Processing Virgin and refined olive and avocado oils

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Why refine Avocado and olive oil at all?

This very brief review is not targeted at refiners who should know all this stuff but at food industry personnel who must source oils for their food manufacturing lines. The comments apply to most liquid oils such as high oleic sunflower, canola, rice bran etc. The traditional practises of refining all edible oils and fats were reviewed in a chapter in the Oils and Fats Group of NZIC's publication *Handbook of Australasian edible oils*. (Eyres, 2007).

Seed oils in their crude form, like canola, sunflower and safflower are usually inedible until fully refined (RBD). On the other hand, avocado and olive oil, if produced correctly and with care in the appropriate processing plant, are tasty and nutritious without needing refining. A key factor for the quality of avocado oil is the quality and maturity of the fruit and the extraction technique in relation to temperature, solvents, and conservation. "Virgin" best describes these unrefined oils which meet standards of quality and taste. This ideal situation is not always achieved in processing the fruit oils and high-acidity or rancid oils, particularly "old" oils from abroad do not do the reputation of these good oils any favours.

In New Zealand, the terms light or lite etc. are used widely to describe fully refined oils, with little or no flavour. These are a major component of the market.

In New Zealand we first reported on virgin avocado oil back in 2001 (Eyres et.al,2001). Since then, there has been an avalanche of publications with often erroneous references to high smoke point, normally by people with no scientific background. The preferable option these days is to have unrefined quality virgin oils for domestic consumption, but there are markets that require fully refined and bland RBD oils such as the food manufacturing and cosmetic industries. Certain food applications such as frying oils, spreads and confectionery require stable, bland low acidity oils. virgin oils do not comply.

Background

The fruit of *Persea americana Mill.*, commonly known as avocado, contains a high amount of lipids and essential minerals like magnesium, potassium, and phosphorus in the mesocarp. It is from the Lauraceae family. The avocado tree is an evergreen dicotyledonous plant grown in tropical or subtropical climates. The largest avocado producing countries in the world, 2012 to 2017, are Mexico, Dominican Republic, Peru, Colombia, and Indonesia. Fresh avocado fruit contributes to a large market worldwide, along with its use in the cosmetic, edible oil and food processing industries.

In the past, avocado oil was mostly extracted using harsh technologies (e.g., organic solvents and/or elevated temperatures) with the extracted oil then going through the refining, bleaching, and deodorising (RBD) processes to remove undesirable impurities and improve the organoleptic properties. The utilisation of elevated temperatures in the RBD processes, particularly the deodorisation stage (>200°C), can significantly diminish the heat-sensitive bioactive substances such as phytosterols, phenolics and carotenoids. Elevated temperatures can also assist the production of undesirable components such as trans and GE and MCPD esters.

Nowadays, one would hope that consumers are more aware of the differences between refined and unrefined edible oil, from the perspective of quality and health benefits. Informed consumers are willing to purchase unrefined edible oil extracted from green and sustainable technologies. These consumers prefer to avoid overly processed foods, which in turn bolsters demand for unrefined, virgin oils.

In New Zealand, Virgin, quality cold-pressed avocado and olive oils are seen now as staples, but it was not always so. Refined, bleached, and deodorised oil, available since the 1970s was the norm. The total market for Virgin olive and avocado oils is around six hundred tonnes whilst the RBD market is around 40,000 tonnes, all imported. These latter oils are of dubious specification and are usually old and tired. Australia tightened the rules for virgin olive oils but here, due to commercial pressure, the rules did not change for the IOC specification which is so loose as to be useless.

The refining process

Storage of oils prior to any processing

The best practice is to store the starting material, free of moisture, in stainless tanks under nitrogen.

The objective of treatments (chemical and physical refining) to achieve RBD status, is to get a better quality, a more acceptable aspect (limpidity), a lighter odour and colour, longer stability, and good safety through the elimination of pollutants while minimising

A modern small scale, 2000kg/hour, physical refining plant. Image courtesy of Dr. Bronner in the USA

oil and nutrient loss during processing. However, the problem is that refining removes some essential nutrients and often generates other undesirable compounds such as 3-MCPD-esters and trans-fatty acids. These compounds directly influence the safety level of refined oil if not done according to some key processing principles. (Matthaus, 2020)

Degumming – to remove phosphatides.

The first step in physical refining is acid degumming to remove "gums" which are predominantly phosphatides.

