of new projects, current market trends, future projections, and key players operating in the market are measured in the report. A detailed analysis of technological improvements and market trends is carried out by analysts. The report briefs readers about key product segments and also gives a clear picture of the competitive landscape. By using industry-standard tools such as SWOT analysis, strengths, weaknesses, opportunities, and threats of key companies are measured in the report.

Extra virgin olive oil is the least processed, unrefined, and high-quality olive oil that contains no chemicals and is rich in nutrients. It retains the original taste of olives and has lower levels of oleic acid; thus, regarded as one of the healthiest oils around.

Its nutritional composition includes vitamins D and K, monosaturated fats, and high levels of antioxidants. Extra virgin olive oil is also perceived to reduce the risk of cardiovascular disease, inflammation, and bad cholesterol.

The ongoing health consciousness trend promotes the use of extra virgin olive oil, significantly boosting the sales of products containing this super healthy oil. This is one of the main factors expanding the global olive oil market size.

Olives are mostly cultivated in the Mediterranean region in countries such as Spain, Greece, Italy, Turkey, Morocco, and Egypt. These countries are among the leading producers of olives, and olive farming is one of the important businesses across these countries.

Europe accounts for more than 60% share of global olive oil production, whereas, the Middle East & Africa accounts for more than 30% of the market share. As such, these regions are the most attractive for new entrants in the global olive oil market.

The markets in China and India are projected to experience high growth in East Asia and South Asia, respectively. The increasing popularity and high rate of adoption of healthy extra virgin olive oil in a wide range of applications is an important factor, on the back of which, these economies are expected to witness exponential growth rates in the global olive oil market. However, the presence of fraudulent products and adulteration of olive oil is also hindering the growth of the global olive oil market.

1.5. Socioeconomic importance

The olive tree is heavily associated with human existence in Greece, and especially in the Messinian region. Messinian olive oil is associated with the tradition of the region and can trigger the olive oil–culture–tourism–economy relationship. The purpose of this study is to examine whether a traditional agricultural product, such as olive oil, can contribute significantly to sustainable regional development twofold. On one hand, the cultivation of olive and olive oil is an integral part of the Messinian land. Olive oil is a mix of symbolism, values, faith, and traditions, constitutes an invaluable intangible cultural heritage of this region, and on the other hand, this Messinian Olive oil is a high-quality agricultural product, famous for its benefits (health, nutrition, well-being). The key point is to link the tradition of olive cultivation with new, innovative ideas that, without neglecting the past, modernize it and link it to other forms of economic activity, adding added value to olive oil and yielding multiplier benefits to the economic and social sector. Also, the existence of innovative strategies such as product certification is able to create “identity”-a brand name and promote tourism development specializing in olive cultivation, and it should be it cultural heritage. A brand name is created that harmoniously combines history with tradition, nature, and the excellent quality of the Messinian Olive oil.

1.6. Commercially grown varieties

Its varieties can be divided into 2 categories. They are:

Oil type

1. Carolea,
2. Coratina,
3. Pendolino,
4. Frontoio,
5. Canino,
6. Sdcolanaterena
7. Aglandeau

Pickle Type

- Ascolano
- Mission
- Grosseune
- Picholine
- Cornicobra,
- Coratina

1.7. Cultivation Scenario

While olives are on the tree, the oil inside the fruit is in perfect condition (low acidity level, flavorful as to variety, and non-oxidized. Changes that influence quality occur during and after harvest. Harvest methods all vary regarding how much damage they do to the fruit. Hand harvest is the best, but very expensive. If done properly with the right equipment, mechanical harvest can be almost as good and much less expensive. The key is to not break the fruit skin in any way and to process the fruit within a few hours. Farm labor for olive harvest is expensive ($200 - 400/ton) for hand picking making it the single most expensive aspect of olive growing. In order to help make olive oil production more profitable researchers around the world have been experimenting with various pruning methods, different tree forms, and mechanical or machine assisted harvest. Tree shakers and tarps are used in many countries where land is flat enough and varieties are grown that have fruit that are easily removed from the tree. Hand held vibrating combs that knock the fruit down onto tarps could also significantly reduce costs compared to hand harvest. Many oil olives around me world are still hand harvested where machine use is not practical. In areas where hand harvest is too expensive and mechanical harvest is impossible the fruit are allowed to fall naturally and then picked up from the ground. Ground fruit produces a low quality, low value oil that is refined. In many countries, this oil forms the base for low cost oils. Mechanical harvesting of fruit will be essential to economically rationalize oil olive production in California. Future olive orchards will have to be planted and pruned to accommodate mechanical harvesting of some type. Most production systems do not allow branch development below three feet in order to accommodate a shaker head. High-density plantings (900 trees/acre) using dwarf varieties and over-the-row harvesters are in the early stages of experimental evaluation. A new vibrating-finger type harvester for large trees is also being studied as an alternative to shakers for mechanical fruit removal. These systems should be available in the near future to reduce harvest costs. One tree form, the central leader system has advantages for better fruit harvest, but comes into bearing later and is difficult to maintain. The bush system attempts to keep the trees low for hand harvest, but hard pruning to limit tree size in olives trees often promotes excessively vigorous vegetative growth. The open center pruned olive tree is still the most popular. Olive trees tend to be alternate bearing: heavy crops are usually followed by light ones the next year. Cultural practices, such as heavier pruning during flowering, in years with excessive bloom, should be employed to moderate crops from year to year. The best overall oil yields are obtained from moderate crops of 3-6 tons per acre produced on an annual basis. Late January harvesting of black fruit also causes lighter cropping the following year. The best-quality oil comes from olives matured to the red-ripe stage. Fully mature black fruit yield a "sweeter" oil, but during harvest they are soft and easily damaged. Immature olives that are green or straw colored are sometimes processed because of the unique flavor that less mature fruit impart to oil. The trend is to harvest earlier to achieve an oil with a green color and piquant character. Harvest date, however, is a maze of choices between type of oil desired, long-term stability of the oil, color, and linoleic acid content. For example, with low polyphenol content varieties a one-month delay in harvest can cause a four-month loss in oil stability due to the drop in polyphenol content. Later harvest usually yields a better percentage of oil per ton of fruit so growers are often interested in harvesting as late as possible to allow the fruit to accumulate the greatest quantity of oil. The olive tree manufactures and stores oil in the fruit throughout the season but the rate of oil storage flattens out before maturity due to low Fight intensity and cool temperatures providing no real gain in oil content. Olives naturally lose moisture in the maturation process. The perceived rise in oil content, late in the growing season, is actually a loss of moisture. Post-harvest handling has a major effect on olive oil quality. Olives left in bins for long periods before pressing will ferment and mold; the resulting oil must be refined to remove the disagreeable flavor. Olives should be transported in shallow bins to prevent smashing bottom fruit and the bins must have ventilation holes (to reduce fermentation). If possible olives should not be stored but harvested, transported to the processing plant, and processed immediately. If storage is necessary olives should be kept cool by harvesting in the morning, placed in the shade, or in cold storage at 45°F with 90-96% relative humidity. Olives will keep well with little quality deterioration for up to 15 days in cold storage if the fruit is in perfect condition. Fruit quality can be maintained for longer periods with controlled atmosphere storage at 3% CO_2 and 5% O_2.

