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Artículo Original

Extra virgin olive oil and oleic acid

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SUMMARY

For many decades, researchers have investigated the relationships between health status and consumption of extra virgin olive oil. Extra virgin olive oil (and oleic acid) is considered important for the prevention of coronary heart disease. While the biomolecular aspects involving G protein need further research, oleic acid levels in platelets may be a discriminating factor, together with linoleic and arachidonic acid, for coronary heart disease. There is still ample debate regarding the effects of oleic acid alone or in combination with antioxidants.

KEY WORDS

Olive oil, oleic acid, platelets, coronary heart disease, depression, G protein.

INTRODUCTION

Diseases of the cardiovascular system, hypertension, aneurysms, thrombosis, heart attack, stroke, etc., in addition to being the leading cause of death in all developed nations are often debilitating diseases and are designed to grow with the increase of expectation of life. At one time it was thought that these illnesses affect only the industrialized nations, but today's data show that 80% of deaths occur in developing countries or those with emerging economies.

The major known risk factors are mainly related to inappropriate lifestyles such as smoking tobacco, reduced physical activity, obesity and eating mostly incorrect: the simultaneous presence of two or more factors multiplies the risk of experiencing cardiovascular disease.

According to the World Health Organization in 2005 there were 17.5 million deaths in the world for cardiovascular disease, representing 30% of all deaths. Of these, 7.6 million are due to heart disease and 5.7 million to stroke (1). It is estimated that by 2015 the number of deaths from these diseases will increase, globally, to reach 20 million units, confirming its position as the leading cause of death in the world (1).

In 2005 the United States, 865 thousand people have died from cardiovascular diseases (35.3% of the total, ie one death every 2.8), with coronary heart disease known to be the leading cause of death overall with 445 thousand deaths. The number of deaths was far greater than the sum of deaths from cancer, accidents and HIV / AIDS (2). In the United States it is estimated that in 2006 80 million people have been affected by one or more cardiovascular diseases.

Despite a death toll so high, if one examines the period between 1995 and 2005 there is a decline from previous years with a reduction of 9.6% in the number of deaths in absolute terms, while the standardized mortality rate decreased by 26.4%.

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As for the near future, however, estimates derived from a report on demographic changes and cardiovascular disease in the period 1950-2050 indicate that mortality from cardiovascular disease in the U.S. could increase between 2000 and 2030 (3, 2). This latest analysis suggests the need for a strong and immediate preventive action.

An analysis of cardiovascular diseases in the European Union indicates that these are responsible for 2 million deaths each year and, throughout the European continent, 4.3 million (1, 4). Coronary artery diseases are the diseases most responsible for fatalities from 741 thousand in the European Union member states and 1.9 million across Europe.

One thing is comforting only in part from the analysis of mortality rates in 20 years that have fallen in Western Europe and North America (37% in Finland and 42% in the United Kingdom), but have grown rapidly in some countries of Central and Eastern Europe (57% in Albania and 19% in Ukraine) (1,5).

In Italy, cardiovascular diseases still represent the leading cause of death, although the mid-'70s to today, the death rate is slowly decreasing.

The importance of health and socio-economic on data reported seems obvious and requires more effort because, according to available estimates, at least 50% of the risk factors of cardiovascular diseases can be prevented, attenuated or terminated by changing habits and lifestyle of the subject, with considerable health and socio economic advantages. (6). In fact, the cardio-vascular disease is, after parturition, the second leading cause of hospitalization but with much higher costs: these should be added to the potential years of life lost for death and in case of survival, the abandonment of work, rehabilitation, home care and continuous medical care (7).

Taken together, the health costs are fairly high: in Europe in 2006 the total economic impact of cardiovascular diseases has reached 192 billion euro, equivalent to 391 euros per capita, 57% of which were for direct health care costs and 43% for indirect costs for lost productivity and other costs in health care (1).

Health expenditure per capita average for cardiovascular disease in Europe amounts to 223 euros, but in Germany amounts to 413 euros, in the United Kingdom to 313 euros, 235 euros in Italy, France and Spain 207 euros and 130 euros. The total costs of cardiovascular diseases in Italy have been calculated at around 21.8 billion euros for 2006 (1, 8). As part of the habits and lifestyle, the nutritional aspect of the quantity and quality of food given daily, plays a major role.

The incidence of myocardial infarction, however, is highly variable, with lower rates in Mediterranean countries compared to those in northern Europe, USA, or Australia (9). Paradoxically, the low incidence of myocardial infarction occurs in spite of a high prevalence of classical cardiovascular risk factors (10).

Olive oil is the primary source of fat in the Mediterranean diet. The beneficial effects of olive oil on CHD have now been recognized, and are often attributed to the high levels of monounsaturated fatty acids (MUFA) (11). Indeed, in November 2004, the US Federal Drug Administration (FDA) allowed a claim on olive oil labels concerning "the benefits on the risk of coronary heart disease of eating about two tablespoons (23 g) of olive oil daily, due to the MUFA in olive oil" (12).

