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Oil as a byproduct of the avocado

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SYNOPSIS
Avocado oil, its history, physical and chemical properties, nutritional value, uses, and commercial production in the Republic of South Africa, is discussed.

HISTORICAL BACKGROUND

The avocado fruit *Persea americana* (Mill) of the family Lauraceae, was first described by Martin Fernandez de Encisco Sevilla Spain in 1519 and was first seen near Santa Maria in Columbia.

In the subtropical states of South and Central America three different varieties were found, namely the West Indian, the Guatemalan and Mexican variety (Popenoe, 1941).

By the selection of these varieties and by cross-breeding, numerous avocado cultivars were developed over the years, of which at present mostly Fuerte, Hass and Edranol cultivars are grown commercially in South Africa.

In 1918 the British Imperial Institute in England already drew attention to the possibility of using avocado oil as a source of oil being suitable for edible purposes.

Round about 1930 avocados were planted on a small scale in the Lowveld of the Transvaal and today avocado growing has a prominent place amongst the horticultural crops grown in this region.

The Californian State Chamber of Commerce reported in 1934 that companies in California, USA used culled and blemished fruit for avocado oil extraction purposes.

In 1956 extensive research was undertaken by analysing the oil content of all the various avocado cultivars grown in the Letaba district at that time.

The best methods for extracting oil were also investigated and in 1958 by using the centrifuge method, the first' avocado oil was extracted commercially at Politsi, Northern Transvaal.

FACTORS INFLUENCING THE OIL CONTENT OF AVOCADOS

The cultivar

As mentioned previously there is a very large number of avocado cultivars available, but only those cultivars with the highest oil content should be considered for oil extraction. During the last two months of the avocado season (August and September), the percentage of the oil in the fruit is the highest. Analysis of the dried pulp of the Fuerte and Hass cultivars indicated that the oil content is between 25 and 30 per cent whereas for the Edranol cultivar it is about 23 per cent. As the oil in the avocado is mainly contained in the pulp or edible portion, it is important to select the cultivars with the highest percentage of pulp as well as small pips and a minimum of skin content.

The average percentage of pips and peel in the above-mentioned cultivars is as follows:

Fuerte pips	=	17,2%
Fuerte peel	=	12,0%
TOTAL		29,2%
Hass pips	=	10,7%
Hass peel	=	14,4%
TOTAL		25,1%

The highest percentage of pulp is 74,9 per cent and is from the Hass cultivar which is recommended as the most suitable cultivar for commercial oil extraction.

Stage of maturity

As the avocado fruit develops on the tree, the matured fruit shows, during senescence, a characteristic respiratory pattern known as the 'climacteric'. As the respiration rate rises and falls it is accompanied by a complex of other biochemical changes in the fruit, which EI-Zeftawi (1978) called the ripening of the fruit. In the ripening process the oil content of the fruit gradually increases and the moisture content decreases. Smith & Huisman (1982) assessed that for Fuerte and Edranol cultivars analysed at weekly intervals from February to September, the weekly increase of the oil content was 0,68 and 0,43 per cent for the two cultivars respectively. The avocado does not show any external changes during the ripening process, and only ripens fully to a soft stage after picking.

Maturity therefore is taken to mean acceptability of the fruit for consumer use, rather than for processing. The increase of the oil content may be used as an indication of the stage of maturity of the fruit. The most accurate method for this oil determination is to dry the pulp (mesocarp) and determine the oil content by the solvent extraction method. This, however, is a tedious method and it may take as long as 12 hours or more to obtain the final results.

It was found that there is a very close correlation between the oil and the moisture content of the avocado. Swarts (1976) described a method where only the moisture content of the pulp is determined and by using a constant for the various cultivars it is now possible to determine the oil content for all practical purposes in a very short time.

Normally for practical purposes it is considered that when the oil content of avocados reaches about eight per cent, it is sufficiently mature to be picked and the fruit will then ripen normally.

Lee (1981) suggested drying the pulp of the avocado in a micro-oven and when a dried weight of 19,1 per cent for Fuerte, and 18,9 per cent for Hass cultivars is reached, it is recommended as a maturity standard for picking of the fruit.

In South Africa and depending on the altitude where the avocado orchards are situated, the fruit normally reaches the right maturity for picking as early as February or March. At this stage, the fruit may be ready to be picked for the consumer, but due to the low oil content (about eight per cent), it is not yet suitable for oil extraction.

The majority of the fruit picked is for the export or local markets and it is only the culled fruit that is blemished or too small that is available for the extraction of oil.

