NUTRITION AND BIOLOGICAL VALUE

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It is the purpose of this chapter to briefly review our present knowledge regarding the relationship between olive oil consumption, human nutrition and health.

CHEMICAL COMPOSITION OF OLIVE OIL – NOT JUST MONOUNSATURATED

Grades of olive oil

Olives contain 20% oil. Oil is most often extracted by using mechanical pressing combined with heat and/or solvents. The fats are contained in the cells of the plant material. When the material is heated to temperatures of over 200°C, the cell walls become permeable, which makes it easier for the oil to be pressed out. Heating also makes the oil thinner, which assists its flow. The oil that is left in the residue can be extracted by the use of solvents (hexane, isopropanol, acetone). Once extracted, some oils are then refined – to remove impurities such as some fatty acids and protein fragments, and deodorised and bleached to improve and neutralise the flavour because not all olives are of the same grade and quality.

Olive oils come in a range of grades. The best oil comes from the first pressing whereby only mechanical pressing is used and no heat, known as «cold-pressed» oils. Each successive pressing yields oil of lower grade, which must generally be refined to improve the flavour and keepability. However, the characteristic flavour of these oils is usually lost, they have much higher acidity than virgin oils and this is neutralised with alkali in the presence of solvents.

The oil from the first pressing is labelled «Extra Virgin oil» – it is premium olive oil from the best-quality, barely ripe olives, and is of low acidity. Because it has not been heated, it contains fewer impurities and so usually does not need refining. Its natural flavour is better retained and so are the nutrients. A true cold-pressed oil has a deeper colour (deep yellow or green) and higher viscosity.

«Virgin» oil also comes from the first pressing but heat may have been applied. «Refined» olive oil is obtained by refining «Virgin» oil. «Olive oil» is a blend of «Virgin» and «Refined» oils. The virgin oil is added because it contains natural antioxidants which will protect the lower grade olive oil from becoming rancid. «Olive Pomace» oil is obtained by solvent extraction of the olive residue remaining after mechanical extraction of the «Virgin» oil. It is made edible by refining. A newcomer on the market is «light» olive oil. This term refers to the flavour, not the fat content. «Light» olive oil has a milder, more neutral taste, as it rarely contains any virgin oil and has usually been refined, deodorised and bleached, to further reduce its flavour and colour to a light yellow (Fedeli and Testolin, 1991; Rogers 1990).

Composition of olive oil

Olive oil consists of a saponifiable fraction (triglycerides) 99% and an unsaponifiable fraction (minor components) 1%. In fatty acid composition, no differences exist between «Virgin» and refined oil. The main fatty acid in olive oil is the monounsaturated fatty acid omega 9 oleic (63-83%), followed by the saturated fatty acids palmitic (7-17%), stearic (1,5-5%) and palmitoleic (0.3-3.0%) and polyunsaturated fatty acids omega 6 linoleic (3-14%), and omega 3 linolenic (< 1.5%).

Olive oils from the more southerly, warmer regions of the Mediterranean tend to be higher in linoleic acid than in more northerly regions. The human body cannot synthesize either omega 6 linoleic acid (18:2 n-6) or omega 3 a-linolenic acid (18:3 n-3). Large amounts of these fatty acids are not required to prevent manifestations of deficiency and olive oil provides a low but adequate amount of these fatty acids. The requirements of linoleic and linolenic acid are estimated at 1%-2% and 0.2-0.6% respectively of total energy intake, supplied by 2-3 tablespoons of olive oil/2700 kcal per day (Fedeli and Testolin, 1991).

The unsaponifiable fraction of olive oil contains vitamin E, other antioxidants and non-nutrients, found in greater quantity in the virgin grade (Yoo et al., 1988; Cortesi and Fedeli, 1983).

- *Vitamin E* – 15-17mg/100 ml of oil, of which 90% of the tocopherols present are in alpha form (the most biologically active form); it acts as an antiosidant.

- *Phenolic compounds* – e.g phenols, phenolic acids, polyphenols, have antioxidant activity.
- *Phytoestrogens* – exhibit both oestrogen and anti-oestrogen activity.
- *Sterols* – e.g b-sitosterol, a substance which counters intestinal absorption of dietary cholesterol.
- *Hydrocarbons* – e.g squalene, 0.15mg/100ml of oil, a substance which can inhibit cholesterol synthesis via the enzyme L-CAT; b-carotene, which has vitamin A and antioxidant properties.
- *Terpenic alcohols* – e.g cyclo-arthenol, assists faecal excretion of cholesterol through increased bile acid secretion.
- *Colouring substances* – e.g carotenoids, chlorophyll, have antioxidant activity
- *Aromatic substances* – provide the characteristic aroma and taste of olive oil.