A CRUCIAL ELEMENT FOR A HEALTHY HEART: OLEIC ACID AND PLATELETS

Oleic acid, and especially that obtained from pressing olives, is a crucial element in prevention of ischemic cardiovascular disease, as has been demonstrated by a series of international scientific activity. Fatty acids other than n-3 Polyunsaturated Fatty Acids (PUFAs) can interact with metabolism of eicosanoids and potentially influence platelet function. For example, there is evidence that diets rich in unsaturated fatty acids, such as linoleic acid and oleic acid, can also decrease thromboembolic risk by replacing arachidonic acid in platelet phospholipids, decreasing, at least in vitro, the production of thromboxane A_2 [TXA2] and platelet aggregation. However, there is little conclusive evidence that platelet function in vivo is affected by diet (13).

Oleic acid has been found to be a potent inhibitor of platelet aggregating factor (PAF) induced platelet aggregation and serotonin secretion. Consequently, in order to understand the molecular mechanisms of oleic acid action, the effects of this fatty acid on several biochemical events associated with platelet aggregation induced by PAF have been investigated. In particular, it has been found that oleic acid causes a decrease in the levels of phosphatidylinositide (PIP) and PIP2, which is associated with an inhibition of platelet aggregation induced by PAF. These results suggest that inhibition of the PAF response by oleic acid may be at least one of the steps involved in signal transduction (14).

Several reports in the literature have further suggested that olive oil may inhibit platelet function. This possible effect is of interest for two reasons. First, it may contribute to the apparent anti-atherogenic effects of olive oil, and second, it may invalidate the use of olive oil as an inert placebo in studies of platelet function. After exposure to olive oil, platelet aggregation and TXA2 release decreased, and the content of platelet membrane oleic acid increased significantly; platelet membrane arachidonic acid content was found to significantly decrease. This suggests that excess of oleic acid impairs the incorporation of arachidonic acid into platelet phospholipids.

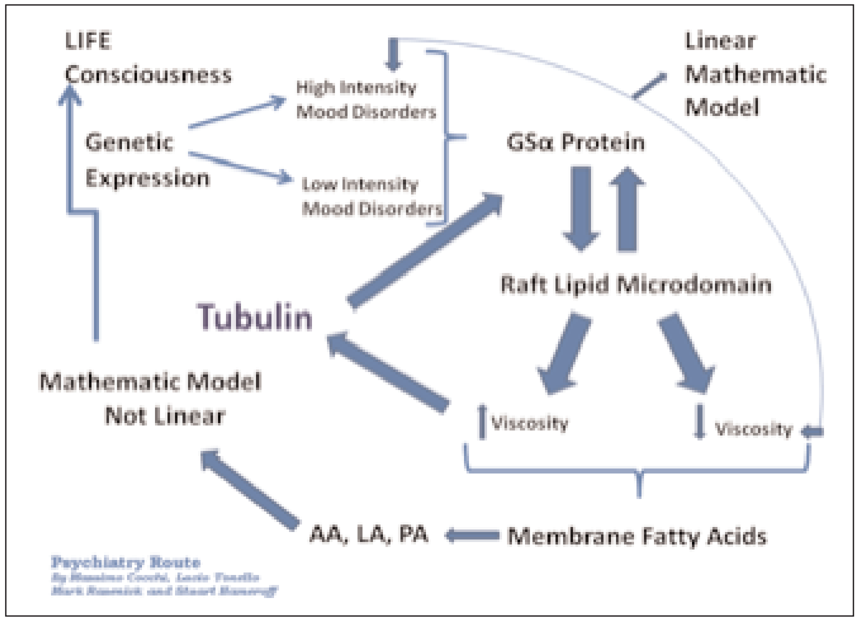
Olive oil also has an inhibitory effect on various aspects of platelet function, which might be associated with decreased risk for heart disease, although fish intake also plays a protective role (15).

The beneficial effects of olive oil can be attributed to its high content of oleic acid (70-80%). The consumption of olive oil increases the levels of oleic acid in cell membranes, which helps to regulate the structure of membrane lipids through control of signal-mediated G-protein, causing a reduction in blood pressure (16).

In rats, cardiovascular tissues treated with 2-OHOA (hydroxy oleic acid) show activation of cAMP in response to activation of Gsα protein, which can be attributed to increased expression of Gsα proteins. As a result, there is significant reduction in systolic blood pressure (17). The involvement of Gs alpha protein is also of interest considering the hypothesis forwarded by Cocchi, Tonello, Rasenick and Hameroff in psychiatric disorders as depression, suicide etc. (private meeting, 2008). In light of the below model, the role of Gsα protein in ischemic heart disease merits further investigation.

In figure 1, the molecular depression hypothesis described by Cocchi et al. (18, 19, 20), Donati et al. (21) and Hameroff and Penrose (22) is shown. The hypotesis is based on the connexion between Gsα protein and tubulin (23).

Figure 1. Description of selected biochemical and biomolecular events potentially involved in psychiatric disorders.