1.8. Health Benefits of olive oil

- Olive oil has distinct flavor and taste. Unlike many other oils, which are extracted from nuts and seeds, the olive is obtained from the olive berries and hence, carries large amounts of plant-derived antioxidants, phytosterols, and vitamins.
- Olive oil is recognized as one of the healthiest edible oils since it contains less saturated fats. Additionally, it composes linoleic (omega-6) and linolenic (omega-3) essential fatty acids at a recommended 8:1 ratio.
- The oil is high in calories. Its high-calorie content chiefly comes from its fats. However, it is especially rich in mono-unsaturated fatty acids (MUFA) like oleic acid (18:1) and palmitoleic acid (16:1) that help to decrease LDL or "bad cholesterol" and to increase HDL or "good cholesterol" in the blood. Research studies suggest that Mediterranean diet which is rich in monounsaturated fatty acids help to prevent coronary artery disease and strokes by favoring healthy blood lipid profile.
- Olive oil, especially extra virgin, contains tyrosol phenolic compounds such as oleuropein and oleocanthal. These compounds are responsible for its bitter, and pungent taste. Oleocanthal, oleuropein, and its derivative hydroxytyrosol are nature’s most powerful

antioxidants. Together with vitamin-E and carotenoids, they play a vital role fighting against cancer, inflammation, coronary artery disease, degenerative nerve diseases, diabetes, etc.

- Studies suggest that oleocanthal has ibuprofen (NSAID) like anti-inflammatory activities. The Mediterranean diet that uses olive oil may be responsible in part for the low incidence of coronary artery disease.
- Being a vegetable source, it has very high levels of plant sterols, especially ß-sitosterol. The FDA has approved the following claim for phytosterols: "Foods containing at least 0.4 gram per serving of plant sterols, eaten twice a day with meals for a daily total intake of at least 0.8 gram, as part of a diet low in saturated fat and cholesterol, may reduce the risk of heart disease". Phyto-sterols competitively inhibit cholesterol absorption in the gut and thereby can reduce total cholesterol levels by 10% to 15%.
- Olive oil is rich in vitamin E. 100 g fresh extra-virgin oil contains 14.39 mcg (about 96% of RDA) of alpha-tocopherol. Vitamin E is a powerful lipid soluble antioxidant, required for maintaining the integrity of cell membrane of mucosa and skin by protecting it from harmful oxygen-free radicals.
- Additionally, extra-virgin oil is also an excellent source of vitamin-K; 100 g provides about 50% of DRI. Vitamin-K has a potential role in the increase of bone mass by promoting osteotropic activity in the bone. It also has established role in the treatment of Alzheimer's disease patients by limiting neuronal damage in the brain.

Nutritional value of Olive oil (*Olea europaea*)

Principle	**Nutrient Value(per 100 g)**	**Percentage of RDA**
Energy	884 Kcal	44%
Carbohydrates	0 g	0%
Protein	0 g	0%
Total Fat	100 g	500%
Cholesterol	0 mg	0%
Dietary Fiber	0 g	0%
Vitamins		
Folates	0 µg	0%

Niacin	0 mg	0%
Pantothenic acid	0 mg	0%
Pyridoxine	0 mg	0%
Riboflavin	0 mg	0%
Thiamin	0 mg	0%
Vitamin-A	0 IU	0%
Vitamin-C	0	0%
Vitamin-E	14.39 mg	96%
Vitamin-K	60.2 µg	50%
Electrolytes		
Sodium	2 mg	0%
Potassium	1 mg	0%
Minerals		
Calcium	1 mg	0%
Copper	0 mg	0%
Iron	0.56 mg	7%
Magnesium	0 mg	0%
Manganese	0 mg	0%
Phosphorus	0 mg	0%
Selenium	0 µg	0%
Zinc	0.01 mg	<1%
Phyto-nutrients		
Carotene-ß	0 µg	--
Crypto-xanthin-ß	0 µg	--
Lutein-zeaxanthin	0 µg	--
Phytosterols	221 mg	--

Source: USDA National Nutrient data base

CHAPTER -2

PROCESSING OF OLIVE OIL

2.1. Process Flow chart for Production of olive oil

- Harvesting and transport
- Washing and Leaf Removal
- Milling
- Mixing of the Olive Paste (Malaxation)
- Oil Extraction from the Paste
- Processing Waste
- Oil Storage & Bottling

2.1.1. Harvesting and Transport

The optimal harvesting time is when oil levels are high in the olive fruit. Harvest should begin before natural fruit drop. In normal-ripening varieties the time to start harvesting can be judged by the color of the fruit skin. When there are no green olives left on the tree, perhaps only some fruits at color-change, oil biosynthesis has ceased and harvesting can begin. Improper handling during these phases can result in undesirable enzymatic reactions and the growth of yeasts and molds. The best way to transport the olives is in open-mesh plastic crates that allow air to circulate and prevent the harmful heating caused by the catabolic activity of the fruit. When stored before processing, the olives must be spread in shallow layers and kept in well-ventilated, cool, dry areas. Storing of the olives in jute sacks has to be avoided. To ensure that the olives retain the quality characteristics they possessed at the time of harvesting they must be delivered immediately to the extraction plant for processing.