Cooking and olive oil

Olive oil, unlike seed oils, remains stable even at high frying temperatures because of both its antioxidant content and its high oleic acid content, making it less vulnerable to oxidation and subsequent formation of toxic products (e.g peroxides and polymers). Also, studies by Varela et al. (1982) have shown that olive oil does not penetrate the food but remains on the surface, unlike other fats and oils which penetrate most or all of the food. Nor does the digestibility of used olive oil change, not even after 10 repeated fryings of meat or sardines (Varela et al., 1984).

OLIVE OIL IN HEALTH AND DISEASE – NOT JUST HEART DISEASE

THE CHOLESTEROL CONNECTION

Over the last 35 years, nutrition research has produced evidence that polyunsaturated fats (PUFA) were hypocholesterolaemic, that saturated fats (SFA) were cholesterol-raising, and monounsaturated fats (MUFA) were neutral. Saturated fats, such as myristic found in dairy fats and coconut oil and palmitic found in animal fat and palm oil, have been found to raise LDL cholesterol whereas stearic acid in beef fat and chocolate has been found to be neutral but may encourage thrombosis (US National Research Counci, 1989).

The focus has been exclusively on the ratio of PUFA to SFA FATS (i.e P/S ratio), with MUFA receiving little attention; a P/S ratio of 2 was recommended as desirable to counterbalance the cholesterol-raising effect of SFA fat (Keys et al., 1965). Linoleic acid became the preferverd polyunsaturated fat. So for some time, health educators have encouraged us to replace SFA in our diet with PUFA resulting in the current high intake of about 10% of total energy intake in most developed countries.

Recently there has been some concern that a high intake of PUFA may not be as healthy as was originally thought This century there has been a huge human experiment, unprecedented in the history of man, with regards to the high intakes of linoleic acid in vegetable oils. They may have helped to lower heart disease rates but there has also been a rise in cancer death rates. Animal studies and other studies that followed by various groups, raised the suspicion that PUFA may favour tumour development in the presence of chemical carcinogens and that they may lead to immune suppression (Spiller, 1991).

Some studies suggest that, as well as reducing the level of low density lipoproteins (LDL), eating large quantities of PUFA (>10% of total energy intake) can also reduce the level of high density lipoproteins (HDL) in the blood (Mattson and Grundy, 1985; Spiller 1991). But other studies have shown that a usual diet would not contain sufficiently high levels of PUFA for this to occur (Mensink and Katan 1989).

The higher the PUFA intake the higher the intake of antioxidants required (vitamin E requirements can increase 200-fold as PUFA intake increases) due to the vulnerability of these fats to oxidation and formation of free radicals. For this reason PUFA oils are normally accompanied by antioxidants, most of which are required by the oil as a preservative, with little actually available for biological activity in the human body after consumption. In the absence of adequate amounts of antioxidants, large amounts of PUFA in the diet may produce lipid peroxidation and free radicals. Free radicals are now considered to be involved in carcinogenesis and to be the key to the process of atherosclerosis since free radical damage to cholesterol transforms the cholesterol into a potent stimulus for the commencement of arterial lesions (James et al., 1989; Yamamoto et al., 1988).

A competitive interaction exists between the metabolism of fatty acids. Omega 6 linoleic acid suppresses the metabolism of omega 3 fatty acids (e.g linolenic acid, eicosapentaenoic acid and docosahexanoic acid) and vice versa, at the rate limiting step (desaturase enzyme 6D) and they both suppress the metabolism of omega 9 oleic acid (US International Life Sciences Institute Nutrition Foundation, 1990). Thus a high intake of omega 6 linoleic does not allow dietary omega 3 fatty acids to be incorporated into cell and platelet membranes where they exhibit antithrombotic, antiinflammatory and vasodilatory properties. The omega 3 fatty acids have been identified to protect against coronary heart disease due to these properties as well as by lowering blood triglyceride levels, not cholesterol. The benefits of these fats were first identified in population studies of Eskimos and Japanese fishermen, who had a very low incidence of the disease, despite a diet which included large amounts of fatty fish, high in cholesterol (Kromhout et al., 1985).