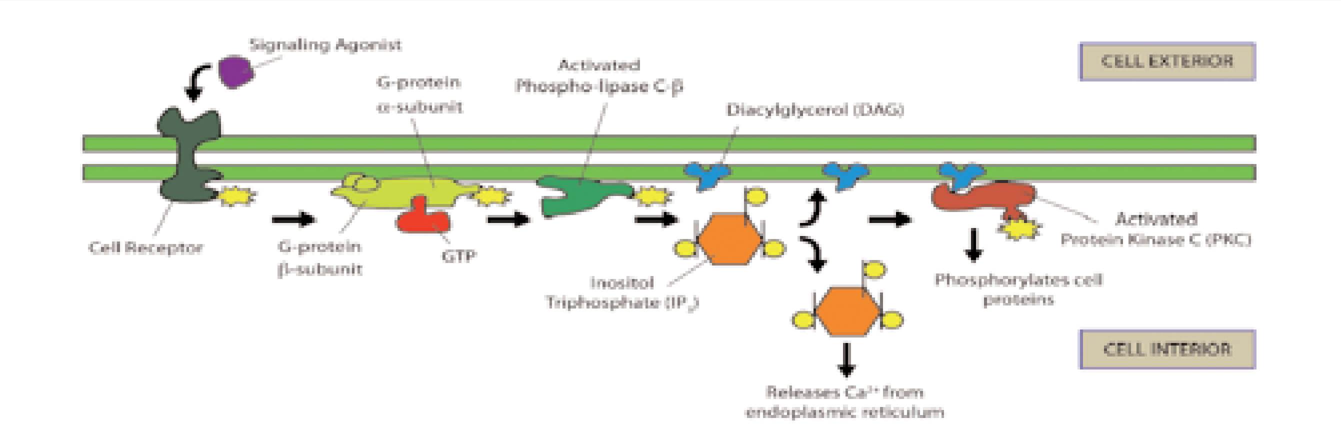


Depending on local membrane lipid composition, tubulin may serve as a positive or negative regulator of phosphatidylinositol bisphosphate hydrolysis (PIP2) similar to G proteins. Tubulin is known to form high-affinity complexes with certain G proteins. The formation of these complexes allows tubulin to activate Gα protein, which, in turn, can activate the Protein Kinase C (PKC), and creates a system whereby elements of the cytoskeleton can influence G-protein signaling. Rapid changes in membrane lipid composition or the cytoskeleton can modify neuronal signaling through such a mechanism. Because of the possible similarity of the platelet to neurons (24-34), membrane viscosity can modify Gsα protein status and tubulin.

Protein kinase C (PKC) activation (Figure 2) is preceded by a number of steps, originating from the binding of an extracellular ligand that activates a G-protein on the cytosolic side of the plasma membrane. This G-protein, using guanosine triphosphate (GTP) as an energy source, then activates protein kinase C (PKC) via the phosphatidylinositol bisphosphate (PIP2) intermediate, which is shown as the diacylglycerol DAG/IP3 complex.

The exclusive use of olive oil during food preparation seems to offer significant protection against ischemic heart disease, in spite the poor clinical, lifestyle and other characteristics of individuals (36)]. In addition, several historical papers have reported on the positive effects of olive oil on CHD.

Figure 2. Description of PKC activation. Adapted and modified from Alberts et al. (35).



In 1985, Mattson and Grundy (37) reported that olive oil increases HDL cholesterol, which plays a protective, anti-atherogenic function, favoring the elimination of LDL-cholesterol. In 1986, Sirtori et al. (38) have shown that in addition to its effects on cholesterol and atherosclerosis, olive oil has preventive action on thrombosis and platelet aggregation. High intake of olive oil is not harmful, and reduces the levels of LDL-cholesterol, but not HDL (39-47).

DEPRESSION AND ISCHEMIC HEART DISEASE: A COMMON ROLE FOR OLEIC ACID?

Because of the particular role of platelets in control of depressive and thrombogenetic risk, our group has investigated the platelet fatty acid profile in three groups of subjects: healthy (n=60), ischemic (n= 50) and depressive (n= 84). The aim of the study was to understand which fatty acid could be utilized as markers of ischemic cardiovascular pathology and depressive disorder, and to classify subjects using an artificial neural network (ANN). All the ANNs tested gave essentially the same result. However, one type of ANN, known as a self-organizing map (SOM), (48, 49, 50), gave additional information by allowing the results to be described in a two-dimensional plane with potentially informative border areas. The central property of the SOM is that it forms a nonlinear projection of a high-dimensional data manifold on a regular, low-dimensional (usually 2D) grid.

A series of repeated and independent SOM simulations, with the input parameters being changed each time, led to the finding that the best discriminate map was that obtained by inclusion of the following three fatty acids: palmitic acid (C16:0), linoleic acid (C18:2 *n*-6) and arachidonic acid (C20:4 *n*-6) for depressive subjects and oleic acid (C18:1), linoleic acid and arachidonic acid for ischemic subjects (18, 19, 20, 51, 52, 53, 54, 55) (Figures 3, 4).

