NSW DPI
primefacts
PROFITABLE & SUSTAINABLE PRIMARY INDUSTRIES www.dpi.nsw.gov.au
AUGUST 2006 PRIMEFACT 227 (REPLACES AGNOTE DPI-368)

Chemistry and quality of olive oil

Rod Mailer

Principal Research Scientist, Pulse/Oil Seed Genetics and Improvement, Wagga Wagga

Outline

Many fruits, seeds, vegetables and plants contain edible oils. The oils are similar in many respects, but a few minor differences have a significant effect on the characteristics of the oil. For seed oils, such as canola, there is little a farmer can do to alter quality – other than to choose the best cultivars and grow the crop under the best agronomic practices. Environmental conditions will dictate the oil content and chemical composition. Seed oil quality is generally very stable in the intact seed as long as the seed is free of admixture and stored under good conditions.

For olive oil, however, handling by the grower and processor will largely control the quality. During harvest and storage, bruising or damage to the fruit will result in reduced quality in the oil. Olive growers therefore need to have a basic understanding of what oil quality is and how it is preserved.

This Primefact covers a range of topics related to quality in olive oil, including:

- basic composition of olive oil,
- acceptable composition of extra virgin olive oil,
- current research being undertaken at NSW Department of Primary Industries, Wagga Wagga Institute.

Basic composition of olive oil

Fatty acids

The most important components in olive oil are the fatty acids. Fatty acids are simple structures made up of long chains of various numbers of carbon atoms. There are only a few types of fatty acids in olive oil, but the proportions of each strongly influence the characteristics and nutritive value of the oil.

The majority of olive oil fatty acid chains contain 16 or 18 carbon atoms – shown as ‘C16’ and ‘C18’ respectively. The carbon chains of all fatty acids have a carboxyl group (COOH) at one end. The fatty acid chain for stearic acid (C18) is therefore:

C-C-C-C-C-C-C-C-C-C-C-C-C-C-C-C-C-C-COOH

Fig.1. Stearic acid (C18)

Edible oil fatty acids can have between 12 and 24 carbons. Nearly all of the fatty acids have an even number of carbons, – 16, 18 or 20. Olive oil contains a small proportion of fatty acids with 17 carbons.

Although fatty acids are relatively similar in structure, there are some variations that have a strong influence on their properties. The number of carbon atoms will determine if they are:

- volatile – such as butyric acid, C4,
- solid at room temperature – such as palmitic acid, C16, or
- liquid – oleic acid, C18.

Fatty acids can also be ‘saturated’ or ‘unsaturated’.

- A saturated fatty acid has all of the carbon atoms attached by single bonds.
- A monounsaturated fatty acid has one double bond joining two of the carbon atoms.
- A polyunsaturated fatty acid has two or more double bonds, each joining two carbon atoms.
- The number of double bonds is defined by the abbreviation, for example ‘C18:1’ denotes 18 carbons and one double bond.
- The fatty acids can be bent (cis form) or straight (trans form). See Figure 2.

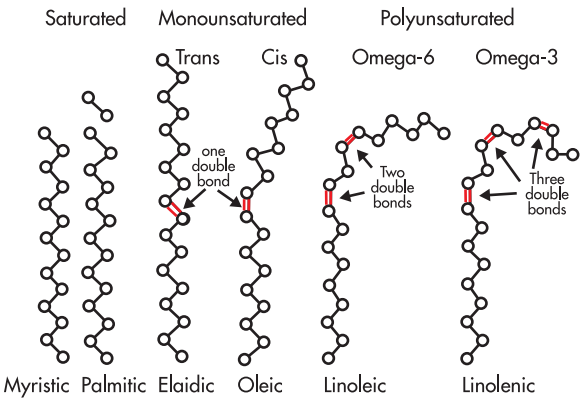

Fig. 2. Various types and forms of edible oil fatty acids (illustration courtesy Meadow Lea Foods).

Triacylglycerol

In a unit (or molecule) of olive oil, the fatty acids are bound in groups of three together with a unit of glycerol. These units are called triacylglycerol molecules or TAGs (see Figures 3 and 4).

Only when the fatty acids are bound in these small units are they considered to be good quality oil. A triacylglycerol unit may lose one fatty acid to become a diacylglycerol – or if it loses two fatty acids it is a monoacylglycerol. The fatty acid which is lost from the triacylglycerol is then called a 'free fatty acid.'

