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RESEARCH ARTICLE

Palm oil and human health. Meeting report of NFI: Nutrition Foundation of Italy symposium

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ABSTRACT

The use of palm oil by the food industry is increasingly criticized, especially in Italy, for its purported negative effects on human health and environment. This paper summarizes the conclusions of a Symposium on this topic, gathered by the Nutrition Foundation of Italy, among experts representing a number of Italian Medical and Nutritional Scientific Societies. Toxicological and environmental issues were not considered.

Participants agreed that: no evidence does exist on the specific health effects of palm oil consumption as compared to other saturated fatty acids-rich fats; the stereospecific distribution of saturated fatty acids in the triacylglycerol molecule of palm oil limits their absorption rate and metabolic effects; in agreement with International guidelines, saturated fatty acids intake should be kept <10% of total energy, within a balanced diet; within these limits, no effect of palm oil consumption on human health (and specifically on CVD or cancer risk) can be foreseen.

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Introduction

Due to its physical and chemical properties, easy availability, and neutral taste, palm oil is increasingly employed by the food industry. However, a heavy debate is ongoing on the purported effects on human health of palm oil as a component of some industrially produced food, especially in some European countries, such as Italy.

This paper summarizes the presentations and the discussion held during the Symposium that NFI – Nutrition Foundation of Italy organized, on 3 May 2016, by gathering a selected group of Italian experts, most of whom representing Italian Medical and Nutritional Scientific Societies. The symposium was aimed at addressing the nutritional and health effects of palm oil and its industrial alternatives in a comprehensive way, based on the latest published scientific evidence. Toxicological and environmental issues were not considered.

The meeting was convened also to compensate for the substantial absence of the scientific community in the public debate on the use of palm oil in food: such

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absence has in fact the obvious consequence that current information on this topic in the media is very often not based on high-quality scientific evidence. In such context, the aim of the meeting has been the definition of a sound scientific document, shared and signed by experts and scientific societies, to contribute to a more objective evaluation of the topic.

Specific aspects of information to the public on nutrition topics and related critical issues have been the subject of the round table that took place at the end of the symposium.

Biochemistry and human metabolism of palm oil

Palm oil is produced from palm nuts, i.e. 3–5 cm fruits that are gathered in clusters (up to about 500 units per bunch), each containing a seed (kernel), also rich in fats, which does not usually break during the processing of fruits and can hence be separated from the fruit pulp. Palm oil exists as solid in room temperature, due to its high proportion of saturated fatty acids. Its relatively high melting point allows for its utilization, even in warm climates, in many industrial food applications. The crude palm oil contains high concentrations of antioxidant substances; however, these molecules are largely lost during refinement (Edem 2002).

The first historical record of the human use of oil palm dates back to 5000 years ago, in Egypt, where it was used for mummification procedures. Subsequently, its use has spread in West and Central Africa. Finally, palm oil was imported in Europe, to be used in artisanal and industrial manufacturing. Only in the nineteenth century, its use for food purposes has become relevant. Today, palm oil is one of the most used vegetable oil by food industry, and the most used in many countries (Obahiagbon 2012).

In terms of biochemistry and human metabolism, the most outstanding feature of palm oil is its fatty acids composition. Palm oil (produced, as mentioned, from the fruit and not from palm seeds) has a high content of saturated fatty acids and, in particular, of palmitic acid, which represents about 35–45% of total fatty acids. Small amounts of shorter chain fatty acids (caprylic, capric and lauric acids) are also present, while the monounsaturated oleic acid (39%) and the omega-6 polyunsaturated linoleic acid (10%) are more abundant (Sambanthamurthi et al. 2000). The balance between saturated and monounsaturated plus polyunsaturated fatty acids (about 1:1) is nutritionally favorable.

Palm oil must not be confused with the oil derived from the kernel of the palm fruits (palm kernel oil), which has a completely different fatty acid composition: a significantly higher (over 80%) content of saturated fatty acids, much lower levels of monounsaturated fatty acids and negligible concentrations of polyunsaturated fatty acids.

Table 1. Positional distribution of fatty acids (as percentage of total fatty acids) in the triacylglycerol molecule in palm oil (Modified from Berry & Sanders 2005).

	Position in the triacylglycerol molecule		
Fatty acids	sn-1	sn-2	sn-3
C 16:0	60	13	72
C 18:0	3	trace	8
C 18:1	27	68	14
C 18:2	9	18	3

Palmitic acid and stearic acid in palm oil are mainly esterified to the terminal carbons of the triglyceride glycerol (sn-1 and sn-3), whereas the unsaturated oleic and linoleic fatty acids are esterified mainly to the middle sn-2 position (Table 1) (Bracco 1994, Berry & Sanders 2005).

This particular stereospecific distribution markedly affects the metabolic fate of the different fatty acids during digestion and absorption. The fatty acids esterified in position sn-1 and sn-3 are rapidly hydrolyzed to free fatty acids by pancreatic and intestinal lipases, and released in the intestinal tract. Moreover, due to their high melting point (over 60 °C), and the consequent solidification at body temperature, these fatty acids are, in fact, not efficiently absorbed, and are largely excreted along with the feces as calcium salts (Figure 1). The fatty acids in position sn-2 are, instead, not cleaved from the glycerol, and are efficiently absorbed as monoglycerides (after the hydrolysis of the fatty acids in position 1 and 3), maintaining the same position (sn-2). Sn-1 and sn-3 positions are subsequently re-acylated on the cytoplasmatic surface of the endoplasmatic reticulum in the enterocytes.

These metabolic behavior, clearly occurring in infants, but also present in children and in adults, do influence the absorption of palm oil fatty acids, which is efficient for monounsaturated and polyunsaturated fats (mainly in sn-2 position) and low for the saturated ones (palmitic and stearic), mainly in sn-1 and sn-3 position (Mattson et al. 1979, German & Dillard 2004).