COMMONALITIES BETWEEN CHD AND DEPRESSION

To demonstrate the powerful grouping capacity of the SOM, a new network has been created where all three groups were inserted and grouped simultaneously on the basis of the characteristics of the triplets previously highlighted, which were all different from one another (55) (Figure 5).

As shown by the SOM, it is possible that reduced amounts of oleic acid not only are critical in the biochemical classification of ischemic heart disease, but

Figure 3. SOM classification of depressive subjects (red) against normal subjects (green). Platelet arachidonic acid ($C_{20:4}$), palmitic acid ($C_{16:0}$), and linoleic acid ($C_{18:2}$) can discriminate depression and have diagnostic power.

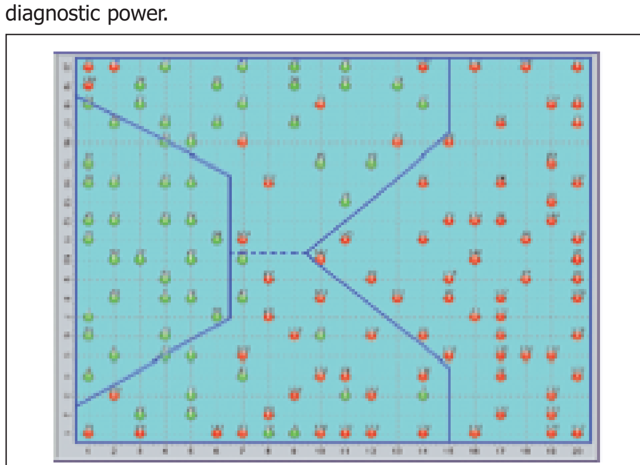


Figure 4. SOM classification of ischemic subjects (red) against normal subjects (green). Platelet oleic acid ($C_{18:1}$), arachidonic acid ($C_{20:4}$), linoleic acid ($C_{18:2}$) can discriminate ischemia and have diagnostic power.

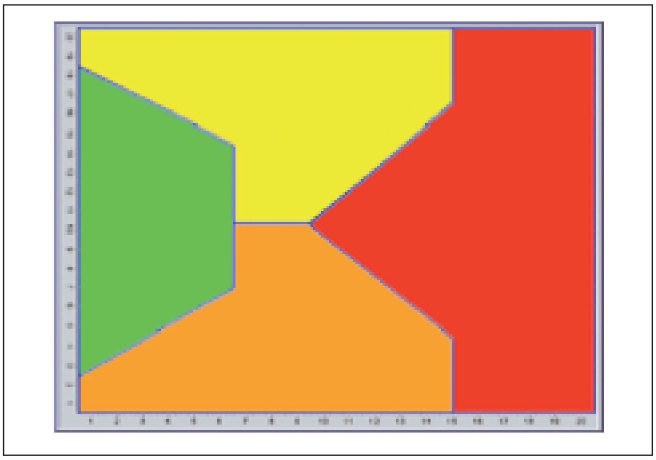
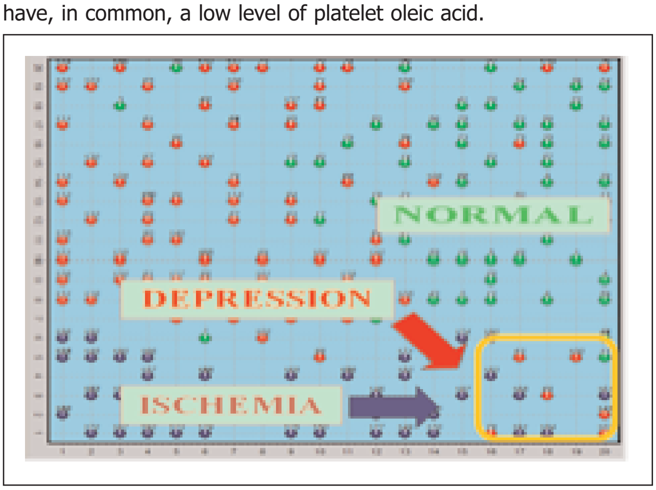


Figure 5. Simultaneous classification, using the SOM, of three groups of subjects (normal, depressive and ischemic). In the right corner of the map, ischemic and depressive subjects are mixed and have, in common, a low level of platelet oleic acid.



are also common to a condition that characterizes a relationship between depression and ischemia (55). It seems possible that level of C18:1 in platelets dominates in ischemia, and is linked to depression (55, 56).

The relationships between depression and ischemic heart disease have been widely studied (57, 58). Interestingly, Weyers and Colquhoun (59) reported improvements in depressive symptoms in patients with CHD after consumption of olive oil.

DO WE EAT ENOUGH EXTRA VIRGIN OLIVE OIL?