2.1.2. Fruit cleaning and washing

Fruit cleaning entails two operations: leaf removal and washing. Defoliators suck the leaves, twigs, and dirt through a powerful airflow generated by an exhaust fan. After that, the olives are washed in a current of water. This water is recycled after decanting and clean water is constantly mixed in pre-set proportions. To improve washer efficiency, the washing vat is equipped with a shaker that shakes any impurities through screens as well as with an air injection system to create turbulence in the mass.


2.1.3. Milling

Olive fruit is made up of approximately 1/3 solid material, 1/3 water, and 1/3 oil. The objective of the first true step of olive oil production, crushing the olives, is to produce a paste with easily extracted oil droplets. Two types of machines are used to crush olives: stone mills and stainless steel hammer mills. Each has advantages. A new system just introduced, removes the olive pits prior to crushing.

Stone mills The older of the two methods, stone crushers consist of a stone base and upright millstones enclosed in a metal basin, often with scrapers and paddles to guide the fruit under the stones and to circulate and expel the paste. The slow movement of the stone crushers does not heat the paste and results in less emulsification so the oil is easier to extract without as much mixing (malaxation).

The major disadvantages of this method are the bulky machinery and its slowness, its high cost, and its inability to be continuously operated. The stones are also more difficult to clean, and the slow milling time can increase oxygen exposure and paste fermentation. Stone mills, because of their inefficiency, have been replaced by hammer mills in most large operations.

Hammer mills generally consists of a metal body that rotates at high speed, hurling the olives against a metal grate. The major advantage of metal crushers is their speed and continuous operation, which translate into high output, compact size, and low cost. Their major disadvantage is the type of paste produced. The oil is more emulsified, requiring a longer mixing period to achieve a good oil extraction and the speed of metal crushing can produce elevated temperatures and possible metal contamination. Both factors reduce oil quality.

The hammer mill is easier to clean and much faster, allowing for the deployment of a continuous flow system. Oil produced from a hammer mill is generally greener since the skins are broken up more. The emulsification problem is overcome by malaxation for a slightly longer period and new stainless steel mills do not impart a metallic flavor into the oil.

The size of the hammer mill mesh should be changed as the season progresses and the fruit becomes riper and softer. A smaller mesh screen is needed to produce a finer paste from firm olives. This improves the breakup of the oil cells. As the fruit ripens, the cells break up and oil release is more rapid. A larger mesh screen can be used, and a more coarse paste can be worked.

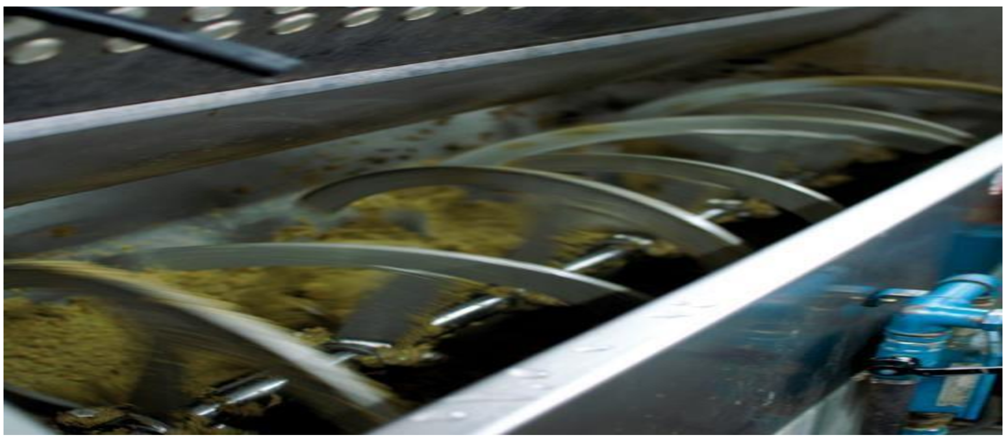
2.1.4. Mixing of the Olive Paste (Malaxation)

Malaxation prepares the paste for separation of the oil from the pomace. This step is particularly important if the paste was produced in a hammer mill. The mixing process optimizes the amount of oil extracted through the formation of larger oil droplets and a reduction of the oil-water emulsion.

The paste is slowly mixed, bringing small droplets of oil in contact with each other to form larger droplets. This improves the extractability of the oil. Optimally, the malaxator is designed to assure thorough mixing, leaving no portion unmixed. Malaxation usually requires 45 minutes to one hour. The longer the contact between the oil and the fruit water, the more the final polyphenol content of the oil is reduced.

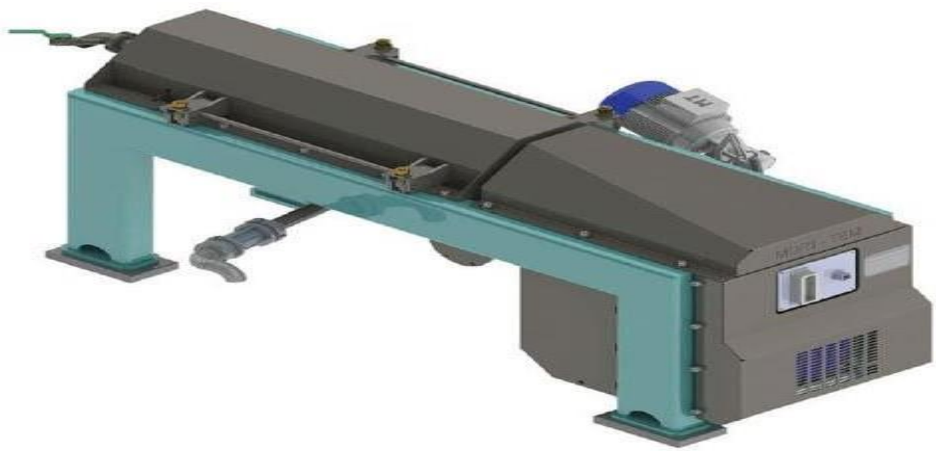
The temperature of the paste during malaxation is very important. It should be warm (26° to 30° C, which is still cold to the touch) to improve the viscosity of the oil and improve extractability. Temperatures above 30° C can cause problems such as loss of fruit flavors, increases in bitterness, and increases in astringency.