Likewise, the more efficient absorption of the sn-2 fatty acids compared to sn-1 and sn-3, also explains the differential fatty acid absorption of human versus bovine milk. The esterification of palmitic acid also at sn-2 in human milk facilitates its absorption by the

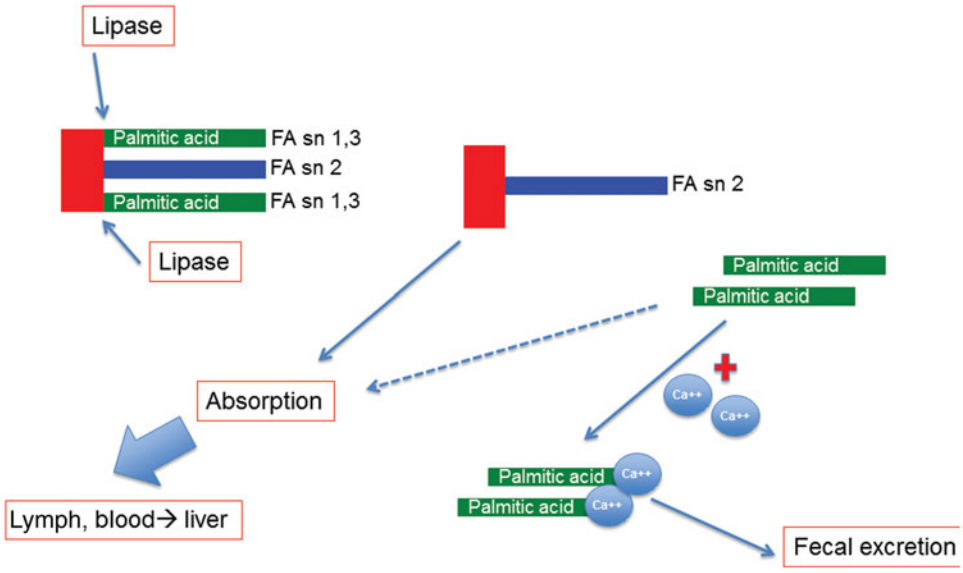

Figure 1. Different metabolic fate of fatty acids in the sn-1,3 versus sn-2 position of triglycerides, in humans.

infant, necessary to support the rapid growth during the first months of life (López-López et al. 2002; Innis 2016). On the contrary, in bovine milk palmitic acid is usually located in the sn-1 and sn-3 positions, as in palm oil, and hence is poorly absorbed (Berry 2009).

Palm oil undergoing interesterification procedures ("swapping", in other words, of the position of the different fatty acids in triglycerides) has a homogeneous and not selective distribution of palmitic acid and other saturated fatty acids in the three binding positions of glycerol. After interesterification, as a consequence, the saturated fatty acids, also present in the sn-2 position, are no longer selectively excreted in the feces and are, therefore, absorbed to a greater extent. This process also affects some functional effects of palm oil; in experimental animal models, for example, greater platelet aggregation is observed after the administration of interesterified palm oil than after the untreated oil. These observations confirm that the position occupied by fatty acids on the glycerol backbone plays primary roles in modulating lipid metabolism and the biological effects of dietary triglycerides (Mu & Porsgaard 2005).

In infant formula, the interesterification of palmitic acid from palm oil increases its presence in the sn-2 position of the triglyceride, and hence its absorption rate, bringing it to levels more similar to those found in human milk (Carnielli et al. 1995).

Crude ("red") palm oil has a high content of alpha and beta carotenoids (Bonnie & Choo 2000). However, they are almost completely lost during refining, which also bleaches the oil. Palm oil is also rich in other antioxidants, which may play protective functions against oxidative stress in biological systems, tocopherols and tocotrienols, which might protect cell membranes and modulate the synthesis of thromboxane, thus influencing platelet aggregation.

Technological features and industrial applications

Given the easy cultivation of the palm plant and its high yield (90% of the total pulp), palm oil is inexpensive, especially when compared to other saturated vegetable fat such as cocoa butter and coconut oil, and hence it is of considerable interest to food companies (Erikson & List 1985).

Because of its features, palm oil can be fractionated into products with higher or lower fluidity characteristics, which can be employed in several areas by the food industry: the less solid fraction is used for creams and fillings, the more solid form as an ingredient of desserts and baked goods.

The contribution of palm oil as an ingredient is important for food technologists, because the rigidity of the triglycerides (due to the relative abundance of saturated fatty acids) directly correlates with the stability and, in turn, with the shelf-life of the product, by slowing rancidity and starch crystallization. Palm oil is, however, poorly suitable for frying. In fact, its production involves an initial boiling, which induces partial (4–10%) hydrolysis of triglycerides with the formation of free fatty acids and diglycerides, increasing the oil emulsifying potency. During frying, the presence of foam reduces, in fact, heat transfer, in turn diminishing the product quality. Furthermore, the use of palm oil repeatedly subjected to heating cycles (in cooking or frying) in restaurants and food manufacturing may create specific problems

(Minihane & Harland 2007). As for all oils relatively rich in unsaturated fatty acids, these procedures lead to the production and release of potentially toxic oxidation products.

On the other hand, the stability of palm oil toward oxidation is generally good, although lower than that of palm kernel or coconut oils, because of the higher abundance of unsaturated fatty acids. Of note, the oxidative stability of saturated (solid) fat is a prerequisite for the industrial preparation of baked goods: it prevents staling and degradation, improves flavor, traps aromas and allows their slow release, consequently improving the organoleptic properties. Finally, it protects flour lipids, which are present in low amounts but are highly unsaturated.

The main alternatives to palm oil for the use in food industry are the following:

1. Saturated animal fats (butter, tallow, lard) which are solid or semi-solid at room temperature in most western countries.
2. Vegetable fat solid at room temperature (cocoa butter, coconut butter, palm kernel oil).
3. Other vegetable oils, liquid at room temperature, from fruits (olive oil), seeds (sunflower oil), legumes (soy and peanut oils), cruciferae (rapeseed oil) or cereals (rice and corn oils).

Each of these alternatives, however, has potential drawbacks, for technological reasons or because they do not match consumers' or food companies needs or preferences. Solid animal fats (mainly butter), which are costly, have been generally and gradually substituted, in the last years, due to their purported negative health effects (above all, the plasma LDL cholesterol increasing effect).

Cocoa butter, which could be the best alternative to palm oil from a technological point of view, is the most expensive fat, widely used in cosmetics. In order to limit costs, its use by the food industry would require blending with other fats. Indeed, for economical reasons, the European chocolate industry (although not the Italian one) has already replaced up to 5% of cocoa butter with other fats.