The culled fruit picked at the eight per cent oil level, is left by the oil processors to ripen at room temperature until it is fully soft.

Although the oil content of culled fruit may be eight or 12 per cent, it is most difficult to extract oil from the fruit by means of the centrifugal method. The reason for this may be that at this early stage the cell walls of the cells containing the oil, are still very thick and difficult to rupture.

These oil cells are also bound together by pectic substances of the middle lamella and at this stage it is most difficult to disrupt the oil cells and break them up so as to enable them to release the oil.

Dolendo *et al* (1966) in an article on the relation of pectic and fatty acid changes during the ripening process of avocados, mentioned that at the start of the ripening process to about the fourth day, it was accompanied by a rapid decrease in protopectin and an increase in water-soluble pectin.

A decrease in the degree of esterification of the pectin of the avocado fruit was also noted and this de-esterification of the pectic substances - the binding or cementing substances of the oil cells (middle lamella) - also contribute to the observed changes in the fruit texture.

This process of de-esterification of the middle lamella loosens the cells from each other and at that stage the cell walls may also be more easily ruptured, resulting in the release of the oil in the cells.

As the season progresses the oil content of the fruit also increases month by month, as the oil cells release the oil more readily.

The monthly averages of avocado oil extraction on a commercial scale, by means of the centrifugal process of whole Fuerte avocados (including pulp and peel) are listed in Table 1:

TABLE 1 Monthly averages oil in ripe, whole Fuerte avocados including pips and peel as extracted commercially by the centrifugal method.

For month of	Average % oil in whole rust	% Oil extracted	Recovery %
April	133	7,0	52,6
May	150	11,0	73,3
June	170	13,0	76,4
July	190	15,0	78,9
August	208	18,4	88,4
September	201	18,5	92,0
October	242	20,3	83,8

As indicated above, an oil recovery rate of 90 per cent may be achieved from avocados processed in September when the oil is more freely released from the cells.

For some unexplained reason the percentage of oil in the whole fruit reaches its peak in October but the oil to be recovered has a tendency to decrease again slightly.

To obtain avocados with the maximum oil content farmers have to be encouraged to pick the fruit selectively and leave the blemished and small fruit on the trees until September and October.

METHOD USED FOR THE EXTRACTION OF AVOCADO OIL

Various methods for the extraction of avocado oil have been published over the years of which a few may be mentioned.

(i) Eaton & Ball (1934) suggested drying avocado slices without heat and then with pressures of 3000 to 4000 pounds per square inch, pressing out the oil.

(ii) Dean (1938) described a process for heating the pulp under steam pressure and with a cage press of special design, pressing out the oil.

(iii) Love (1942) also described a process of hydraulic pressing the dried avocado slices, followed by solvent extraction of the press cake. He also mentioned treating the pulp with lime so as to release the oil.

(iv) Pike & Routledge filed a Patent 70/6598 here in South Africa in 1970 where sodium xylene sulphonate is used as a solvent for avocado oil extraction.

(vi) Turatti *et* al (1958), described a process of centrifugation, solvent extraction, freeze-drying of the pulp and hydraulic pressing, as methods of extraction of avocado oil.

(vii) Rendering Process: By heating the avocado pulp in avocado oil, the moisture in the mesocarp evaporates and leaves the oil and other dried plant materials behind. After settling, the oil may be decanted and the remaining slurry may be further subjected to hydraulic pressure so as to press out as much of the remaining oil as possible.

Small-scale laboratory experiments indicate that after the evaporation of the water, the mixture is allowed to settle, and 57 per cent of the oil may be decanted. In the remaining oil/slurry mixture, when subjected to high hydraulic pressures, 37 per cent of the oil may still be recovered resulting in a total recovery of 94 per cent oil.

(viii) Oil extraction by using a tube press plant, which consists of one or two tubes, was developed in England by Messrs Alfa Laval.

These tubes are filled with avocado pulp and with hydraulic pressure oil is pressed through perforations within the inner tubes.

The aim of the above oil extraction methods is to extract as much of the oil in the avocado mesocarp as possible without damaging the quality of the oil. The solvent extraction method will give the highest yield, but the problem is in the installation of the plant which is very expensive plus the solvents which are dangerous to work with due to their inflammability. The recovery of the solvent, on the other hand, needs a sophisticated plant. The removal of all the solvent from the oil is also difficult and traces left may be detrimental to the quality of the oil.