Sometimes it is difficult to get good oil extraction from certain pastes and it is usually because the olives have too much moisture. The solution is to let the olives sit for a few days in a well-ventilated area, raise the temperature of the paste, or add talc to absorb the excess moisture. A paste moisture content of < 45% is easily worked but the moisture content of > 50% is more difficult to extract oil.

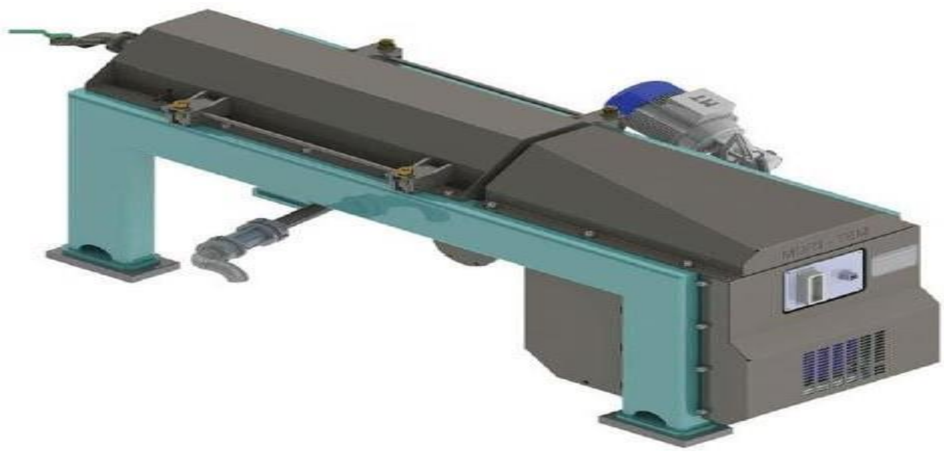


2.1.5. Oil Extraction from the Paste

The next step is extracting the oil from the paste and fruit water (water of vegetation). The oil can be extracted by pressing, centrifugation, percolation, or through combinations of the different methods. Traditional Press: Pressing is the oldest method of oil extraction. The method involves applying pressure to stacked filter mats, smeared with paste, that alternate with metal disks; a central spike allows the expressed oil and water (olive juice) to exit. The machinery, however, is cumbersome, the process requires more labor than other extraction methods, the cycle is not continuous, and the filter mats can easily become contaminated. Cleanliness of the mats is extremely important. Each time the mats are used small particles of paste plug the filtration channels and can cause a loss of oil. The number one problem with the use of traditional presses is in getting fermentation defects into the oil from the mats. Mats can start to ferment if not used continuously or if not cleaned regularly. The solution is to wash the mats every day, or to use the presses continuously until harvest is finished.



The decanters spin at approximately 3,000 rpm. Centrifugal force moves the heavier solid materials to the outside; a lighter water layer is formed in the middle with the lightest oil layer on the inside. There is no exact line of separation between the three phases of solid, water, and oil so the solid phase usually has some water in it, the water has some oil in it and the oil contains some water. In the latter case, which extracts the maximum quantity of oil, an additional vertical centrifugation is used to remove more of the vegetation water from the oil. The 3-Phase system decanter separates the paste into a relatively dry solid, fruit-water, and oil. Water is added to this system to get it to flow through the decanter. A minimum quantity of water is added to separate the solid material better and to retain water-soluble polyphenols as much as possible. The system should be run at approximately 65 to 70% of maximum capacity to get good separation of phases. Samples should be taken every hour and analyzed daily to determine the status of the separation. Preferably, the solid should have an oil content of no more than 6-7% and 50% moisture while the vegetation water should not contain over 0.3% oil and-8% solids. 2-Phase system decanters were introduced in the early 1990's. They function under the same principle as 3-Phase decanters except that the solid and fruit-water exit together. No water needs to be added to the 2-Phase system. Experience with the two systems has shown that the 2-Phase system has some advantages, i.e., better retention of polyphenols because no water is added and less loss of oil if the system is operated properly. One problem with the 2-Phase system is a greater potential to lose oil when the olives are low in moisture because there is a thinner interface between the two phases during centrifugation. Another difficulty is less visual evidence of what is happening with waste characteristics because the solid and vegetation water phases are mixed. Water can be added to the paste just prior to entering the 2-Phase decanter if the moisture content of the olives falls below 42%. Talc (a water absorbing neutral compound) can be added to the paste early in the season, if the olives have an excessive moisture content, to help extract a greater quantity of oil with no negative effect on quality.



The 2-phase system produces the greatest weight of solid waste because it has the highest moisture content. It also produces the least amount of wastewater with the lowest Biological Oxygen Demand (BOD). The polyphenol content of the oil is lowest in the 3- phase system because of the addition of water. When very clean oil (containing no water) is obtained from a 2-Phase system, it means that there is a loss of oil to the waste solids because of the limited separation area within the decanter. The solution is to extract oil with some water in it and immediately run it through a vertical centrifuge to clean the oil further.

2.1.6. Vertical Centrifuge

A vertical centrifuge spin at two times the velocity of a decanter and provides four times the separation force for the solid, water, and oil phases. They provide an additional separation of the three phases to further remove solid particles and water from the oil. Fresh warm water is added to "clean" the oil, creating a greater interface area between the phases. Many processors use two centrifuges, one for the "wet" oil from the decanter and a second one to separate the oil from the wastewater of the first centrifuge. Added water is only 2-4°F warmer than the water/oil mixture to be separated.

2.1.7. Oil Storage & Bottling

Premium quality oils should be stored in stainless steel and maintained at a constant temperature of between 7 - 20°C after processing oil should be stored in bulk for 1-3 months to further settle out any particulate matter and fruit water.