The use of partially hydrogenated fat, high in *trans* unsaturated fatty acids, has been abandoned because of their untoward health effects (de Souza et al. 2015), while the use of coconut and palm kernel fats is quite limited, due to their high content in fatty acids with 12 and 14 carbons (i.e. lauric and myristic), which show the most marked effect in increasing LDL cholesterol levels in plasma (Sundram et al. 1992).

The replacement of saturated fats with the unsaturated, which is favorable from a nutritional and functional viewpoint, involves a series of disadvantages (especially in the preparation of bakery products). In fact, the high unsaturation degree makes them unstable at high temperature and more susceptible to oxidation, resulting in faster rancidity and off-flavors release, thus limiting the final product shelf life. In addition, organoleptic characteristics of some of these oils (extra virgin olive oil, for example) may interfere with the flavors of the finished foodstuff, or lead to loss of crunchiness, palatability and taste (Mba et al. 2015).

Italian and international guidelines on dietary total and saturated fat intake

Current nutritional recommendations suggest that fat intake should not exceed 30–35% of total calories, with a 10% maximum from saturated fats. These indications originated after the conclusion of the Seven Countries Study, at the end of the 1970s: the first recommendations on fat consumption, which date back to 1936, did not in fact define an upper limit, but, rather, recommended incorporating fat in the diet as energy and, in part, as vitamins A and D supplier (Aranceta & Pérez-Rodrigo 2012).

In 1977, the first US guideline was drafted which pointed out the need to rebalance the American diet, by reducing refined carbohydrate consumption, increasing that of whole grains, and reducing total fat intake from 40 to 30% of energy, with a limit to the consumption of saturated fat of 10% of total calories. These recommendations have not substantially changed until today.

In Italy, in 1979, the National Institute of Nutrition and the Ministry of Health jointly drew the first nutritional guidelines for the Italian population. The upper limit for total fat was set at 30% of energy for children and adolescents and at 25% for subjects aged 20 years or older (*Livelli di Assunzione Raccomandati di Nutrienti ed Energia*, LARN, 1976). This document did not mention saturated fats; an upper limit of intake for such fats (10%, within 25% from total fats) was introduced in the first revision of the Italian LARN (recommended dietary intakes) prepared by the Italian Society of Human Nutrition (SINU) in 1986.

In 1994, the Food and Agriculture Organisation of the United Nations (FAO) stated that fat consumption should not exceed 30% of the total energy intake for the sedentary population, and 35% for physically active individuals. The recommended proportion of saturated was maintained at 10%. The same upper

limit for saturated fats was confirmed by the second revision of the Italian recommended dietary intakes (1996), in which the intake of total fats was set at a level not exceeding 30% of total calories for children and adolescents and 25% for adults.

At the beginning of the new millennium, a Consensus Document by World Health Organization (WHO)/FAO experts was published suggesting a range of total fat intake between 15 and 35% of total energy, according to the level of physical activity (WHO 2003).

In 2012, the new dietary recommendations for Scandinavians, the Nordic Nutrition Recommendation, increased the acceptable upper limit for total fat to 40% of total calories (Nordic Nutrition Recommendations 2012). The same document stated that a fat consumption below 20% of total energy would increase the risk of deficiency of essential fatty acids and liposoluble vitamins. The limit for saturated fat was maintained at 10% of total calories. Indeed, the year before, the French National Agency for Food Health and Environment Security (ANSES 2011), confirmed the 10% limit for saturated fats and recognized that no evidence is available supporting the benefits of total fat intake below 35% of energy and that a fat consumption above 40% of total calories is associated with a higher risk in terms of both excessive calorie intake and cardiovascular diseases.

The fourth, and most recent, revision of the LARN (dietary reference intakes) (SINU 2014) introduces the 20–35% range for caloric intake from total fat, in order to maintain health, within a healthy and balanced diet. At the same time, the document sets a range between 45 and 60% of total energy for carbohydrates. The adequate range for total fat is increased to 35–40% for children up to 3 years; the maximum intake of saturated fat is kept at 10% for all ages.

The very recent (2015–2020) US guidelines for Americans confirm the range for calories from fat between 30 and 40% for children and between 25 and 35%, for 4 years onwards, still keeping saturates below 10% (US Department of Health and Human Services 2015).

The last published Italian nutritional survey (INRAN-SCAI 2005–06) shows that the mean fat intake by the general population slightly exceeds the recommendations, both for total (36%) and saturated (11%) fats (Sette et al. 2011). In Italy, the major dietary sources of saturated fatty acids are milk and its derivatives, being cheese the main contributor, followed by olive oil, fresh and processed meat and by cookies and sweets (Sette et al. 2013).

Such consumption levels could be improved by including in the diet other sources of protein, such as legumes and milk or yogurt, in partial substitution of red and processed meat portions and cheese. This would in fact reduce the intake of total and saturated fats, as well as of salt, in turn reducing cardiovascular risks.

Palm oil: food content and consumption data. The Italian scenario

Data on total fat and saturated fat consumption in Italy are highly variable, and dependent on the method used for the collection of information (questionnaire, food diary), the kind of survey (telephone interview, self-filling, medical examination, etc.), the seasonality, the sample selection (randomized or not) and the characteristics of the subjects involved in the research (age, gender, geographic area).

The latest published information on this topic comes from the Italian cohort of the European Prospective Investigation on Cancer and Nutrition (EPIC) study, a European survey that examined the eating habits of more than 500,000 men and women in 10 countries. The EPIC cohort was not representative of the general population, and included selected *ad hoc* subjects in primary prevention or subjects belonging to well defined groups such as blood donors. In the Italian EPIC cohort, the recommended total fat supply is exceeded by women, especially in the Southern regions (Freisling et al. 2010). The same is true for saturated fats. These levels are, however, lower than those recorded in other countries of North and Center Europe.

Data from the INRAN-SCAI 2005–2006 survey, performed on a randomized representative sample of the Italian population, dating back to 10 years ago, are still the only available source of information about dietary habits in Italy (Leclercq et al. 2009). The subanalysis by age groups showed intakes of total and saturated fats exceeding the recommendations in children aged between 3 and 18 years. However, the data are highly dispersed in this age range, which is also characterized by great changes in terms of requirements and consumptions (Sette et al. 2011).