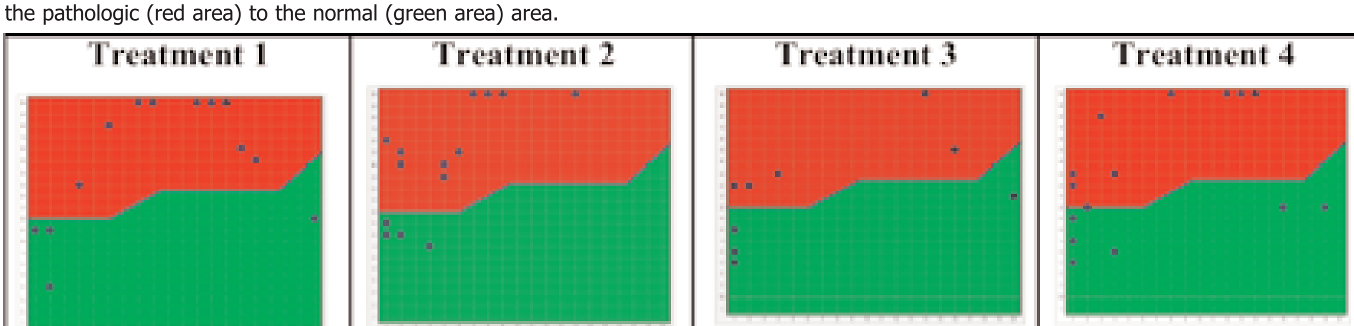
The question then arises as to whether there is sufficient consumption of olive oil and oleic acid in the Italian population. Knowing that oleic acid can significantly change the composition of platelet fatty acids, which are crucial in the genesis of plaque formation, and can significantly alter the amount of oleic acid in platelet membranes, an experiment on a large group of pigs (80 Duroc x Large White) was performed (60). Four groups of pigs were studied, 20 animals each, which received four diets containing different lipid fractions, as follows:

Diet 1: corn oil (low linoleic acid.), diet 2: corn oil (medium linoleic acid.), diet 3: sunflower oil (high oleic acid.), diet 4: sunflower oil (high oleic acid) + palm oil (high palmitic acid). Significant changes in platelet fatty acid composition were seen in the different groups.

The modifications in fatty acid platelet composition were plotted as for ischemic and normal human subjects in the SOM for ischemia (Figure 6).

It is feasible to obtain similar results in humans. If one considers the characteristics described for the pig

Figure 6. By increasing the oleic acid content in diets is possible to move pig platelets, in agreement with the fatty acid triplet (51, 52], from the pathologic (red area) to the normal (green area) area.



Summary	N	%
Normal Area	5	25
Ischemic Area	15	75
Border line	0	0
Total	20	100

Summary	N	%
Normal Area	5	25
Ischemic Area	15	75
Border line	0	0
Total	20	100

Summary	N	%
Normal Area	8	40
Ischemic Area	12	60
Border line	0	0
Total	20	100

Summary	N	%
Normal Area	8	30
Ischemic Area	12	65
Border line	0	5
Total	20	100

model of atherosclerosis (61), and applying similar characteristics to humans, it can be assumed that we should consume a quantity of oleic acid, and consequently, extra virgin olive oil, that is at least twice that of current levels. To demonstrate this, we made simple considerations based on data on the consumption of olive oil in Italy (Table 1).

Based on data provided and taking into account that the value derived from the table should be increased by 40%, since about 40% of purchase data were excluded, the consumption of extra virgin olive oil for each Italian is on average, about 11.76 grams of oleic acid daily, considering an that olive oil is on average value about 70% oleic acid. This value is even likely to be less, as much oil is also used for frying, and therefore cannot be included as part of raw consumption. While this quantity is very small, there are also regional differences between the north and south of Italy.

This observation is also related to the observation that current eating behavior does not allow large consumption of olive oil. It should be remembered that meals eaten out of the household, often consisting of a sandwich, make it difficult to consume extra virgin olive oil in larger quantities. While the eating habits of rural areas may still be able to compensate for the problem, there is an increasing trend to gradually move away from such traditions.

Given this, as Ancel Keys pointed out, one wonders if the Mediterranean diet is still a model of health, considering the consumption of extra virgin olive oil.

CHEMICAL AND TECHNOLOGICAL CONSIDERATIONS ABOUT OLEIC ACID

Fatty acids have different functions in living organisms, including structural, which are determined by the length of their hydrocarbon chain and the presence or absence of double bonds. Hydrocarbon chain length, in the same conditions of unsaturation, is directly proportional to the melting point (as well as the boiling point) (Table 2).

The solubility in water (Table 3) and unsaturation, for the same chain length, is inversely proportional to the melting point (see Table 2), with very few exceptions.

These chemical differences are determined in large part by chemical and physical interactions that exist when molecules are close enough to unsaturate them. In the case of fatty acids, the possibility to join molecules depends only on the hydrocarbon chain (Van der Waals forces), which is facilitated when it is saturated and more difficult when unsaturated (especially at the point of unsaturation). The longer and more linear the chain, the greater the interaction, and the more unsaturated it will be, and consequently, the interaction will be lower. When fatty acids are part of a triglyceride or phospholipid, the effect occurs in a similar manner and therefore, in biological membranes, a greater or lesser chance of interaction corresponds to greater or lesser "fluidity" of the membrane, which is proportional to more or less functionality (permeability).