REFINING OF AVOCADO OIL

The oil extracted as described above, on account of its high chlorophyll content, is a dark-green transparent oil with a brownish tint and is referred to in the trade as crude avocado oil. Further refining maybe necessary and consists of the following steps:

Bleaching

Bleaching of the dark-green crude oil can be done by treating the oil with acidified activated earth at an elevated temperature.

After bleaching, filtration is necessary and by using an instrument such as a spectrophotometer it is possible to monitor the bleaching process by measuring the optical density of the bleached oil. Bleaching losses here may be as high as five per cent.

Deodorising

During the bleaching process the oil picks up a pungent odour and this may be removed by sparging the oil with steam jets under a high vacuum and at an elevated temperature. Further losses after deodorising may be as high as seven per cent.

Winterising
At low temperatures the refined oil may become cloudy due to certain high melting point components in the oil which crystallises at low temperatures.

In this process a winterising aid such as oxystearin is added; this enhances the growth of larger crystals and causes the complete crystallisation of the high molecular stearins which precipitate out and may be removed by decanting and filtration.

Alkali refining
When fresh, well-ripe avocados are used for oil extraction the free fatty acid content is normally below one per cent.

Avocado oil contains a natural anti-oxidant in the form of tocopherol (Vitamin E) which will protect the oil for long periods before it may go rancid.

However, when bad (rotten) fruit is used in the extraction process, the free fatty acid content will be high and may increase in a short time to five or six per cent, and at that time will have a strong rancid smell. By alkali refining, the oil is treated with sodium hydroxide so as to neutralise the fatty acids. This is a very tedious process and refining losses may also be as high as seven to eight per cent.

Another method for reducing the free fatty acids is by steam stripping as described by Bailey (1951). The oil is heated under a high vacuum at elevated temperatures, and sparged with live steam which causes the free fatty acids to be distilled off.

PHYSICAL AND CHEMICAL PROPERTIES OF AVOCADO OIL

Crude avocado oil appears deep red when viewed under reflected light and is on account of its high chlorophyl content, deep green by transmitted light. It also presents a somewhat fluorescent appearance.

A typical analysis of crude avocado oil is listed in Table 2.

NUTRITIONAL VALUE OF AVOCADO OIL

Apart from the chemical composition of avocado oil as listed in Table 2, Schwob reported that the oil contained about 2,1 per cent protein, 5,95 per cent sugar and 1,32 per cent minerals.

The vitamin content as analysed by the Shankman Laboratories in Los Angeles is depicted in Table 3.

It is important that 80 to 85 per cent of the free fatty acid composition of avocado oil is unsaturated fatty acids (refer to Table 2). Dr Horace P Pearce (1959) wrote an article on the nutritional value of avocado oil in the *Californian Avocado Yearbook,* 1959, and states as follows:

"It has been found that the oil of the avocado is one of the most valuable of the unsaturated fatty acids, being fifth on the list of the most desirable oils known as an anticholestrol agent. The liberal use of unsaturated oils in the diet has been found to retard and prevent the collection or the forming of clots which result in the commonly known heart attack, known as coronary heart disease."

TABLE 2 Typical analysis of crude avocado oil.

Fatty Acids			%
Palmetic Acid	C16 :	1	11,85
Palmitoleic Acid	C16 :	1	3,98
Stearic Acid	C18 :	0	0,87
Oleic Acid	C18 :	1	70,54
Linoleic Acid	C18 :	2	9,45
Linolenic Acid	C18 :	3	0,87
Arachidic Acid	C20 :	0	0,50
Eliosenoic Acid	C20 :	1	0,39
Behenic Acid	C22 :	0	0,61
Lignoceric Acid	C24 :	0	0,34
Iodine Value (Wijs)		79,0	
Saponification Value		191	
Acid Value		1,65	
Peroxide Value (Milli-equivalents of Peroxide per 1 000 g oil)		3,3	
Free fatty acids		0,82%	
Specific gravity at 25°C		0,9122	
Refractive Index at 25°C		1,4691	
Smoke point		181 °C	
Cloud point		-15°C	
Flash point		245°C	
Unsaponifiables		1,6%	

(Private analysis done by Messrs McLachlan and Lazar (Pty) Ltd, Consulting Industrial Chemists, PO Box 3344, Johannesburg, RSA.)

On the influence of avocado oil on serum cholesterol, Grant (1960) reported in a study feeding 16 male patients age 27 to 72 years, that 50 per cent of the patients showed significant decreases from 8,7 to 42,8 per cent in total serum cholesterol and in no individual did the cholesterol value rise during the avocado feeding experiments.

THE UNSAPONIFIABLE FRACTION OF AVOCADO OIL

The French pharmaceutical industry considers the unsaponifiable fraction that may be recovered from avocado oil to be of great value.