According to the results of the INRAN-SCAI 2005–2006 study, the behavior of Italian in terms of fat intake improves from 18 years of age onward. In fact, values assessed in the adult population (both males and females aged between 18 and 64 years) are very similar to those indicated as dietary reference intakes in Italy (LARN 2014). In particular, the average consumption levels of total fat are within the reference values, while those of saturated fats are close to the upper recommended limits.

Table 2. Estimated daily dietary intake of saturated fats from palm oil in Italy.

	Mean food consumption[a] g/day	Saturated fat content[b] g/100 g	Saturated fat supply g/day	Palm oil/saturated fats[c] %	Saturated fat supply from palm oil g/day
(A) Children 3–10 years					
Crackers	6.00	6.30	0.38	70	0.26
Biscuits	18.00	9.25	1.67	70	1.17
Cakes/snacks	28.00	10.6	2.97	90	2.67
Ice Cream	14.00	8.40	1.18	25	0.29
Chocolate	7.00	22.00	1.54	25	0.39
				Total	4.78
(B) Adults 18–64 years					
Crackers	7.00	6.30	0.44	70	0.31
Biscuits	13.00	9.25	1.20	70	0.84
Cakes/snacks	17.00	10.60	1.80	90	1.62
Ice Cream	10.00	8.40	0.84	25	0.21
Chocolate	2.00	22.00	0.44	25	0.11
				Total	3.09

[a]Leclercq et al. 2009.
[b]Gnagnarella et al. 2000.
[c]AIDEPI 201.

The already mentioned INRAN-SCAI data on the contribution of the different food groups to saturated fat intakes in the Italian population are in line with those available within the FAO database (FAOSTAT). In particular, as concerns the main vegetable oils (the second source of saturated fats) in Italy, the mean daily per capita intakes are the following: 30 g of olive oil, 22 g of soybean oil, 10 g of sunflower oil and 3.5 g of palm oil per day.

A document on the intake of saturated fats from palm oil with foods in Italy has been recently released by the Italian Institute of Health (Istituto Superiore di Sanità: ISS), based on consumption levels of food products possibly containing palm oil, evaluated on the basis of the INRAN-SCAI study database (Italian Ministry of Health 2016) and data of the Italian food composition table (Gnagnarella et al. 2000). According to this document, bakery products (namely biscuits, savory fine bakery products, cakes and sweet snacks) represent significant sources of saturated fats from palm oil, especially for the younger, supplying 9.5% of total saturated fats to children up to 10 years and 9.3% to adolescents (Sette et al. 2013).

It should be considered, however, that the ISS report is based on an extremely conservative assessment, assuming that palm oil is the exclusive fat used in bakery production. According to this assumption, using the data obtained by INRAN-SCAI, the per-capita intake of saturated fats from palm oil is, on average, 4.8 g/day for adults and 7.7 g/day for children.

These estimates require some additional attention. First, not all fats contained in sweets and bakery products come from palm oil. Based on the labels of the currently available products, it could be approximately estimated that palm oil fats represent about 90% of total fat in snacks, 70% in biscuits, and significantly less (conservatively, we assumed 25%) in chocolate and ice creams, where cocoa butter and coconut oil prevail (Table 2). In this context, starting from data published within the INRAN-SCAI 2005–06 survey, we can calculate that the contribution of palm oil to saturated fats is more likely to be, in adults, about 3.09 g/day (Table 2(B)). Moreover, the observation of the negative market trend of bakery foods in Italy since 2006 (the year of the INRAN-SCAI survey), and in particular a 5% decrease of biscuit sales in these last 10 years, although not considered in our calculation, could lead to a further reduction of the amount of saturated fats provided from this food group.

The ISS document points out that the 3–10 years age group, consuming higher amounts of bakery products than other age groups, is potentially more exposed to palm oil. The daily consumption of saturated palm fat in children is about 4.78 g (Table 2(A)), if the previously described criteria are used. In children aged between 3 and 10 years, consumptions are highly variable, however, and these data should be evaluated with great attention.

Palm oil: health effects in children

Lipids play an essential role in infant nutrition. Breastfed infants, who obtain up to 50% of energy from fat, gain weight rapidly (i.e. they double birth weight by 4 months), mainly due to lipid depots (body fat triples in 4 months) (Cripps et al. 2005). The lipid content in human milk, which is in large part dependent on the maternal diet, varies from feed to feed and even from the beginning to the end of the same feed.

Human milk represents the ideal source of nutrients for the newborn and the gold standard for

infant formula, which are prepared to be as similar as possible to human milk (for cases when breastfeeding is not feasible) (Stam et al. 2013). The typical lipid composition of breast milk is imitated in infant formula production by using bovine milk enriched with oleic acid and the saturated lauric, myristic and palmitic acid (Innis 2016).

The high fat intake during the first months of life is critical for growth and development. At 24 months, the brain mass is increased from 300 g at birth, on average, to 1200 g and reaches 1400 g in adulthood. Of note, being the brain largely composed of fat (white matter), the milk fat intake is essential for brain growth.

Weaning involves important changes in children's diet: the percentage of energy from fats decreases from 50% (with breastfeeding) to 35–40% at 24 months, in parallel with a progressive increase in the carbohydrate portion, which continues into adulthood (from 70 g of carbohydrates at 4 months on the average, to about 300–350 g at 30 years) (Uauy & Castillo 2003). Proportionally, the increase of fat intake from early childhood to adulthood is much smaller (35 g at 4 months and 60–70 g at 30 years). Therefore, the 100% increase in the supply of fats (mainly playing a structural role) from the first months to later life, corresponds to a 500% increase of carbohydrates, which play important metabolic roles. According to the LARN (SINU 2014), fat intake should not exceed 35% of total energy from the fourth year of life onwards and 40% of total energy for toddlers aged 1–3 years. An adequate intake of 40% of energy has been proposed for infants in the second semester of life.

As already pointed out, in breast milk palmitic acid is predominantly esterified at the sn-2 position of the triglyceride, which favors the absorption (López-López et al. 2002). In formulas, instead, palmitic is often found in the sn-1 or sn-3 position and, consequently, is largely eliminated along with the feces as calcium salts.

A recent study (Havlicekova et al. 2016) showed that the monoglyceride in which palmitic acid is in sn-2 position (also called beta-palmitate), a natural component of breast milk, when added to formulas plays favorable metabolic and functional roles, with immunomodulatory and anti-inflammatory effects. In infant formulas, the percentage of palmitic acid in the sn-2 position and, thus, its absorption, is increased by using blends of interesterified triglycerides from different vegetable oils (Delplanque et al. 2015).