Bulk storage and decantation eliminate the problems of sediment in bottles and oil contact with processing water residues that could lead to off-flavors in the oil. Oils bottled and sold immediately after processing must be consumed quickly (within a few weeks) to avoid flavor changes within the bottle.

2.2. Processing Waste

There are two predominant olive oil processing waste products produced in the press and 3-phase decanter systems, the solid material (pomace), that is relatively dry, and the fruit water, often referred to as water of vegetation. The 2-phase system produces one waste product that is a mixture of the water and solid material. In countries where significant production occurs, the pomace is often sold for further oil extraction with solvents. The water of vegetation (fruit water) can be a significant pollutant because of its high organic load. If added to natural waterways the high biological oxygen demand (BOD) causes damage to aquatic life. Both the solid and liquid portions of the process are composed of the same organic materials as most fruits, leaves, or other organic material left in the field to decompose naturally. Because of the small particle size, however, it is difficult to filter out the pure water from dissolved organic substances. If these substances decompose anaerobically, disagreeable odors are produced. Incorporation with dry solid materials in order to create aerobic conditions produces compost that can be spread back onto the land.

CHAPTER -3

PACKAGING TECHNOLOGIES OF OLIVE OIL

3.1. Packaging aspects of oils

Bulk quantities of oils are packed and transported inexpensive tin containers and galvanized iron drums and sold in loose form by retail vendors. This practice gives scope to adulteration with less expensive oil, which have been a cause of ill health in India and many other parts of the world. As a consequence, the governments of these countries have been trying to enforce compulsory packing of edible oils in inexpensive plastic unit packages. Distribution of oils / fats in-unit consumer packs is becoming increasingly popular as it assures quality products packed under hygienic conditions in unadulterated forms. In view of their logistic advantages such as lightweight, low cost and convenient shapes and tailor-made functionality, plastics in rigid, semi-rigid, and flexible forms are replacing conventional bulk packages.

Proper packaging plays a vital role in the marketing system by retardation of deterioration and prevention of social hazards of adulteration and possibility of under-weighing.

3.1.1. Hydrolytic Rancidity:

Moisture is one of the chief causes of spoilage of oils. Even though fats and oils are hydrophobic in nature, even small variations in moisture content can be detrimental to the keeping quality of the product as it alters the equilibrium relative humidity of the product. Unlike other common foods, water holding capacity increases with temperature in the oil. Hydrolytic rancidity is caused by moisture due to the hydrolysis of oils to glycerol and free fatty acids which are responsible for the off odor. This is catalyzed by enzyme (lipase) activity and increases with time.

3.1.2. Oxidative Rancidity

This is caused by oxygen resulting in the oxidation of oils and fats. The extent of oxidation is also affected by moisture content. Aldehydes and ketones are the final products of oxidation responsible for the rancid odor of oils. Unrefined oils are less prone to oxidation than refined oils due to the presence of natural antioxidants and pigments.

3.1.3. Growth of microorganisms due to increase in water activity:

This can occur at moisture content corresponding to above 65% RH. Colour and vitamin degradation in oil occurs due to exposure to UV light and further accelerated by oxygen.

Therefore, oil needs to be protected from light by using opaque and pigmented packaging materials.

3.2. Packaging Material Requirements

To prevent or retard chemical deteriorations of fats and oils, and for easy handling, transportation and to ensure that the product reaches the ultimate consumer in a safe condition and to satisfy legal requirements for their sale, the packaging material should maintain chemical quality, purity, colour, flavour, and other required attributes. Therefore, the material should be a barrier to water vapour, oxygen, and odor and also should be grease resistant and fulfill the following requirements.

- Should be a barrier to volatile and taint proof towards prints, inks, the solvent used for inks, adhesive, etc.
- Should be opaque or pigmented to screen the UV light.
- Should have good impact resistance to prevent loss or contamination due to breakage or leakage of the package.
- Should possess good stiffness, tensile strength, tear-resistance, and heat seal strength to work well on automatic Form-Fill-Seal machines (for flexible films).
- Should be non-toxic and be compatible with the product.
- Should be tamper-proof and have airtight sealing.
- Should be economical, easily available, printable, and disposable.

3.3. The following packaging materials are commonly used.

3.3.1. Rigid Containers: Metal/Glass/ Plastic

Square/cylindrical metal containers of 15 kg capacity are used as institutional packs and 2 to 5 kg square containers for vanaspati and cylindrical containers for oils are in use as family packs. Metal containers act as a perfect barrier to moisture and oxygen, shield the effects of harmful UV radiation and offer a shelf life of one year.

The escalating cost of conventional metal containers and the possible adulteration during retail sales have led to the use of alternate economical packaging material. Tin-free steel cans coated with epoxy phenolic lacquer are found to offer the required shelf life to oil. Although glass bottles for oils and jars for ghee are being used, heavyweight and fragility restrict their use. Now plastics are widely replacing expensive metal containers due to their lightweight, low cost, optimum barrier properties, strength, and availability in different shapes and sizes. PVC and PET bottles have replaced tin containers to some extent. Even though PVC became popular for its low cost and excellent grease resistance property.

3.3.2. Semi-rigid Packages

In view of the logistic and cost advantages, plastics in semi-rigid and flexible forms have become more popular. Lined folding carton is made from suitable laminates like Met. PET/PE, Al. foil laminate which gives required protection to the product and the outer duplex board carton is meant for extra protection to the primary pouch, graphic design, and display. Studies have indicated that the shelf life of double-filtered groundnut oil and refined sunflower oil packed in the foil-based carton was better than that in PET bottles. Nylon based bag-in-box with built-in tap system is also available for oil packaging in view of convenience of easy opening and reclosing system and cost-effectiveness. Also, while dispensing oil, the volume of headspace air does not increase as in the case of bottles and jars and thus helps in controlling oxidation. The minimum unit pack size commonly available is one liter and its cost is beyond the purchasing power of the common man in the country. Tetra Pak cartons of varying capacity from 200 ml to 1 liter are also being used for the packaging of oils.