Recently research has also broadened its focus and taken an interest in MUFA. It now seems that MUFA are just about as effective as PUFA in reducing the level of LDL cholesterol in the blood, but do not lower the level of HDL (Grundy et al., 1988). In support of the claims for MUFA, it has been observed that blood cholesterol levels and the incidence of heart disease are lower in some Mediterranean countries, which consume olive oil almost exclusively, than in other European countries where the total amount of fat in the diet is similar but not obtained from olive oil (Keys, 1980).

In contrast to PUFA, MUFA are more stable and do not oxidise as easily thus not requiring so many antioxidants. The antioxidants found in olive oil are therefore not only available for protecting MUFA from oxidation but also for protecting blood cholesterol from oxidation and damage. Furthermore, unlike omega 6 linoleic acid, omega 9 oleic acid does not compete for the desaturase enzyme. A high background diet of olive oil allows the omega 3 fatty acids to be metabolised into their beneficial by-products. Additionally, if very little omega 6 linoleic acid is consumed, there will be an increase in eicosatetraenoic acid (a breakdown product of oleic acid) which is now known to have potent antiinflammatory action (US Surgeon General's Report 1988; Wahlqvist and Kouris-Blazos, 1991).

The definition of the ultimate mix of fatty acids which is optimal for health and safe in the context of national diets has been under some speculation lately, especially with emerging evidence about the importance of omega 3 fatty acids and oleic acid. Currently it is recommended by most national bodies to consume 7-8% calories as saturated fats (current intake about 13%), 7% calories as linoleic acid (current intake 7-10%) and 10-15% as oleic acid (current intake <10%). No recommendations are given for omega 3 fatty acids. A monounsaturated to polyunsaturated ratio (M/P) or a polyunsaturated + monounsaturated/saturated fat ratio (P+M/S) of 2 is now recommended. In fact, only 1-2% of total energy intake as linoleic acids is required to prevent essential fatty acid deficiency and evidence is emerging that an intake as low as this may be necessary to get the benefits of higher intakes of omega 3 and oleic acids (US National Research Council, 1989; Wahlqvist and Kouris-Blazos, 1991).

However, it may be that not all MUFA-rich oils (e.g almond, rape seed (Canola), macadamia, peanut) have the same effect as olive oil, since the minor components of olive oil may also play an important role.

GLYCAEMIC CONTROL

Garg and co-workers (Garg et al., 1988) compared a high-carbohydrate diet with a high MUFA diet (33% energy intake) in patients with non-insulin dependent diabetes. Better glycaemic control was observed in the patients on the MUFA diet.

OBESITY

Observations on the Cretan cohort of the Seven Countries Study appear to support the notion that the high olive oil Cretan diet is associated with low coronary risk (Keys et al., 1986). However, recent observations in Crete suggest that, in spite of continued high olive oil intake, Cretan men and boys no longer have very favourable blood lipoprotein values (Katan et al., 1987).

One possible explanation for this is obesity, which has become very common in Crete in the past 25 years. This is probably related to the decrease in hard physical labour combined with a continued high intake of fat in the form of olive oil. Short-term clinical studies in humans indicate that high fat diets are associated with weight gain and increase in total energy intake (Lissner et al. 1987). The diet that worked well for Cretan peasants in the 1950s could produce severe overweight in sedentary city-dwellers of the late 1980s, and thus cancel the favourable effects of lipoproteins which olive oil produces in controlled isocaloric experiments. A high MUFA diet is beneficial as long as total fat intake is kept within limits or exercise levels are maintained or increased to avoid obesity.

CANCER

The weight of the evidence in several types of epidemiological studies indicates that a high-fat (especially saturated fat) intake coupled with low plant food intake is associated with increased risk of cancer, with little or no correlation with PUFA intake. This has been explained on the basis that human diets normally contain enough linoleic acid to satisfy the threshold requirement for tumour promotion observed in animal studies.

Experiments in animals suggest a twofold requirement in promotion of carcinogenesis by dietary fat. The dietary fat must provide a certain amount of linoleic acid (4-5% total energy intake) and when this requirement is satisfied, the promoting effect of additional dietary fat appears to be unrelated to the type of fat. The amount of linoleic acid in olive oil is insufficient for maximum promoting activity (Carroll et al., 1986).
Two recent case-control studies in Europe suggest that MUFA may actually have a protective effect against colorectal cancer, but this finding needs further confirmation (Tuyns et al., 1987). Olive oil in animal models and in the Mediterranean region where it is the main component of fat intake, appears to have a neutral or protective action on hormone metabolism and thus does not have an enhancing effect on endocrine-related cancers (prostate, breast, ovary) (Weisburger, 1991). It has been postulated that this may be related to phytoestrogens found in the Mediterranean diet, namely in vegetables, legumes and olive oil which may assist in decreasing endogenous oestrogen production (James et al., 1989; Adlercreutz et al., 1987). The antioxidants found in olive oil may also be protective against free radical damage and carcinogenesis.