However, it is difficult to assess the metabolic impact of a single fatty acid and its possible long-term consequences on the lipid profile. The effects of different meal components (nutrients and foods) on lipid digestion and absorption, genetics, individual behavior (especially physical activity level, being fat oxidation mainly based in muscles) need attention too. Finally, the availability of specific markers is critical for the assessment of selected metabolic patterns of a single nutrient. In this regard, scientific evidence is lacking concern in children.

Future research is required aimed at quantifying the supply of different fats in pregnant women, infants, children and adolescents and at exploring possible correlations between intakes of selected fatty acids and lipid profile and cardiovascular risk at different ages. To date, there is no evidence of any convincing association between fat intake during the first 2 years of life and later health conditions (Agostoni & Caroli 2012). Moreover, the impact on plasma lipid profile of other factors (gender, weight, body fat distribution, level of physical activity, macronutrient supply, meal frequency, etc.) should be clarified, also with respect to the dietary fatty acids (Maffeis et al. 2008).

Dietary saturated fats, cardiovascular disease, and all-cause mortality

The scientific evidence supporting the concept that dietary intake of saturated fatty acids should be kept below 10% of total calories to prevent cardiovascular diseases, as a number of guidelines suggest, is controversial (Nettleton et al. 2014).

Since the 1970s, the Seven Countries Study is showing that dietary intake of saturated fatty acids correlates with the average blood total and LDL cholesterol in the different Countries considered (Kromhout et al. 2000); yet, the association between the saturated fat intake and the incidence of coronary heart disease is less clear.

In the Nurses' Health Study (Hu et al. 1999), the incidence of coronary heart disease did not increase significantly along the five quintiles of saturated fats intake (Hu 1999). More recently, the Kuopio study, performed in subjects with high cardiovascular risk, observed no significant associations between saturated fats intake and CHD incidence or mortality (Virtanen et al. 2014).

The most recent scientific literature has paid specific attention to the relationship between dietary intake of saturated fatty acids and all-cause mortality. In 2015, a meta-analysis on this topic (de Souza et al. 2015) also evaluated the relationship between saturated fat intake and the risk of developing diabetes, the incidence or mortality for coronary or

cardiovascular diseases. The meta-analysis was unable to identify significant associations between dietary saturated fats and any of the assessed outcomes; the association with overall mortality, specifically, was absent (HR: 0.99, CI95% 0.91–1.09). Also, in the PREDIMED study, a randomized clinical trial performed in a Mediterranean population with a high cardiovascular risk, the association between dietary fats and all-cause mortality shows an unexpected pattern (Guasch-Ferré et al. 2015). Saturated fats, indeed, do not increase the risk, while monounsaturated induce a moderate reduction and polyunsaturated fatty acids cut down the risk by 50%; only *trans* unsaturated fats (as in the de Souza meta-analysis) increase the risk for all-cause death. These different effects of saturated and unsaturated fats may explain the protection frequently reported in association with the dietary substitutions of mono/poly-unsaturated fats for saturated fats; a protective effect is also observed with the substitution of whole cereals, but not of starch or refined sugars, for saturated fats.

In early 2016, the NutriCoDe Group published a detailed document (Wang et al. 2016b) evaluating the theoretical effect of the modification of the different dietary fat intakes on coronary heart disease mortality, country by country: in Italy, the largest positive effect (−11%) would be obtained if omega-6 polyunsaturated fatty acids were increased, while a reduction of saturated fats to 10% of total calories would only lead to a 1% reduction of coronary deaths. In the world, generally speaking, saturated reduction would bring modest benefits in term of coronary death reduction.

The assessment of the direct effects of palm oil on coronary heart disease incidence or mortality is difficult, due to the lack in the literature of targeted studies. Interestingly, in the Nurses' Study, no association between palmitic acid intake and CHD risk was observed, for a supply up to 10% of total energy intake (Hu et al. 1999, Wang et al. 2016a).

The impact of palm oil on lipid profile, on the opposite, emerges from a meta-analysis of the studies that evaluated the effect of substituting palm oil with different fats (Fattore et al. 2014). The main results are as follows: substituting palm oil for fats rich in mono- or polyunsaturated increases both LDL and HDL cholesterol (with no effect on the LDL/HDL ratio). An opposite effect (reduction of both LDL and HDL cholesterol) is observed when palm oil is substituted for sources of myristic or lauric acid (the LDL/HDL ratio is, also in this case, unchanged). Palm oil substitution for *trans* unsaturated fats improves the lipid profile (increasing HDL cholesterol, and decreasing LDL cholesterol and LDL/HDL ratio).

The lipid effects of palm oil substitution for oils containing mono/poly-unsaturated are evident only in the oldest age cohorts studied; among the youngest, the impact of the substitution is negligible. The effect of palm oil on plasma LDL cholesterol, in any case, is smaller (about half) than expected, based on the equations linking changes of dietary fats and plasma LDL cholesterol. This is possibly due to the large presence of palmitic acid, in palm oil, in the sn-1 and sn-3 positions of the triglyceride, that, as discussed, limits its absorption and, hence, its metabolic effect.

The mixed effects of palm oil (and of saturated fats) on the lipid profile, affecting in the same direction both plasma HDL and LDL cholesterol (without changing the ratio) may help to understand the neutral effect of saturated fats on CHD risk, observed in the aforementioned meta-analysis.

According to a Malaysian study published in 2011 (Voon et al. 2011), a diet rich in palmitic acid from palm olein does not affect plasma levels of inflammatory markers, when compared with coconut oil (high in myristic and lauric acids) or olive oil rich diets.

Fats, palm oil and cancer risk

The implications of palm oil use on cancer risk are poorly explored: a standard search on search engines such as Medline and Pubmed provides no specific data in this regard. In Italy, a well-recognized research group started conducting epidemiological studies on the relationship between diet and tumors more than 30 years ago (in the early 1980s), when, based on population studies, it was believed that a high dietary fat intake would increase the risk of cancers of bowel, breast and other sites (Bosetti et al. 2009). When specific studies were conducted, the role of fat on cancer risk was clarified; today it is known that the consumption of total fat has no significant impact on cancer risk, although it is possible that different classes of dietary fat do have an effect (American Cancer Society 2016). In studies carried out in Italy, the only cut-clear result was that the substitution of 5% of unsaturated fats for saturated seemed to have a favorable impact on breast or colon cancers (La Vecchia et al. 1998), but this was most likely due to the replacement of one kind of fat with another one and not to a reduction of calories from fat (Fattore & Fanelli 2013).