3.3.3. Flexible Pouches

The minimum unit pack size in rigid/ semi-rigid containers is 500 ml, a quantity that is too large to purchase by the common man in the country. Hence even today, edible oil is being sold loose. The high packaging cost of rigid/semi-rigid packs and lack of assurance on quality and quantity in buying loose oil has led to the introduction of flexible pouches as retail packs. Flexible packaging materials have the following advantages:

- Optimum balance between cost and benefits,
- Lower storage and handling costs,
- Amenable to high-speed FFS machines.

Unit packages in different forms like pillow pouch, flat pouch, three sides sealed pouch, 4 sides sealed pouch, stand up pouch are available. Selection of packaging materials depends upon several factors such as nature and type of oil, storage conditions, expected shelf life, properties of packaging materials, cost, etc.

Rigid packages for edible oils and fats, their costs and shelf life offered

Sl. No.	Size (kg)	Packaging material	Approximate Cost(Rs)	Weight (g)	Approximate shelf life
1	15	Tinplate can new	42	900	About 1 year
2	15	HDPE jerry can	33	500	> 180 days
3	5	HDPE jar	14	185	> 180 days
4	2	Tinplate can	8		About 1 year
5	2	HDPE jar	8	90	180 days
6	2	PVC Bottle	6		180 days
7	1	PET Bottle	3	33	180 days
8	1	PVC Bottle	4		180 days
9	1	HDPE Container	5.60		180 days
10	0.5	PET bottle	2	18	180 days

3.3.4. Mono films:

The keeping quality of oils were tested in LDPE, HDPE, and PP pouches. They were not at all suitable for various reasons. The grease resistance of LDPE is only seven days at 38°C. Even 75-125 μm thick LDPE pouch was sticky within 15 days of packing. It is also prone to environmental stress cracking. HDPE has the drawbacks like cracking and higher heat sealing temperature. PP has a very poor impact strength. In spite of careful filing and sealing without contaminating the sealing area, leakages were observed in many pouches during storage under accelerated storage conditions. All polyolefin thus failed to offer the desired physical protection. Because of their poor flavor barrier properties, the freshness of refined oils and the characteristic flavor of unrefined oils were lost within very few days of storage. As they are very poor oxygen barriers also, the maximum shelf life of only 15-20 days and 30-40 days were observed under accelerated and normal storage conditions respectively. Hence, mono films fail to offer the necessary physical or chemical protection for oils. Only 100 μm HMHDPE pouch, when tested for hydrogenated oil (vanaspati), was found to satisfy the BIS requirement.

3.3.5. Two-layer films

The keeping quality of different oils were tested in two-layer co-extruded films like HDPE/LDPE, HDPE/ Ionomer, PP/Ionomer, and PET/Ionomer laminate, etc. Even though co-extruded HDPE/LLDPE film improved with respect to its grease resistance, environmental stress cracking, etc., over LDPE and sealability and cracking resistance over HDPE, leaker rates were still high and it emerged as the cheapest material for packing oil. The good grease resistance, ability to give good heat seal even with contamination, low-temperature sealing, and high hot tack renders ionomer the best sealant layer for oils and fats.

Leaker rates were reduced substantially with the usage of ionomer. EAA also was found comparable to ionomer in these respects. Ionomer or EAA as the sealant contact layer offered the desired physical protection from chemical deterioration.

3.3.6. Three-layer structures

Laminates like PET/HDPE-LDPE and met PET/HDPE- LDPE offers good protection as indicated by shelf life of 60-70 days and 120-180 days under accelerated and normal storage conditions, respectively; foil based laminate pouches offer more than 180 days storage life under both the storage conditions. But PET and foil-based laminates are available as preformed pouches and are to be filled without contaminating the sealing area as they do not contain EAA or Ionomer.

Yields and costs of unit packaging materials

Flexible packaging material	Thickness, μm	Yield, m^2/kg	Approx. cost, Rs/kg
HDPE	25	41.2	70
HM-HDPE	25	40.5	70
CPP	25	44.0	65
BOPP	25	46.0	100
LDPE/HDPE	25/25	21.0	70
HMHDPE/LDPE/LLDPE	110	11.0	82
LLDPE/HDPE/LDPE/LDPE/LDPE	95	11.3	90
LLDPE/BA/PB/BA/LDPE	95	10.7	170
LLDPE/BA/PA/BA/EAA	95	10.7	200
PET/LDPE	12/37	19.6	200
PET/HDPE-LDPE	12/37	18.6	150
MET.PET/LDPE	12/37	19.6	225
MET.PET/HDPE-LDPE	12/100	9.5	200
PAPER/Al FOIL/LDPE	40/9/37	10.2	180
PET/Al FOIL/LDPE	12/9/37	13.3	260

3.3.7. BIS Standards/Regulations

- Oil is a commodity consumed by every person. It may become health hazardous unless protected properly.
- Therefore, different standards like PFA, Agmark, and BIS are formulated which give specifications on the quality parameters of oil at the time of sale, the shelf life of the oil in different plastic packaging materials, and specifications on safety and performance of packaging materials.
- The shelf life required for oil in PET/PVC bottles is 60 and 180 days under normal and accelerated storage conditions, respectively.

- The vinyl chloride (VC) monomer content in PVC should be < 1 ppm and VC migration into oil < 10 ppb.

3.4. BIS Specifications for plastic packaging materials for packing edible oils/fats

IS No.- Year	Specification
12724-1989	Flexible packaging materials for packaging of refined edible oil
12883-1989	Polyvinyl chloride (PVC) bottle for edible oils.
12887-1989	Polyethylene terephthalate (PET) bottles for packaging of edible oils.
11352-1985	Specification for flexible packs for packaging vanaspati.
10840-1994	Blow molded HDPE container for packaging of vanaspati.

3.5. Future Trends

Considerable progress has been made in the country in the field of oils and fat packaging.