At room temperature, in terms of membrane structure, fatty acids are important, and the ones that are

Table 1. Purchase of olive oil in Italy, by region, provided by the Istituto di Servizi per il Mercato Agricolo Alimentare (ISMEA).

	1000s liters	
	2008	**2007**
Total domestic purchases of olive oil in Italy	302,554	296,150
Piemonte, Val d'Aosta, Liguria	31,009	30,763
Lombardia	40,344	42,232
Triveneto	31,855	31,275
Emilia Romagna	19,890	18,712
Toscana, Sardegna, Umbria, Marche	41,647	39,965
Lazio	26,482	23,442
Campania, Abruzzo, Molise, Puglia	64,022	66,608
Sicilia, Calabria, Basilicata	47,301	43,156
Source: Ismea-Nielsen		

Table 2. Selected chemical and physical characteristics of fatty acids.
(see: http://216.239.59.104/search?q=cache:qTHq_xfePkIJ:www.cyberlipid.org/fa/acid0001.htm+Aitzetm%C3%BCller+K&hl=it)

Systematic name	Trivial name	Shorthand designation	Molecular weight	Melting point (°C)
butanoic	butyric	4:0	88.1	-7.9
pentanoic	valeric	5:0		
hexanoic	caproic	6:0	116.1	-3.4
octanoic	caprylic	8:0	144.2	16.7
nonanoic	pelargonic	9:0	158.2	12.5
decanoic	capric	10:0	172.3	31.6
dodecanoic	lauric	12:0	200.3	44.2
tetradecanoic	myristic	14:0	228.4	53.9
hexadecanoic	palmitic	16:0	256.4	63.1
heptadecanoic	margaric (daturic)	17:0	270.4	61.3
octadecanoic	stearic	18:0	284.4	69.6
eicosanoic	arachidic	20:0	312.5	75.3
docosanoic	behenic	22:0	340.5	79.9
tetracosanoic	lignoceric	24:0	368.6	84.2
cis-9-hexadecenoic	palmitoleic	16:1(n-7)	254.4	0.5
cis-9-octadecenoic	oleic	18:1(n-9)	282.4	16.2
trans-9-octadecenoic	elaidic	tr18:1(n-9)	282.4	43.7
cis-11-octadecenoic	cis-vaccenic (asclepic)	18:1(n-7)	282.4	39
cis-9-eicosenoic	gadoleic	20:1(n-11)	310.5	25
cis-13-docosenoic	erucic	22:1(n-9)	338.6	33.4
9,12-octadecadienoic	linoleic	18:2(n-6)	280.4	-5
6,9,12-octadecatrienoic	γ-linolenic	18:3(n-6)	278.4	
9,12,15-octadecatrienoic	α-linolenic	18:3(n-3)	278.4	-11
8,11,14-eicosatrienoic	dihomo-γ-linolenic	20:3(n-6)	306.5	
5,8,11,14-eicosatetraenoic	arachidonic	20:4(n-6)	304.5	-50
6,9,12,15-octadecatetraenoic	stearidonic	18:4(n-3)	276.4	-57
5,8,11,14,17-eicosapentaenoic	EPA	20:5(n-3)	302.5	-54
7,10,13,16,19-docosapentaenoic	DPA	22:5(n-3)	330.6	
4,7,10,13,16,19-docosahexaenoic	DHA	22:6(n-3)	328.6	-44

more widespread in nature are those with 18 total carbon atoms, especially unsaturated. Modulation of proper membrane fluidity requires that some fatty acids are relatively "rigid", such as palmitic and stearic acid, with a preference for the former since it has a lower melting point and thus is more effective in bringing about small changes.

One of the most important aspects of biological systems that protect themselves through membranes is the preservation of integrity of the membrane itself, which is

Table 3. Fatty acid solubility in water at 20°C (in grams per liter).

Carbon number	Solubility
2	Infinite
4	Infinite
6	9.7
8	0.7
10	0.15
12	0.055
14	0.02
16	0.007
18	0.003

subject to contact with chemical reactive oxygen species (ROS), and capable of chemically attacking the unsaturated zone of the molecule. Greater effectiveness is related to a greater level of unsaturation, leading to subsequent breakage of the molecule with increased membrane fragility. For these reasons, the membrane is associated with a series of antioxidants, whose action is linked to their position in the membrane (62).

Oleic acid is the least oxidizable among unsaturated fatty acids (Table 4), and is also not too fluid or too rigid, and is thus suitable for prolonging membrane stability [63, 64].

The rate of oxidation between various unsaturated fatty acids shown in Table 4 appears increased between oleic acid (monoenes) and linoleic acid (dienes), but upon increasing the unsaturation (trienes), the variation is much less pronounced. In biological systems, the position of the fatty acid in glycerides or phospholipids (65) appears to influence the rate of oxidation, and is slower when inserted in position 2 (or in the b position) of the molecule. In the case of olive oil, as in all vegetable fats (Table 5), the 2 position is occupied by unsaturated fatty acids, and is more available in that position because it can directly cross the intestinal wall of the 2-monoglycerides, resulting from digestion of glycerides by pancreatic lipase. In particular, on a molar basis, 83% of unsaturated fatty acids, in position 2 of triglycerides in olive oil, are occupied by oleic acid.