Other studies conducted in the Mediterranean area have confirmed a protective effect of olive oil against the risk of head and neck cancers (Pelucchi et al. 2011). The effect is observed comparing regular consumers of butter and regular consumers of olive oil, with relative risks around 2.3–2.4 for high butter

consumers and 0.5 in the quintile with greatest olive oil consumption. Only a moderately favorable effect of olive oil has been found on colorectal cancer. Actually, it is not clear whether the olive oil effect is due to its fat composition; it is in fact possible that it is associated to some components of extra virgin olive oil (polyphenols, carotenoids). In addition, we cannot exclude that consumption of olive oil is just a marker of adherence to a Mediterranean dietary habit.

Palm "red" unrefined oil is also rich in carotenoids, tocopherols and tocotrienols (Bonnie & Choo 2000) that might exert a protective effect on cancer risk, possibly through antioxidant or anti-inflammatory activities. Yet, such molecules are lacking in the oil usually used by food manufacturers in Italy and Europe.

The available indirect evidence, as a whole, indicates that consumers of palm oil through standard prepackaged food have no significant alterations in terms of risk or protection from cancer.

General discussion

A general consensus among participants was found on the following statements:

The health effects of palm oil consumption should be considered similar to that of other oils or solid fats rich in saturated fatty acids. Published data, in fact, do not provide direct or indirect evidence that palm oil, as a source of saturated fatty acids, affects cardiovascular risk and general health differently from other dietary fats with similar fatty acid composition (Fattore et al. 2014).

Nevertheless, the excessive consumption of palm oil, which is composed for 50% of saturated fatty acids, as well as that of other highly saturated fats, prevents the achievement of correct nutritional targets. Among the major sources of palm oil, ready to eat meals, crisps, snacks, pre-fried foods, etc., should be specifically considered (Italian Ministry of Health 2016). The replacement of palm oil with other fats in food production – where this is possible – can contribute to the improvement of the lipid fraction of these foods, although not necessarily to the overall nutritional profile.

In general, it was underscored that, regardless of the presence of palm oil, the recommendations to reduce the consumption of high-fat foods (shared by all the national and international dietary guidelines), should be considered still effective, especially for children.

A good adherence to the guidelines for a healthy Italian diet, with adequate intakes particularly of fiber and legumes, allows to obtain a saturated fat intake of less than 10%, the goal currently suggested for cardiovascular prevention, but also for the reduction of all-cause mortality (Giacosa et al. 2013).

More specifically, it was agreed that the most recent evidence supports the customization of the diet depending on the characteristic of the subject/patient. For example, the limit of 10% of energy set for saturated fats might not be adequate for patients with high LDL cholesterol or insulin resistance, or with a previous cardiovascular event; in these cases saturated fats should be contained within 7–8% of total calories, and the total fat intake between 20% and 35% (Rydén et al. 2013; Catapano et al. 2016). The improvement of fat quality was deemed to be generally more important than total fat reduction.

According to some published evidence, insulin sensitivity, which is a recognized risk factor for diabetes and cardiovascular disease, is also reduced, by a diet high in saturated fat; the opposite occurs with unsaturated fatty acids. The protective effect of unsaturated fats on insulin sensitivity, on the other hand, is also modulated by the total amount of dietary fats (Vessby et al. 2001).

As far as the exposure to palm oil in pediatric age is concerned, it was emphasized that the INRAN-SCAI 2005–06 data, on which the previously mentioned analysis of the Italian Institute of Health is based, have been obtained from a limited-size population sample, showing a large heterogeneity between the different age groups (ISS 2015). This highlights the importance of obtaining adequate and up-to-date information on the consumption of saturated fats by children in Italy. Considering, however, the national data on the high prevalence of overweight/obesity in children, it was felt desirable to underscore the need of limiting the consumption of all products high in total and saturated fat, even in this age group.

Round table: communication on nutrition in modern societies

The large echo gained in the Italian media by the discussion on the possible health effects of palm oil prompted Symposium participants to examine and discuss also the role of nutritional information, of its sources and of its scientific quality, in modern societies (McNamara 2010).

In recent years, a large increase in the availability of information on nutritional issues for the general population occurred. However, such information is often debatable: with the consequence that, frequently, people may decide to change their eating behavior on

the basis of weak or wrong scientific messages, facing possible health risks. In some cases, such weak or wrong information may lead to highly selective dietary patterns, possibly leading to nutritional deficiencies, rather than improving health. Restrictive eating behaviors, the obsession with "healthy food", and the demonization of certain food categories can moreover be predictive factors, of future eating disorders, especially in young people.

For all these reasons, the promotion of fair and balanced information based on a careful analysis of the scientific research should be one of the main objectives of the scientific community in the field of nutrition.

Pediatricians are highly concerned about the effects of poor communication to consumers. Their specific responsibilities, in fact, include the control of the dietary behavior of their young patients and the involvement in this process of parents and the community, by explaining the short- and long-term risks that are associated.

General Practitioners, at the forefront in the public debate on these issues, are setting up and strengthening targeted tools to improve dialog with patients. In this context, their involvement in *ad hoc* studies may allow to obtain information on the actual consumption data (often not available) of different foods, needed to better focus public health interventions.

Coronary patients in secondary prevention, which should be reeducated to proper lifestyles during hospitalization or rehabilitation, often have requests on when and how to eat and when to do physical activity. The training of cardiologists is very important to effectively answer such key questions, including the quality and quantity of dietary fat.

In general, participants to the Symposium agreed on the importance of assessing diet as a whole, without focusing on single foods/ingredients: the relevance of "nutrition" versus "nutritionism" was specifically emphasized. Many studies are indeed focused on a single nutrient, without considering that we consume, instead, foods that are a complex mixture of nutrients (Freeland-Graves & Nitzke 2013).