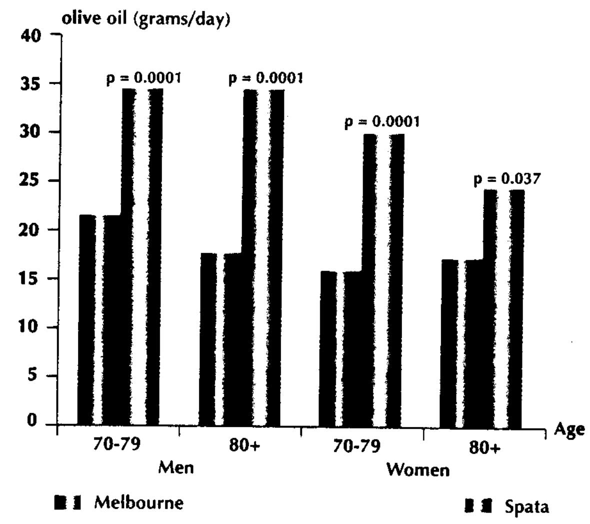
OSTEOPOROSIS

Limited evidence exists on the effect of olive oil on bone mineralization. Laval-Jeantet et al. (1980) were able to prove with an animal model that the best bone mineralization was obtained on an intake of MUFA supplemented by a minimum amount of PUFA (which is what is normally found in olive oil). The phytoestrogens found in olive oil require further investigation to determine their possible role in preventing bone loss by blocking sex hormone-binding globulin and thus increasing the availability of free oestrogen which favours bone mineralization.

CONSUMPTION OF OLIVE OIL

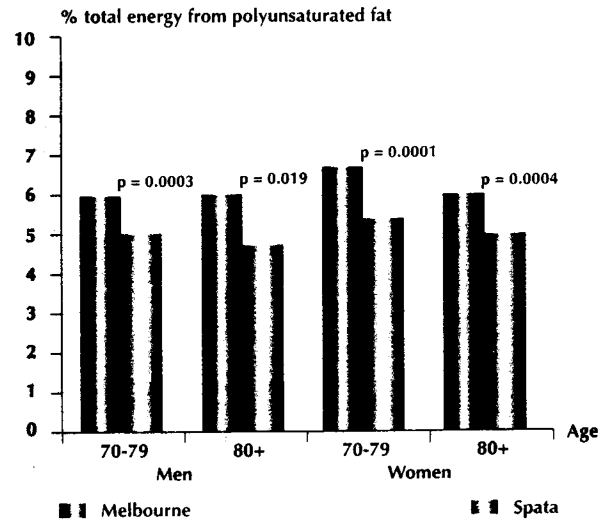
According to food balance sheets published by FAO 1984, Greece has the highest per capita consumption of olive oil (60g/day), followed by Italy (30g/day) and Spain (25g/day). However, intake of olive oil has decreased over the years whereas animal fats and intake of other vegetable oils has increased. The food balance sheets also reveal a doubling of meat, egg and sugar availability since the 1960s, cereal availability has also decreased by a third, availability of pulses has halved, whereas fruit and vegetables have almost doubled (Trichopoulou et al., 1990). Trichopoulou (1991) reports that these trends imply a progressive «northernization» of the Mediterranean diet and that further evidence pointing in the same direction comes from Household Budget Surveys (Trichopoulou, 1989) and from ad hoc studies in several Mediterranean countries (Ferro Luzzi and Sette, 1989).
There is also evidence from the Seven Countries Study that olive oil intake has decreased during the last 20 years in Greece (Crete and Corfu) along with bread, other cereals and legumes whereas meat, animal fat, cheese and alcohol have increased (Aravanis and Loannidis, 1984). This decrease in olive oil consumption is reflected in the fatty acid composition of the diets of subjects studied in Crete (Kafatos et al., 1991). In 1960 percent total energy from fat was 40%, 8% SFA, 29% MUFA, 3% PUFA with a P+M/S ratio of 4. In 1988 the percentage total energy intake from fat had decreased to 36%, SFA had increased to 10.2%, MUFA had decreased to 17%, PUFA remained unchanged at 3% and the P+M/S ratio had dropped dramatically to 1.96. These dietary changes parallel the observed increase in the total serum cholesterol from 4.7mmol/l in 1962 to 6.4mmol/l for 181 Cretan men aged 40-60 in 1988, i.e a 36% increase.
Studies on elderly Greeks in Greece and Australia (Wahlqvist and Kouris-Blazos, unpubl. data) have shown that olive oil consumption further decreases on migration. A sample of 104 Greeks (51 men and 53 women) aged over 70 were studied in 1988 in Spata, Greece (20 Km from Athens) and compared to a sample of 189 elderly Greek subjects (94 men and 95 women)