Water degumming was the original processing step and was normally operated as a batch, small-scale operation. The original process of water degumming is inefficient and only removes the water hydratable phosphatides. The more modern unit operations consisted of phosphoric acid (or citric acid) degumming, followed by strong caustic with short residence time mixing and centrifugal separation of the resultant soap in hermetic sealed centrifuges. Fifty percent citric acid is a preferable alternative to phosphoric acid especially if organic certification is required. 40-60% of the phosphatides are present in the crude as Ca and Mg salts and are insoluble in water. The use of strong acid is common to solubilise these at 0.07-0.15% by wt. in crudes containing less than about 1.5% FFA. The amount of acid to be used should be commensurate with the water insoluble part of the phosphatides. The nature and properties of phosphatides have been the topic of speculation and investigation for over 50 years. The elucidation of the mechanism of degumming owes much to the late Albert Dijkstra. (Dijkstra, A.,2020).

The target analysis of 2ppm phosphorus is good to aim for in degumming.

In the USA, the widespread practice in caustic refining is to use the "long mix "method and in Europe the "short mix." Caustic refining, whilst very forgiving and enabling efficient bleaching and deodorising, adds capital cost, complexity, and causes high losses.

Modern Degumming/Physical refining takes place in continuous plants with acid addition, static mixers, and dwell time tubes, followed by active bleaching.

Bleaching

Bleaching with active adsorbents is more than colour removal. It is better termed "adsorptive cleaning." Conducted efficiently it removes traces of gums, oxidation products and trace metals prior to elevated temperature deodorising. The peroxide value after bleaching should be zero.

Natural clays are the only bleaching clay option that meets the "Organic" oil certification because their manufacture does not involve any restricted chemical agent. In some situations, "organic" approved natural acids, such as citric acid, can further enhance the bleaching effectiveness of natural clays and still meet "organic" labelling requirements for chlorophyll-rich oils. This acid can be added to the oil being bleached, or acid-treated clay can be prepared in advance.

Some development work on citric acid-treated earths was conducted at The University of Auckland by a particularly good chemist who sadly passed away at an incredibly early age. (Stahler, 2006)

Filtration

Diatomite, known also as diatomaceous earth, is a classic material used as a precoat. This filter aid is derived from the fossilised remains of microscopic algae (class Bacillariophyceae). Their chemical composition is largely silica (95-98%). Inevitably, some variations exist in the chemical composition of the diverse types of commercial diatomaceous earth, but in general these differences are small and due to different concentrations of impurities (alumina, iron oxide and alkaline earth oxides). However, when an analysis on the particle size is conducted, the variations are more significant. Only lesser amounts of filter aid are needed if applied correctly in modern automated presses.

Deodorising/steam refining

The principle behind the process of deodorisation relies on the physical chemistry around steam distillation of volatiles under