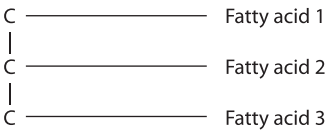

Figure 3. Triacylglycerol (oil) molecule

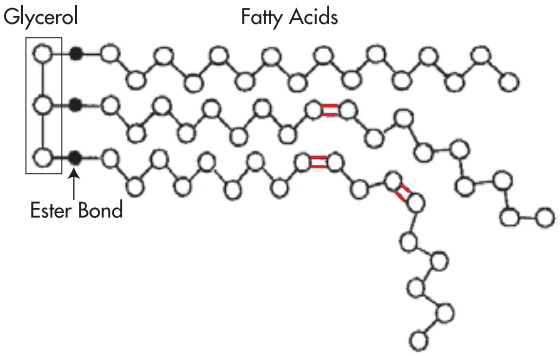

Figure 4. Triacylglycerol (oil) molecule with three different fatty acids attached.

The glycerol unit can have any three of several fatty acids attached to form TAGs. The carbon chains may be different lengths and they may be saturated, monounsaturated or polyunsaturated. It is the relative proportion of these that make one oil different from another.

About 95–98% of olive oil consists of TAGs. The remainder of the oil, although only a small part in proportion to TAGs, includes a very large number of minor compounds, including the phenolics and the sterols. These compounds give olive oil its unique flavour and contribute greatly to the nutritional benefits. Although some of these minor components will be discussed here, the mixture of these in olive oil is very complex. In refined oil, many of these minor components are removed.

Minor components

Phenolics represent a large and varied group of compounds. In olive oil:

- there are many different types,
- they play a major role as antioxidants,
- they contribute to oil colour,
- they contribute to bitterness of the oil,
- many are water soluble and therefore the amount of phenolic compounds in olive oil may depend on the extraction process.

Olive oil is often analysed for the phenolic content to help determine the flavour and/or storage characteristics of the oil. A total polyphenol test measures a large part of the phenolics but does not discriminate between the good ones and others.

Sterols are another large group of components with nutritional benefits for consumers. Researchers have recently recognised the benefits of phytosterol in human health. Margarine manufacturers have developed brands of margarine with added sterols that are now available in supermarkets. These new margarines claim to have dramatic effects in reducing cholesterol absorption into the body.

The measurement of sterols is a very useful test for adulteration of olive oil because the sterols in vegetable oil are often specific for that species. For example, brassicasterol is a sterol that is present in *brassica* crops such as canola. Therefore, any attempt to adulterate olive oil with canola oil can be rapidly detected by the presence of this compound.

Other minor components that contribute to olive oil characteristics are:

- Hydrocarbons, such as squalene and ß-carotene. ß-carotene adds colour to the oil and acts as an antioxidant during storage.
- Tocopherols, which are also antioxidants – including vitamin E.
- Fatty alcohols.
- Waxes, which are generally low in virgin olive oil but are present in high quantities in solvent extracted oil.

- Pigments (chlorophyll, carotenoids). Chlorophyll gives a characteristic and sometimes desirable green colour to olive oil. However, it is a photosensitiser and contributes toward photo-oxidation of the oil.

In addition, there is a range of volatile components which give the oil its odour and contribute to the flavour. These include aldehydes, ketones, thiols, alcohols and acids.

Acceptable composition of extra virgin olive oil

Fatty acid

The International Olive Council (IOC) has produced a list of the allowable levels for each of the fatty acids to be acceptable as extra virgin olive oil.

Generally the range is so great that almost any oil will fit the guidelines. However, there are exceptions to this rule such as linolenic acid. According to IOC standards, linolenic acid should be less than 1% but has been found to exceed 2% in some Australian oils. Although linolenic acid is considered to be nutritionally beneficial, it is a polyunsaturated acid with three double bonds. As a result, it is particularly unstable and susceptible to oxidation (rancidity).

Table 1. Allowable fatty acid ranges for extra virgin olive oil (IOC).

Fatty acid	Carbon number	Allowable Range %
Palmitic	C16:0	7.5–20.0
Palmitoleic	C16:1	0.3–3.5
Stearic	C18:0	0.5–5.0
Oleic	C18:1	55.0–83.0
Linoleic	C18:2	3.5–21.0
Linolenic	C18:3	<1.0
Arachidic	C20:0	<0.6
Gadoleic	C20:1	<0.4

Although the IOC allows such a wide range of fatty acids in extra virgin olive oil, growers are encouraged to select cultivars that have the highest levels of the best fatty acids. Oils that have high levels of monounsaturated oleic acid are considered to be of highest nutritive value (oleic acid is named after olive 'olea'). Ideally the oil should also have less palmitic acid, which is the major saturated fat. The higher levels of linoleic acid, although nutritionally acceptable, are also likely to contribute to reduced storage stability in the oil.