Symposium participants also stressed that the consumer often considers as healthier foods that are "deprived" of something and that the potentially negative effects of the "free from" labels need to be carefully examined (Priven et al. 2015). In the specific case of palm oil, consumers are led to overlook the fact that palm oil removal is often carried out by using other saturated fats (for the technological reasons outlined above); therefore, it is incorrect to consider a "palm free" product as high-quality product.

There was also consensus on the crucial role of physicians and other health professionals to customize counseling to the individual patient, based on the analysis of the overall diet and, more generally, of the lifestyle.

Conclusions and take-home messages

The main conclusions and "take-home messages" arising from the symposium can be summarized as follows:

(1) Palm oil contains high concentrations, i.e. 50% of total fatty acids, as saturated fatty acids, mainly palmitic acid. However, it provides equally relevant (the remaining 50%) amounts of mono and polyunsaturated fatty acids (essentially, oleic and linoleic acid).

(2) Most saturated fatty acids in palm oil are preferentially esterified at the sn-1 and sn-3 carbon of triglycerides; this lowers their specific absorption rate as compared with the mono- and polyunsaturated, that are mainly esterified, on the opposite, in position sn-2. This stereospecific distribution suggests that the biological effects of saturated fatty acids in palm oil might be less relevant than those expected based on pure composition data.

(3) Saturated fats have rheological properties that make them suitable for several food applications, as an alternative to *trans* fats, which have proven negative effects on human health.

(4) The consumption of total fat, and in particular of saturated fat should be monitored in infants and adults. Limits indicated by the dietary guidelines (30% of energy for total fats, and 10% for saturated, within a balanced diet), are still indicating the need to lower intakes in western countries. In Italy, total and saturated fat consumption is only in slight excess as compared to guidelines suggestions.

(5) According to the proposed calculations, the intake of saturated fats from palm oil in Italy can be approximately estimated to be – on average – 3.09 g/day by adults and 4.78 g/day by infants. Such figures could update the ISS data, taking into adequate consideration actual food composition.

(6) In the absence of randomized trials addressing health effects associated to palm oil consumption in adults and/or infants, it seems appropriate to include and compute the intake of saturated fatty acids from palm oil within the limit of 10% of calories, suggested for saturated fats by the International guidelines, within a balanced diet, even if recent meta-analyses question the association between saturated fat intake and coronary and all-cause mortality (possibly because

saturated fatty acids increase both LDL and HDL plasma cholesterol).

(7) Neither experimental nor epidemiological data are available on the association between palm oil consumption and cancer incidence or mortality; such data are unlikely to be produced in the near future. Indirect evidence suggests that consumption of palm oil has neither positive nor negative effects on cancer risk.

In conclusion, palm oil intake does not appear to be a public health priority in Italy, in light of its overall effects and of the available consumption data. The limit of 10% of energy from saturated fats suggested by national and international guidelines, as part of a healthy and balanced diet, should, nevertheless, be pursued at present. Age classes with highest intakes should be specifically identified and properly advised.

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References

Agostoni C, Caroli M. 2012. Role of fats in the first two years of life as related to later development of NCDs. Nutr Metab Cardiovasc Dis. 22:775–780.

AIDEPI – Italian Association of Confectionery and Pasta Industries [cited 2016 Oct 13.]. Available from: http://www.aidepi.it/.

American Cancer Society 2016. Guidelines on Nutrition and Physical Activity for Cancer Prevention [cited 2016 Nov 2]. Available from: http://www.cancer.org/healthy/eathealthygetactive/acsguidelinesonnutritionphysicalactivityforcancerprevention/nupa-guidelines-toc.

ANSES (Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail). 2011. Actualisation des apports nutritionnels conseillés pour les acides gras. Rapport d'expertise collective [cited 2016 Oct 13]. Available from: https://www.anses.fr/fr/system/files/NUT2006sa0359Ra.pdf..

Aranceta J, Pérez-Rodrigo C. 2012. Recommended dietary reference intakes, nutritional goals and dietary guidelines for fat and fatty acids: a systematic review. Br J Nutr. 107:S8–S22.

Berry SE, Sanders TA. 2005. Influence of triacylglycerol structure of stearic acid-rich fats on postprandial lipaemia. Proc Nutr Soc. 64:205–212.

Berry SE. 2009. Triacylglycerol structure and interesterification of palmitic and stearic acid-rich fats: an overview and implications for cardiovascular disease. Nutr Res Rev. 22:3–17.

Bonnie TYP, Choo YM. 2000. Valuable minor constituents of commercial red palm oil: carotenoids, Vitamin E, ubiquinones and sterols. J Oil Palm Res. 12:14–24.

Bosetti C, Pelucchi C, La Vecchia C. 2009. Diet and cancer in Mediterranean countries: carbohydrates and fats. Public Health Nutr. 12:1595–1600.

Bracco U. 1994. Effect of triglyceride structure on fat absorption. Am J Clin Nutr. 60:1002S–1009S.

Carnielli VP, Luijendijk IH, van Beek RH, Boerma GJ, Degenhart HJ, Sauer PJ. 1995. Effect of dietary triacylglycerol fatty acid positional distribution on plasma lipid classes and their fatty acid composition in preterm infants. Am J Clin Nutr. 62:776–778.

Catapano AL, Graham I, De Backer G, Wiklund O, Chapman MJ, Drexel H, Hoes AW, Jennings CS, Landmesser U, Pedersen TR, et al. 2016. 2016 ESC/EAS Guidelines for the Management of Dyslipidaemias: the task force for the management of dyslipidaemias of the European Society of Cardiology (ESC) and European Atherosclerosis Society (EAS) developed with the special contribution of the European Association for Cardiovascular Prevention & Rehabilitation (EACPR). Atherosclerosis. 253:281–344.

Cripps RL, Martin-Gronert MS, Ozanne SE. 2005. Fetal and perinatal programming of appetite. Clin Sci. 109:1–11.

de Souza RJ, Mente A, Maroleanu A, Cozma AI, Ha V, Kishibe T, Uleryk E, Budylowski P, Schünemann H, Beyene J, Anand SS. 2015. Intake of saturated and trans unsaturated fatty acids and risk of all cause mortality, cardiovascular disease, and type 2 diabetes: systematic review and meta-analysis of observational studies. BMJ. 351:h3978

Delplanque B, Gibson R, Koletzko B, Lapillonne A, Strandvik B. 2015. Lipid quality in infant nutrition: current knowledge and future opportunities. J Pediatr Gastroenterol Nutr. 61:8–17.