For extra virgin olive oil, its total unsaturation makes it particularly stable [Table 6, (66, 67)] so that appropriate conservation, which is further prolonged by the presence of numerous and effective natural antioxidants (biophenol) in virgin olive oils, is still present after refining, in contrast to other oils.

Not all olive oils have the same concentration of oleic acid. The International Olive Oil Council (IOOC) has dictated that the content of oleic acid in olive oils can vary from 55% to 83% of total fatty acids (68). The regulations of the European Community do not indicate the amount of oleic acid in olive oil, but simply indicate the specifications of several other parameters that are useful for detecting fraud and require the distinction between various commercial products obtained from olive processing.

Among these, extra virgin oils are those that must have the highest quality. Extra virgin olive oils with the highest content of oleic acid have always been regarded as those with the highest quality, but only because of their higher stability during storage, as a conse-

Table 4. Oxidation rate of several unsaturated fatty acids, modified from Gunstone et al. (64).

FATTY ACIDS	AUTOXIDATION 1)	AUTOXIDATION 2)	PHOTOSENSITIZED OXIDATION (PHOTOXIDATION)
SATURATED	**1**	**1**	
MONOENES	**10**	**100**	**1,1 (32.000)***
DIENES	**100**	**1200**	**2,9 (1600)***
TRIENES	**200**	**2500**	**3,5**
TETRAENES**	300		
PENTAENES**	400		
HESAENES**	500		

* In brackets the ratio between photoxidation and autoxidation
** Hypothesis based on physical-chemical behaviour

Table 5. Main fatty acid (mol %) distribution in the three positions of glycerine molecule of the corresponding triacylglycerols (triglycerides) of several fats and oils.
Mol % = molar percentage

Fat or Oil source	Fatty acid position	14:00	16:00	18:00	18:01	18:02	18:03	20:00	22:00
Cow milk	1	11	36	15	21	1			
	2	20	33	6	14	3			
	3	7	10	4	15	<1			
Pig (behind outside)	1	1	10	30	51	6			
	2	4	72	2	13	3			
	3		-	7	73	8			
Cow (deposit fat)	1	4	41	17	20	4	1		
	2	9	17	9	41	5	1		
	3	1	22	24	37	5	1		
Cocoa butter	1		34	50	12	1			
	2		2	2	87	9			
	3		37	53	9				
Groundnut	1		14	5	59	18		1	-
	2		1	<1	58	39		-	-
	3		11	5	57	10		4	6
Corrn	1		18	3	27	50	1		
	2		2	<1	26	70	<1		
	3		13	3	31	51	1		
Soya	1		14	6	23	48	9		
	2		1	1	21	70	7		
	3		13	6	28	45	8		
Olive	1		13	3	72	10	<1		
	2		1	-	83	14	1		
	3		7	4	74	5	1		

quence of the low reactivity of oleic acid compared with polyunsaturated fats. The Food and Drug Administration (FDA) has stated that U.S. consumption of 23 g of olive oil each day (about two tablespoons) helps in prevention of cardiovascular diseases (12).

Today, there are other sources of oil high in oleic acid, such as safflower, sunflower and canola (the new name for rapeseed oil low in erucic acid), and therefore based solely on the content of oleic acid, these sources would also be optimal in this regard. However, the reputation of olive oil as a healthy product is most likely due to the presence of the numerous "minor elements" contained within [69, 70]. Among these minor components, several compounds are worthy of mention including biophenols, which consists of phenols and polyphenols with high antioxidant and antiradical activity, some triterpene alcohols, phytosterols, squalene, and tocopherols. These latter are considered important because of the content of vitamin E, and for their ability to facilitate the assimilation of polyunsaturated fatty acids: 1 mg allows the assimilation of 1 g of polyunsaturated fatty acids (71).

The discovery of health effects from the minor components in olive oil has led to a large gap in the nutritional properties of edible oils. In fact, oils from seeds, subject to refining, loose many minor components and do not have the health properties that the corresponding matrix has. The technology for olive processing influences the quality and organoleptic characteristics of the final product, which is not always considered by industrial operators as much of the scientific knowledge is particularly new. The olive oil is encapsulated in small drops (10-30 micrometers) within vacuoles with a polysaccharide wall: oil droplets, during processing, are released in crushing and come into contact with the other components of olives during grinding of the paste. It is the prolonged contact with the oil-pasta that allows joining of small droplets such that they can then leave

Table 6. Main fatty acid composition of fats and oils.