Multi-layer films with a variety of film structures that have made a significant entry in food packaging can be explored in view of their tailor-made barrier and functional properties. Metallised BOPP as one of the structures in the multilayer film is being considered. Although costlier, Met. PET/HD-LD laminate pouches can be considered for the better shelf life of oils. Apart from multilayer films, multilayer bottles can have a good future for oils due to their good barrier properties. Stretch blown PET and PVC bottles with good barrier and strength properties and cost-effectiveness are finding more application. Opaque, pigmented HDPE containers offer good protection to oil from light. Bag-in-box with tap and laminate pouches with screw cap spout has great potential in oil packaging in view of their cost-effectiveness and convenience over conventional packages. Tetra Brik packs, in view of their barrier properties, can offer longer storage life.

CHAPTER -4

Food Safety Regulations & Standards

4.1 Definition and Standards:

Olive oil means the oil expressed from the fruit of the olive tree (Olea europaea sativa Hoffm. et Link). It shall be of three types: —

(i) Virgin olive oil means the oil obtained from the fruit of the olive tree by mechanical or other physical means under conditions, particularly thermal, which do not lead to alteration of the oil. Virgin olive oil is oil which is suitable for consumption in the natural state without refining. It shall be clear, yellow to green in colour, with specific odour and taste, free from odours or tastes indicating alteration or pollution of oil. It shall be free from rancidity, suspended or other foreign matter, separated water, added colouring or flavouring substances or mineral oil.

(ii) Refined olive oil means the oil obtained from virgin olive, the acid content and or organoleptic characteristics of which render it unsuitable for consumption in the natural state, by means of refining methods which do not lead to alterations in the initial glyceridic structure. It shall be clear, limpid without sediment, yellow in colour, without specific odour or taste and free from odours or taste indicating alteration or pollution of oil. It shall be free from rancidity, suspended or other foreign matter, separated water, added colouring or flavouring substances or mineral oil. Further, if the oil is obtained by the method of solvent extraction and the oil imported into India whether obtained by solvent extraction or otherwise, it shall be supplied for human consumption only after refining and shall conform to the standards laid down under regulation 2.2.1 (16). The oil so refined shall not contain Hexane more than 5.00 ppm.

(iii) Refined olive-pomace oil means the oil obtained from "olive pomace" by extraction by means of solvents and made edible by means of refining methods which do not lead to alteration in the initial glyceridic structure. It shall be clear, limpid, without sediment, yellow to yellow-brown in colour, without specific odour or taste and free from odours or tastes indicating alteration or pollution of the oil. It shall be free from rancidity, suspended or other foreign matter, separated water, added coloring or flavoring substances or mineral oil.

However, it may contain food additives permitted in these Regulations and Appendices.

Further, if the oil is obtained by the method of solvent extraction and the oil imported into India whether obtained by solvent extraction or otherwise, it shall be supplied for human consumption only after refining and shall conform to the standards laid down under regulation 2.2.1 (16). The oil so refined shall not contain Hexane more than 5.00 ppm It shall conform to the following standards: —

Parameters	**Virgin olive oil**	**Refined olive oil**	**Refined olive - Pomace oil**
B.R. Reading at 40ºC	51.0-55.6	51.0-55.6	51.6-55.9
Refractive Index at 40ºC	1.4600-1.4630	1.4600-1.4630	1.4604-1.4632
Saponification value(mg KOH/g oil)	184-196	184-196	182-193
Iodine value (wijs)	75-94	75-94	75-92
Unsaponifiable matter(using light petroleum)	Not more than15g/kg	Not more than15g/kg	Not more than30g/kg
Acid Value	Not more than 2.0	Not more than 0.3	Not more than 0.3
Bellier test	Not more than 17°C	Not more than 17° C	Not applicable
Semi-Siccative oil test	Negative	Negative	Negative
Olive pomace oil test	Negative	Negative	Negative
Cotton seed oil test	Negative	Negative	Negative
Tea seed oil test	Negative	Negative	Negative
Sesame seed oil test	Negative	Negative	Negative
Test for Argemone oil	Negative	Negative	Negative

4.2. SANITARY AND HYGIENIC REQUIREMENTS FOR FOOD MANUFACTURER/ PROCESSOR/HANDLER

The place where food is manufactured, processed or handled shall comply with the following requirements:

1. The premises shall be located in a sanitary place and free from filthy surroundings and shall maintain overall hygienic environment. All new units shall set up away from environmentally polluted areas.
2. The premises to conduct food business for manufacturing should have adequate space for manufacturing and storage to maintain overall hygienic environment.
3. The premises shall be clean, adequately lighted and ventilated and sufficient free space for movement.
4. Floors, Ceilings and walls must be maintained in a sound condition. They should be smooth and easy to clean with no flaking paint or plaster.
5. The floor and skirted walls shall be washed as per requirement with an effective disinfectant the premises shall be kept free from all insects. No spraying shall be done during the conduct of business, but instead fly swats/ flaps should be used to kill spray flies getting into the premises. Windows, doors and other openings shall be fitted with net or screen, as appropriate to make the premise insect free The water used in the manufacturing shall be potable and if required chemical and bacteriological examination of the water shall be done at regular intervals at any recognized laboratory.
6. Continuous supply of potable water shall be ensured in the premises. In case of intermittent water supply, adequate storage arrangement for water used in food or washing shall be made.
7. Equipment and machinery when employed shall be of such design which will permit easy cleaning. Arrangements for cleaning of containers, tables, working parts of machinery, etc. shall be provided.
8. No vessel, container or other equipment, the use of which is likely to cause metallic contamination injurious to health shall be employed in the preparation, packing or storage of food. (Copper or brass vessels shall have proper lining).
9. All equipments shall be kept clean, washed, dried and stacked at the close of business to ensure freedom from growth of mould/ fungi and infestation.

10. All equipment's shall be placed well away from the walls to allow proper inspection.

11. There should be efficient drainage system and there shall be adequate provisions for disposal of refuse.

12. The workers working in processing and preparation shall use clean aprons, hand gloves, and head wears.

13. Persons suffering from infectious diseases shall not be permitted to work. Any cuts or wounds shall remain covered at all time and the person should not be allowed to come in direct contact with food.