In studies at DPI's Wagga Wagga Oil Research Laboratory, large variations in fatty acids have been observed in olive oil from different varieties of olive trees grown at one orchard. This research indicates that there is a relationship between olive cultivars and their fatty acid profiles. Therefore we would expect the same variation between trees over subsequent years.

Results of analysis of oil from three trees growing at Wagga Wagga are shown in the table below, indicating the variation in the four most prominent fatty acids in olive oil.

Fatty acid	Tree 20 %	Tree 33 %	Tree 4 %
C16:0	21	15	11
C18:1	49	68	77
C18:2	24	10	5
C18:3	0.9	1.0	1.1

Based on the desire to increase the nutritionally preferred fatty acids, Tree 20 is less desirable due to the relatively high level of C16:0 (saturated fat) and the low level of C18:1 (monounsaturated fat). It also contains considerable C18:2 which is polyunsaturated and contributes to the instability of the oil.

However, Tree 4 has low saturated C16:0 and high monounsaturated C18:1 which is considered a nutritionally desirable alternative. The level of polyunsaturates is also low although C18:3 has slightly exceeded the IOC level of 1% maximum.

Other IOC standards

The IOC has a detailed set of standards describing extra virgin olive oil. The basic chemical parameters relate to:

- free fatty acids $\leq$ 0.8%,

and

- peroxide value $\leq$ 20 mEq / kg.

  [mEq = milliEquivalent]

There is also a detailed range of standards designed to prohibit adulteration or processing steps other than mechanical extraction. Some of these tests include:

- Sterol composition,
- Stigmastidiene content,
- Wax content,
- UV Absorption,

- Equivalent carbon number (ECN),
- Trans fatty acids,
- Triacylglycerol composition

Publications containing these standards are available from the IOC headquarters in Madrid (see below).

In addition to all of the chemical characteristics, organoleptic testing ('taste testing') is also a major factor in categorising oil as extra virgin olive oil. Organoleptic analysis requires a trained panel of 8 – 12 tasters. To satisfy the requirements of extra virgin olive oil, the panel must determine that the oil has no taste defects but has some attributes.

Current research and testing at NSW DPI

Optimum harvest timing

Various olive groves have been involved in studies to determine the changes in oil quality during fruit maturation. The changes in oil content, flavour and shelf life stability are being monitored. This study is also considering the influences of irrigation and oil yield. It is apparent that growers can harvest their crop at various stages of maturity to achieve quite different types of oil from pungent and fruity to mild and bland.

Shelf life or stability variation between olive oils

A series of studies is being carried out to determine the qualities that make some olive oils more stable than others during storage. Samples of various oils harvested at different stages of maturity are stored under uniform conditions and tested routinely for chemical and organoleptic quality. It has been shown that olive oil will last for many months without developing rancid flavours or poor chemical quality if stored in clean, unreactive containers, in cool areas away from heat and light. Early harvested olive oil with high phenolics content has a better shelf life than oil with lower phenolic content.

Commercial Testing

NSW DPI now provides a complete commercial testing service including all of the IOC methods for quality analysis as well as testing for export or for adulteration. The laboratory also has developed a certified organoleptic panel for sensory analysis. For more details of the tests and costs contact the Customer Service Officer at NSW DPI Wagga Wagga, Agricultural Institute, Tel 02 6938 1957.

Further information

Further advice is available from various sources including NSW DPI, www.dpi.nsw.gov.au

Tests that growers need to do to ensure oil quality are described in a separate publication, Primefact 231, *Testing olive oil quality: chemical and sensory methods*. There are also many textbooks, which provide more in-depth information.

International Olive Oil Council

Contact details for the International Olive Oil Council are:

Web: www.internationaloliveoil.org/

Address: Príncipe de Vergara 154, 28002, Madrid, Spain

Phone: 34 915 903 638 Fax: 34 915 631 263

Email: iooc@internationaloliveoil.org

Published by NSW Department of Primary Industries

ISSN 1832-6668

Job number 6745

Replaces Agnote DPI-368

Updates of this Primefact are available at www.dpi.nsw.gov.au/primefacts