Fattyacids	Caprylic (C8:0)	Capric (C10:0)	Lauric (C12:0)	Mirystic (C14:0)	Palmitic (C16:0)	Stearic (C18:0)	Oleic (C18:1)	Linoleic (C18:2)	Linolenic (C18:3)	Eicosenoic (C20:1)	Total Unsaturation[a] (unstability factor)	Iodine number
Oil from:												
Groundnut				ND-0.1	8.0-14.0	1.0-4.5	35.0-69.0	12.0-43.0	0-0.3	0.7-1.7	200-481	86-107
Rapeseed (0 erucic)				ND-0.2	2.5-7.0	0.8-3.0	51.0-70.0	15.0-30.0	5.0-14.0	0.1-4.3	320-630	105-126
Safflower				ND-0.2	5.3-8.0	1.9-2.9	8.4-21.3	67.8-83.2	ND-0.1	0.1-0.3	700-740	136-148
Safflower (HO)				ND-0.2	3.6-6.0	1.5-2.4	70.0-83.7	9.0-19.9	ND-0.2	0.1-0.5	175-270	80-100
Sunflower			ND-0.1	ND-0.2	5.0-7.6	2.7-6.5	14.0-39.4	48.3-74.0	0-0.3	0-0.3	531-766	118-141
Sunflower (HO)				ND-0.1	2.6-5.0	2.9-6.2	70.0-90.7	2.1-20.0	ND-3.0	0.1-0.5	118-270	78-90
Corn			ND-0.3	ND-0.3	8.6-14.0	ND-3.3	20.0-42.0	34.0-65.6	0-1.2	0.2-0.6	400-481	103-135
Olive (CODEX)					7.5-20.0		55.0-83.0	3.5-21.0	Max 1.0	Max 0.4	163-285	75-94
Soya Bean			ND-0.1	ND-0.2	8.0-13.5	2.5-5.4	17.0-30.0	48.0-59.0	4.5-11.0	0-0.5	600-840	124-139
Grape seed				ND-0.3	5.5-11.0	3.0-6.5	12.0-28.0	58.0-78.0	0-1.0	0-0.3	596-802	128-150
Fat from:												
Cocoa butter					22.6-30.4	30.2-36.0	29.2-36.4	1.3-4.0	ND-0.5		370-380	34-40
Coconut	4.6-10	5.0-8.0	45.1-53.2	16.8-21.0	7.5-10.2	2.0-4.0	5.0-10.0	1.0-2.5	ND-0.2	ND-0.2	24-34	6.3-10.6
Palm			ND-0.5	0.5-2.0	39.3-47.5	3.5-6.0	36.3-44.0	9.0-12.0	ND-0.5	ND-0.4	130-391	50.0-55.0
Palm olein			0.1-0.5	0.5-1.5	38.0-43.5	3.5-5.0	39.8-46.0	10.0-13.5	ND-0.6	ND-04	158-187	56
Palm stearin			0.1-0.5	1.0-2.0	48.0-74.0	3.9-6.0	15.5-36.0	3.0-10.0	ND-0.5	ND-0.4	76-270	33
Palm kernel	2.4-6.2	2.6-5.0	45.0-55.0	14.0-18.0	6.5-10.0	1.0-3.0	12.0-19.0	1.0-3.5	ND-0.2	ND-0.2	33-51	14.1-21.0

[a] Total unsaturation is calculated as the relative percentage of single fatty acid for a different factor, for each unsaturation, the degree is proportional to the oxidative instability. The factors utilized were: 1 for monounsaturated, 10 for diunsaturated and 20 for triunsaturated fatty acids. HO =high oleic. ND = not detectable

the dough during the separation process that amalgamates or emulsifies all the minor components in oil.

Therefore, both the time and temperature of processing can also affect the final product, and even if the starting characteristics of the olives are similar they can yield very different products. Moreover, during the same oil-paste stage, enzyme activities are capable of forming the fragrance of the oil through a series of biochemical steps that, in part, may reduce the antioxidant ability of biophenol components and their effects on health. Therefore, choices made during the processing of olives should take these effects into consideration.

There are several hundred olive cultivars grown in Italy, which can produce many oils that have a very different composition, although all can be considered of excellent quality. In particular, the richness in antioxidants (especially biophenols) can affect characteristics of the oil in terms of smell, taste, storage stability, and health properties. Even if much scientific knowledge has been learned about olive production and processing technology, there are still many questions that must be answered in order to improve the quality, especially those related to health, of the oils obtained by processing olives.

CONCLUSION

Olive oil, and, particularly an extra virgin olive oil-rich diet, decreases prothrombotic activity, and modify platelet adhesion, coagulation, and fibrinolysis. The wide range of antiatherogenic effects associated with olive oil consumption can help to justify the low rate of cardiovascular mortality found in southern European Mediterranean countries, in comparison with other western countries, despite a high prevalence of CHD risk factors. Experimental evidence confirms a critical role of reduced levels of oleic acid in platelets in ischemic subjects with a diagnostic discriminant capacity from normal subjects. At present, although traditional cardiovascular risk factors are under revision, a new field of research in platelets, and in particular oleic acid and its relationship with linoleic and arachidonic acid, should be pursued. The mechanisms by which olive oil exerts its beneficial effects merit further investigation, and additional studies are required to document the benefits of olive oil consumption on primary endpoints for cardiovascular disease. In this regard, consumption of extra virgin olive oil and daily intake of oleic acid should however be promoted.

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