14. All food handlers shall keep their finger nails trimmed, clean and wash their hands with soap, or detergent and water before commencing work and every time after using toilet. Scratching of body parts, hair shall be avoided during food handling processes.

15. 15. All food handlers should avoid wearing, false nails or other items or loose jewellery that might fall into food and also avoid touching their face or hair.

16. 16. Eating, chewing, smoking, spitting and nose blowing shall be prohibited within the premises especially while handling food.

17. 17. All articles that are stored or are intended for sale shall be fit for consumption and have proper cover to avoid contamination.

18. 18. The vehicles used to transport foods must be maintained in good repair and kept clean.

19. 19. Foods while in transport in packaged form or in containers shall maintain the required temperature.

20. 20. Insecticides / disinfectants shall be kept and stored separately and `away from food manufacturing / storing/ handling areas.

4.3 LABELING

Labeling Requirements

All food products sold in India that are prepackaged are required to comply with the Food Safety and Standards (Packaging and labeling) Regulations, 2011. The Food Safety and Standards Regulation, 2011 is a notification issued by the Food Safety and Standards Authority of India under the Ministry of Health and Family Welfare. In this article, we look at the regulations pertaining to food labeling in India.

Applicability of Food Labeling Regulations

The food labeling regulations require all “Prepackaged” or “Pre-packed food” to comply with the labeling regulations in India. As per the rules, prepackaged food means food, which is placed in a package of any nature, in such a manner that the contents cannot be changed without tampering it and which is ready for sale to the consumer.

General Labeling Requirements

The following labelling requirements must be complied with by all prepackaged food sold in India:

- The label must be in English or Hindi or Devnagri language. In addition to the above, the label can contain information in any other language, as required.
- The label must not contain information about the food that could be deemed to be false, misleading, deceptive or otherwise create an erroneous impression regarding the product.
- The label must be affixed to the container in such a manner that it would not easily be separated from the container.
- The contents or information presented in the label should be clear, prominent, indelible and readily legible by the consumer.
- If the container is covered by a wrapper, then the wrapper must contain necessary information or make the label of the product inside readily legible by not obscuring.
- The name of the food must be mentioned along with the trade name and description of the food contained. In case the food contains more than one ingredient, then a list of ingredients must be presented in descending order of their composition by weight or volume, as the case may be, at the time of its manufacture;

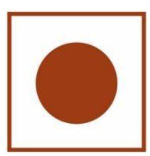
Nutritional Information

Nutritional Information or nutritional facts per 100 gm or 100ml or per serving of the product must be given on the label along with the following information:

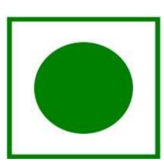
- Energy value in kcal;
- the amounts of protein, carbohydrate (specify the quantity of sugar) and fat in gram (g) or ml;
- the amount of any other nutrient for which a nutrition or health claim is made:
- It is important to note that any “health claim” or “nutrition claim” or “risk reduction” claim made in the label will be thoroughly scrutinized by the FSSAI authorities. Hence,

any such claim must be validated by test data. As per the rules, the following is the definition for “health claim”, “nutrition claim” and “risk reduction” claim:

- “Health claims” means any representation that states, suggests or implies that a relationship exists between a food or a constituent of that food and health and include nutrition claims which describe the physiological role of the nutrient in growth, development and normal functions of the body, other functional claims concerning specific beneficial effect of the consumption of food or its constituents, in the context of the total diet, on normal functions or biological activities of the body and such claims relate to a positive contribution to health or to the improvement of function or to modifying or preserving health, or disease, risk reduction claim relating to the consumption of a food or food constituents, in the context of the total diet, to the reduced risk of developing a disease or health-related condition;
- “Nutrition claim” means any representation which states, suggests or implies that a food has particular nutritional properties which are not limited to the energy value but include protein, fat carbohydrates, vitamins and minerals;
- “Risk reduction” in the context of health claims means significantly altering a major risk factor for a disease or health-related condition;
- Veg or Non-Veg Symbol
- All packaged food that is “Non-Vegetarian” must have a symbol that is a brown colour filled circle inside a square with a brown outline. If a food contains only egg as a non-vegetarian ingredient, then the manufacturer may provide a declaration that the product contains only egg and add the non-vegetarian symbol.



- Packaged vegetarian food should have a symbol that consists of green colour filled circle inside a square with green.



Information Relating to Food Additives, Colours and Flavors

Food additives contained in the food product must be mentioned along with class titles along with the specific names or recognized international numerical identifications. Addition of coloring matter should be mentioned on the label along with certain statements like "CONTAINS PERMITTED NATURAL COLOUR(S)", just beneath the list of the ingredients on the label. In case of addition of extraneous flavoring agent, then it should be mentioned in a statement like "CONTAINS ADDED FLAVOUR" just beneath the list of ingredients on the label.

Name and Complete Address of the Manufacturer

The name and complete address of the manufacturer must be mentioned on every package of food. In the case of imported food, the package must contain the name and complete address of the importer in India.

Net Quantity

All packaged food must carry the bet quantity by weight or volume or number, as the case may be. The net quantity of the commodity contained in the package must exclude the weight of the wrappers and packaging materials.

Lot Number of Batch Identification

A lot number or batch number or code number must be mentioned on all packaged food so that it can be traced while manufacturing and distribution. Only bread and milk including sterilised milk are not required to comply with this regulation.

Date of Manufacture or Packing

The date, month and year in which the commodity is manufactured, packed or pre-packed must be mentioned on the label. In the case of food products having a shelf life of more than three months, then the month and the year of manufacture can be given with the "Best Before Date". In case of products having a shelf life of fewer than three months, the date, month and year in which the commodity is manufactured or prepared or pre-packed must be mentioned on the label with best before date.

Country of Origin for Imported Food

For imported food, the country of origin of the food should be declared on the label of the food. In case a food product undergoes processing in a second country which changes its nature, the country in which the processing is performed should be considered to be the country of origin for the purposes of labeling.

Instructions for Use

Instructions for use, including reconstitution, should be included on the label, if necessary, to ensure correct utilization of the food.

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