FIGURE 1
OLIVE OIL CONSUMPTION
Comparison between Spata (Greece) 1988 and Melbourne (Australia) 1990-1991



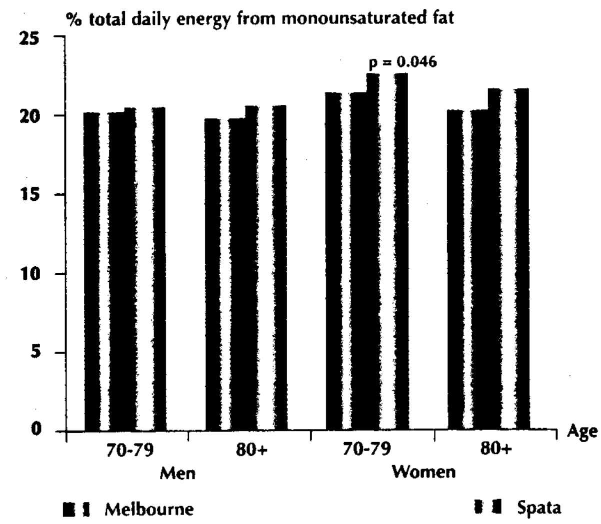
SPATA: men 70 - 79 n = 32; 80 + n = 19; women 70 - 79 n = 31; 80 + n = 22;
MELBOURNE: men 70 - 79 n = 66; 80 + n = 28; women 70 - 79 n = 59; 80 + n = 36

FIGURE 2
DAILY ENERGY INTAKE OF POLYUNSATURATED FATS
Comparison between Spata (Greece) 1988
and Melbourne (Australia) 1990-1991



SPATA: men 70 - 79 n = 32; 80 + n = 19; women 70 - 79 n = 31; 80 + n = 22
MELBOURNE: men 70 -79 n = 66; 80 + n = 28; women 70 - 79 n = 59; 80 + n = 36

FIGURE 3
DAILY ENERGY INTAKE OF MONOSATURATED FATS
Comparison between Spata (Greece) 1988
and Melbourne (Australia) 1990-1991



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over 70 that had migrated to Melbourne, Australia. Olive oil consumption was found to be significantly lower (p<0.0001) in the migrant group (mean intake 18g/day) compared to the Spata elderly (mean intake 30g/day) (see figure 1). This has also been reported in the Levkadian Migrant Health Study, where a total of 1041 subjects of all ages were studied – 488 on the Greek island of Levkada and 533 in Melbourne (of which 60% were related to subjects in Levkada). The migrants reported a mean consumption of olive oil per household per week of 1.3 litres compared to the 3.9 litres per household per week in Levkada (Powles et al., 1988).

It appears that the migrant elderly Greeks have substituted their olive oil with other vegetable oils (mean intake 4g/day) (p<0.01) and margarines (mean intake 3g/day) (p<0.001) which were not consumed in the Spata sample.