From this fraction a chemical at present known as the H-factor may be extracted, which is understood to have certain healing properties.

TABLE 3 Vitamin content of avocado oil (seasonal range) per 100 g

Vitamin A (Carotene)	370 IU - 870 IU
Vitamin B_2 (Riboflavin)	0,08 mg - 0,16 mg
Pyrodixine	0,19 mg - 0,26 mg
Pantothenic acid	0,78 mg - 1,2 mg
Folic acid	0,022 mg - 0,105 mg
Thiamine Hcl	0,08 mg - 0,125 mg
Ascorbic acid	4,0 mg - 13,0 mg
Niacin	1,05 mg - 2,42 mg
Choline	12,0 mg - 22,2 mg
Biotin	2,3 mg - 4,2 mg
Vitamin E	0,8 IU - 4,2 IU

In France certain applicants, called Laboratories Pharmascience, filed a patent No 17/245 in South Africa in 1971 on the improvements relating to the extraction of unsaponifiable fractions from natural fats.

The patent specifically states it to be for the recovery of the unsaponifiable fractions from avocado oil.

In 1972 another French applicant, Societe d'Alimentation et de Recherches Biologiques SARB, registered a patent No 102888 on a process for the concentration of unsaponifiable fatty substances by means of subjecting the crude avocado oil to molecular distillation at 210°C under a vacuum of 1,10-3 mm Hg.

The fact that the French pharmaceutical industry has registered two separate patents for the extraction of the unsaponifiable fraction of avocado oil may indicate that they attach a great importance to this H-factor, but at this stage little is known about its real value.

Turatti *et al* (1985) found that when avocado pulp is dried and subjected to hydraulic pressure the oil so extracted contains the highest percentage of unsaponifiable matter (4,9 per cent) and also the highest percentage of alfatocopherols (6,92 per cent). From the unsaponifiable fraction of avocado oil Joseph & Neeman (1982) isolated polyalcoholic compounds which they claim are only present in avocado oil. By isolating these compounds a basis may now be provided for detecting the adulteration of avocado oil.

BITTER COMPOUND IN AVOCADO OIL

Avocado oil has one disadvantage in so far as that it develops an unpleasant bitter taste as soon as it is subjected to heat.

Various investigators such as Bates (1970), Brown (1972) and Ben-Et et *al* (1983) did extensive research so as to identify and isolate these bitter compounds induced by heat treatment.

The latter authors have isolated 1-acetoxy-2.4 dihydroxy-n-heptadeca-16-en and 1,2,4-trihydroxy-n-hepta-deca-16-en, as the two likely compounds that are responsible for the bitter taste.

Bates (1970) came to the conclusion that one single substance could not be responsible for the formation of the bitter off-taste, but that a number of substances are involved. According to Bates it will be extremely difficult to prevent or to modify heat-induced off-flavour, so as to permit completely successful thermal processing.

THE USES OF AVOCADO OIL

Avocado oil is of great importance to the cosmetic industry in that it contains a sterol called phytosterol which has the same penetrating abilities as lanolin.

This particular quality of avocado oil as reported by the Naarden Newsletter, Oct 1958, make it eminently suitable for skin and massage creams, massage oils and all other preparations which are used for applying to, or rubbing into the skin.

The ability to penetrate the skin is no doubt the key to the success of avocado oil as a natural and effective beauty aid. The quality of the oil makes it ideal as a carrier for other substances which are not capable of their own accord to permeate into the skin.

The flavour of the oil is bland and can replace unpleasant smelling oil such as codliver and turtle oils.

Avocado oil is also used in high-grade toilet soaps and contributes to the soap's superior lathering and cleaning qualities. Avocado oil is easy to emulsify. Its low surface tension produces smoother creams and soaps and makes a superior cosmetic oil.

According to Rolfe (1975) the impressive list of vitamins as listed in Table 3, is of benefit to the cosmetic industry, because vitamin A helps to prevent a dry skin and vitamin E (Tocopherol) and vitamin D are effective against skin wrinkling.

Due to the abundance of unsaturated fatty acids in the oil, its fibrous proteins (about 4 per cent) act as a natural skin moisturiser. Moisture is necessary to make the skin look soft and young.

Avocado oil also has some sun-screening properties. The ultraviolet radiation of the sun may act identical to the ageing process of the skin. It dries the skin and also induces wrinkling.

It is most fortunate that we can gain the protection we need from something so completely natural as avocado oil, the world's finest skin nutrient and truly nature's own cosmetic.

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