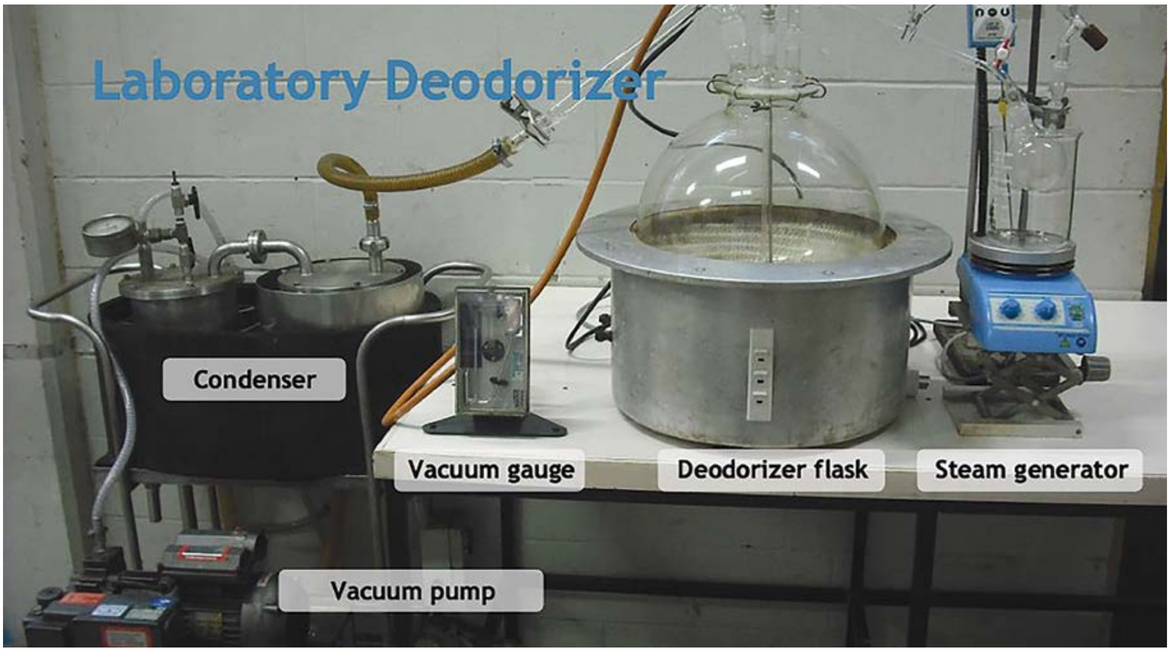


Fig 1. A small scale laboratory deodoriser showing the process steps

Olive and avocado oils	Extra Virgin	Crude	RBD
FFA as oleic	0.8% max.	0.5-3.0%	0.05% max
Peroxide Value	2.0 mEq/kg max.	No specification	1.0 max
Moisture	0.2 % max	NA	0.1% max
Flavour (AOCS taste panel)	Characteristic	Poor	Bland, Score 7 min.
Colour (Lovibond)	Green	-	Pale ,10 Y 1R
Smoke point. AOCS	170C-207C.	Low <180C	250°C
AOM stability. Rancimat	Not specified	Low	20 hours min.
MCPD and GE esters-meets international standards for target markets	Should be below level of detection	Not specified	1-2 ppm

Table I RBD analyses and final specifications. The oil should be tasted by people skilled and trained in the art of sensory and should follow a disciplined technique as laid out in AOCS methods. (Warner,1995) (AOCS method 2-83)

reduced pressure according to Raoult's law. (Low vacuum).

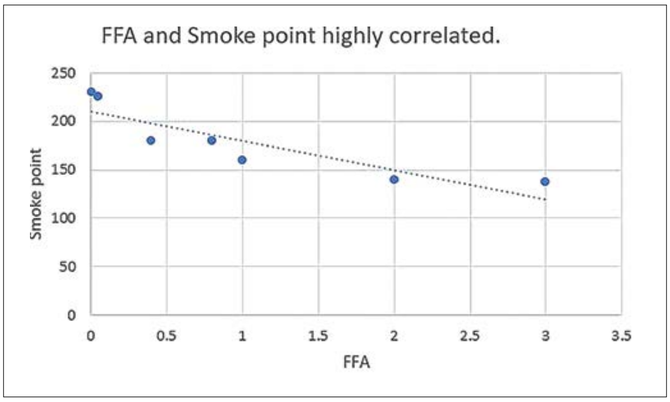
Suppliers of modern deodorising and physical refining equipment include Crown (USA), De Smet (Europe), Kumar (Asia). These suppliers are also excellent sources of technical advice on the process. The efficiency of the process can be judged by a mass balance on inputs and outputs of the production. A good indicator is the FFA of the fatty acids condensed in the fat eliminators. The FFA of the condensate should be >70%. The minimum FFA should be 55%. There will be unsaponifiable matter (sterols etc.) and minor components such as squalene. Losses should be as approximated in the equation below:

Loss in the RBD process(physical) =0.2%+(1.2x FEED FFA)

Trialling of the processing of the crude oil can be done in the laboratory using glass equipment as shown in the photograph of the setup. (Fig 1.) This is done to determine the best possible product quality achievable. It can give an idea of the difference between physical and chemical refining. One can check out the resultant quality with diverse types of adsorbents and examine the effects of temperature on bleaching and required limit on trans fatty acids and MCPD.

A helpful review of deodorising has just been published in Inform, (Gibon et. al.,2023) This shows the benefits of extremely low vacuum.