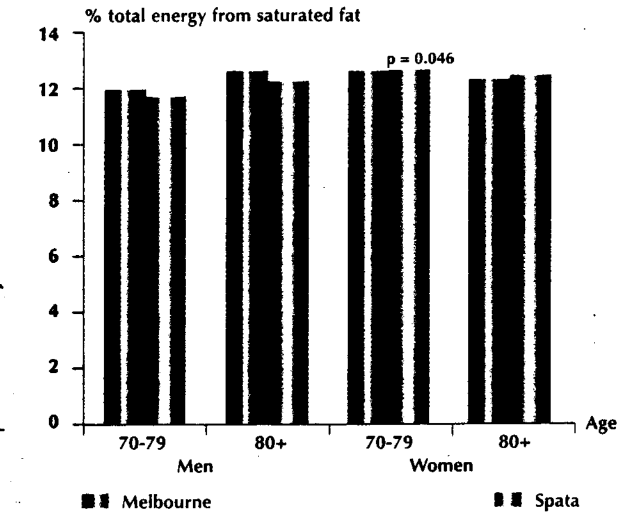
This was also reflected in the percentage energy from PUFA which was significantly higher in the migrant elderly (mean 6%) compared to the Spata elderly (mean 4%) (p<0.001) (see figure 2). The percentage energy intake for total fat was 42%, SFA 12.4%, and MUFA 20.5% which were not significantly different from the Spata elderly (see figures 3 and 4). The P + M/S ratio (mean 2.2) was also similar in both sites (see figure 5).

The Euronut-Seneca study also included a sample of 60 Greeks aged 75 in Markopoulo (actually located near Spata) and 85 Greeks aged 75 on the island of Crete (Euronut SENECA investigators, 1991). The fatty acid intake of these elderly was very similar to the Spata elderly – percentage total energy intake from fat was 43%, SFA 10%, MUFA 20%, PUFA 4% and the P + M/S ratio 2.5.

FOOD BELIEFS ABOUT OLIVE OIL

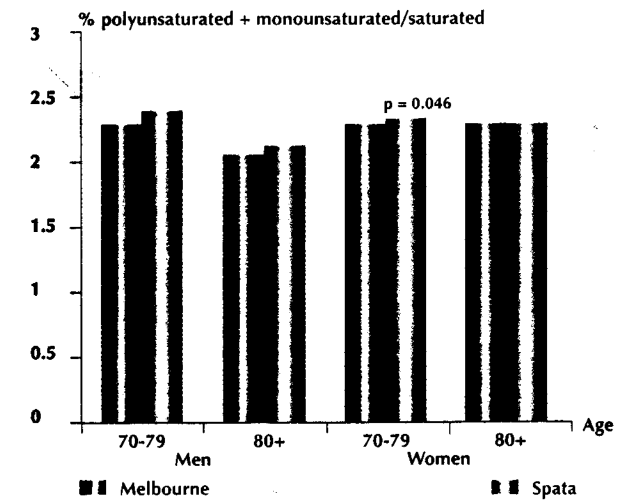
Beliefs and attitudes towards various foods are interesting as they may explain current food intake practices. The elderly Greek study in Melbourne and Spata (Wahlqvist et al., 1991; Kouris et al., 1991) as well as in the Levkadian Migrant Health Study (Powles et al., 1988), endeavoured to obtain information on food beliefs, including beliefs about olive oil. More than 70% of the elderly subjects in both sites believed that «olive oil should be eaten in liberal quantities preferably added to food once cooked and that margarine, butter and other oils are best avoided because they are not as healthy as olive oil». Additionally, 60% believed that olive oil was not fattening. In the Levkadian Migrant Health Study 40% of the Levkadians, and 50% of the emigrants believed that oil was not fattening. Similarly to the elderly study, 88% of Levkadians and 73% of the migrants believed olive oil was very good for health.

FIGURE 4
DAILY ENERGY INTAKE OF SATURATED FATS
Comparison between Spata (Greece) 1988
and Melbourne (Australia) 1990-1991



SPATA: men 70 - 79 n = 32; 80 + n = 19; women 70 - 79 n = 31; 80 + n = 22
MELBOURNE: men 70 - 79 n = 66; 80 + n = 28; women 70 - 79 n = 59; 80 + n = 36

FIGURE 5
RATIO OF POLYUNSATURATED +
MONOUNSATURATED/SATURATED FATS
Comparison between Spata (Greece) 1988
and Melbourne (Australia) 1990-1991



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MELBOURNE: men 70 - 79 n = 66; 80 + n = 28; women 70 - 79 n = 59; 80 + n = 36

CONCLUSION

The ultimate mix of fatty acids which is optimal for health and safe in the context of national diets needs further investigation and research. In the interim, olive oil appears to be a safe source of dietary fats and antioxidants and will provide adequate amounts of essential fatty acids even if used exclusively. However, its indiscriminate use if not balanced with exercise can result in obesity, which is not desirable. Furthermore, beliefs about olive oil may need to be taken into serious consideration if nutrition policies and guidelines are to be effective.

WORLD OLIVE ENCYCLOPAEDIA

INTERNATIONAL OLIVE OIL COUNCIL

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