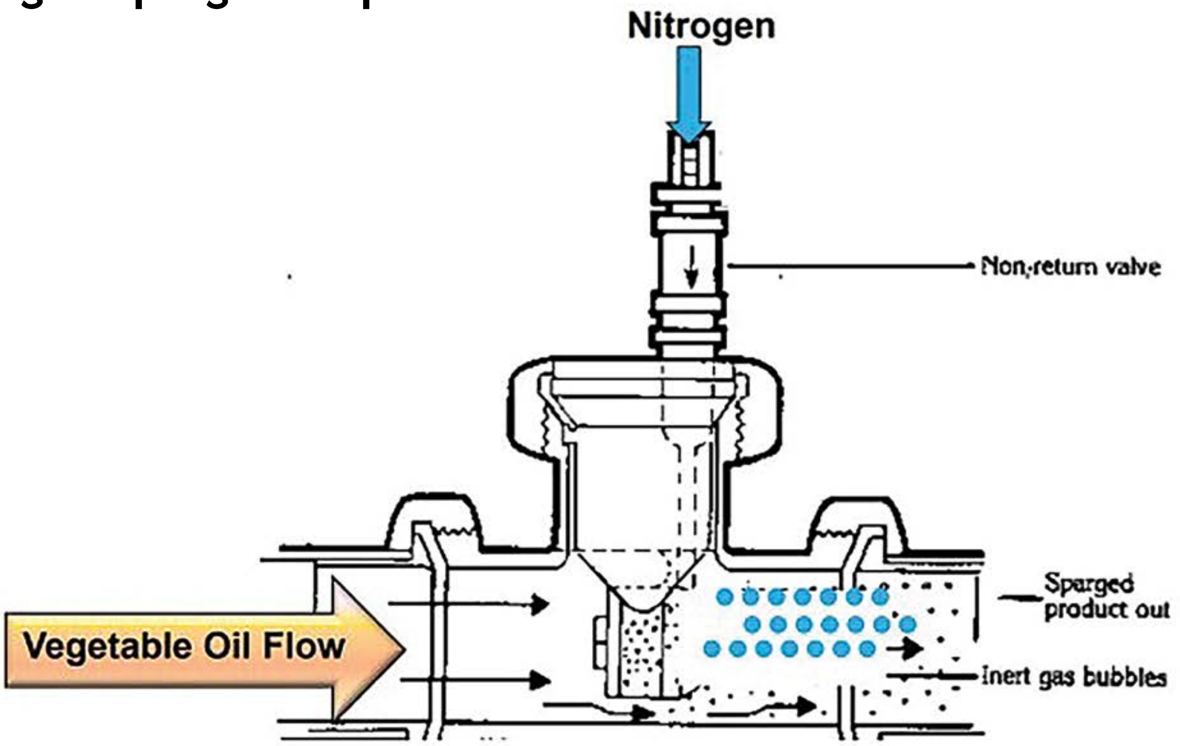
Analytical evaluation of the final processed RBD Oil should include



A high smoke point is a direct function of how much FFA is left in the oil

the standard analytical procedures of acidity and oxidation evaluation as well as flavour evaluation. The science and practice of flavour evaluation of the deodorised oil appears to have been lost due to the paranoia during Covid about sharing containers for tasting.

Nitrogen sparge setup



Nitrogen sparging set-up

Despite exaggerated claims in most literature and marketing sources, a high smoke point is not some divine good luck based on the type of oil: it is a direct function of how much FFA is left in the oil.

Nitrogen sparging

The solubility of oxygen in oil is high (3ml/100 ml at ambient) and the solubility increases with increasing temperature. The initiation of oxidation, however, can begin at lower levels of oxygen. Cascading oil through the air into tanks is bad practice and care should be taken to avoid this. This is particularly important when the oil is being discharged from the deodoriser. Lines should be blown with nitrogen, not air. Once sparged the storage tank should be blanketed with inert gas (nitrogen or argon).

Nutritional issues and concerns with consumer oils

In recent years there have been some nutritional issues raised with consuming fully refined oils. These range from heat induced trans fatty acids to GE and MCPD esters. In business-to-business transactions these issues are fully covered in the purchasing specification but none of this detail appears on the product label for consumers

In my view concerns about consuming light-struck oils from oil in clear containers are much more relevant. In my opinion all the oil at retail in clear plastic or glass is inedible due to being light-struck which creates off-flavours.

The future and innovation

A current processing plant with just the physical structure, equipment and utilities is likely to be around $2.0M for a modest output around two tonne per hour. Many years ago, we looked at just using simple adsorbents such as citric acid-treated earths and charcoal to remove contaminants. Molecular distillation has been tried but the plants tend to be low output and high capital cost. Food scientists/chemists, get your thinking caps on.

Acknowledgements: colleagues and friends

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We are hoping to enable him to attend the annual AOCS conference in Montreal. April 28-May 4th, 2024. This is courtesy of Matt Miller and AAOCS.

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