Edem DO. 2002. Palm oil: Biochemical, physiological, nutritional, hematological, and toxicological aspects: a review. Plant Foods Hum Nutr. 57:319–341.

Erikson DR, List GR. 1985. Storage, handling and stabilization of edible fats and oils. In: Applewhite TD, editor. Mailey's industrial oil and fat products. Vol. III. New York: John Wiley and Sons. p. 273–310.

FAO – Food and Agriculture Organization of the United Nations. 1994. Fats and oils in human nutrition. Report of a Joint Expert Consultation. Food and Nutrition Paper No. 57 [cited 2016 Oct 13]. Available from: http://www.who.int/nutrition/publications/nutrientrequirements/

9251036217/en/.FAOSTAT [cited 2016 Dec 28]. Available from: www.fao.org/faostat/en/#data.

Fattore E, Bosetti C, Brighenti F, Agostoni C, Fattore G. 2014. Palm oil and blood lipid-related markers of cardiovascular disease: a systematic review and meta-analysis of dietary intervention trials. Am J Clin Nutr. 99:1331–1350.

Fattore E, Fanelli R. 2013. Palm oil and palmitic acid: a review on cardiovascular effects and carcinogenicity. Int J Food Sci Nutr. 64:648–659.

Freeland-Graves JH, Nitzke S, Academy of Nutrition and Dietetics. 2013. Position of the academy of nutrition and dietetics: total diet approach to healthy eating. J Acad Nutr Diet. 113:307–317.

Freisling H, Fahey MT, Moskal A, Ocké MC, Ferrari P, Jenab M, Norat T, Naska A, Welch AA, Navarro C, et al. 2010. Region-specific nutrient intake patterns exhibit a geographical gradient within and between European countries. J Nutr. 140:1280–1286.

German JB, Dillard CJ. 2004. Saturated fats: what dietary intake? Am J Clin Nutr. 80:550–559.

Giacosa A, Barale R, Bavaresco L, Gatenby P, Gerbi V, Janssens J, Johnston B, et al. 2013. Cancer prevention in Europe: the Mediterranean diet as a protective choice. Eur J Cancer Prev. 22:90–95.

Gnagnarella P, Salvini S, Parpinel M. 2000. Banca dati di composizione degli alimenti per studi epidemiologici in Italia. Versione 1.2015 [cited 2016 Oct 13]. Available from: http://www.bda-ieo.it/.

Guasch-Ferré M, Babio N, Martínez-González MA, Corella D, Ros E, Martín-Peláez S, Estruch R, PREDIMED Study Investigators, et al. 2015. Dietary fat intake and risk of cardiovascular disease and all-cause mortality in a population at high risk of cardiovascular disease. Am J Clin Nutr. 102:1563–1573.

Havlicekova Z, Jesenak M, Banovcin P, Kuchta M. 2016. Beta-palmitate – a natural component of human milk in supplemental milk formulas. Nutr J. 15:28.

Hu FB, Stampfer MJ, Manson JE, Ascherio A, Colditz GA, Speizer FE, Hennekens CH, Willett WC. 1999. Dietary saturated fats and their food sources in relation to the risk of coronary heart disease in women. Am J Clin Nutr. 70:1001–1008.

Innis SM. 2016. Palmitic acid in early human development. Crit Rev Food Sci Nutr. 9:1952–1199.

Italian Ministry of Health. 2016. Parere dell'Istituto superiore di sanità sulle conseguenze per la salute dell'utilizzo dell'olio di palma come ingrediente alimentare [cited 2016 Oct 13]. Available from: http://www.salute.gov.it/imgs/C_17_pubblicazioni_2481_allegato.pdf.

Kromhout D, Bloemberg B, Feskens E, Menotti A, Nissinen A. 2000. Saturated fat, vitamin C and smoking predict long-term population all-cause mortality rates in the Seven Countries Study. Int J Epidemiol. 29:260–265.

La Vecchia C, Favero A, Franceschi S. 1998. Monounsaturated and other types of fat, and the risk of breast cancer. Eur J Cancer Prev. 7:461–464.

Leclercq C, Arcella D, Piccinelli R, Sette S, Le Donne C, Turrini A. INRAN-SCAI 2005-06 Study Group. 2009. The Italian National Food Consumption Survey INRAN-SCAI 2005-06: main results in terms of food consumption. Public Health Nutr. 12:2504–2532.

López-López A, López-Sabater MC, Campoy-Folgoso C, Rivero-Urgell M, Castellote-Bargalló AI. 2002. Fatty acid and sn-2 fatty acid composition in human milk from Granada (Spain) and in infant formulas. Eur J Clin Nutr. 56:1242–1254.

Maffeis C, Banzato C, Talamini G. Obesity Study Group of the Italian Society of Pediatric Endocrinology and Diabetology. 2008. Waist-to-height ratio, a useful index to identify high metabolic risk in overweight children. J Pediatr. 152:207–213.

Mattson FH, Nolen GA, Webb MR. 1979. The absorbability by rats of various triglycerides of stearic and oleic acid and the effect of dietary calcium and magnesium. J Nutr. 109:1682–1687.

Mba OI, Dumont MJ, Ngadi M. 2015. Palm oil: Processing, characterization and utilization in the food industry – a review. Food Biosci. 10:26–41.

McNamara DJ. 2010. Palm oil and health: a case of manipulated perception and misuse of science. J Am Coll Nutr. 29:240S–244S.

Minihane AM, Harland JI. 2007. Impact of oil used by the frying industry on population fat intake. Crit Rev Food Sci Nutr 47:287–297.

Mu H, Porsgaard T. 2005. The metabolism of structured triacylglycerols. Prog Lipid Res. 44:430–448.

Nettleton JA, Legrand P, Mensink RP. 2015. ISSFAL 2014 Debate: it is time to update saturated fat recommendations. Ann Nutr Metab. 66:104–108.

Nordic Nutrition Recommendations 2012 – Integrating nutrition and physical activity [cited 2016 Oct 13]. Available from: www.norden.org/en/theme/nordic-nutrition-recommendation/nordic-nutrition-recommendations-2012.

Obahiagbon FI. 2012. A review: aspects of the African oil palm (Elaeis guineesis jacq.) and the implications of its bioactives in human health. Am J Biochem Mol Biol. 2:106–119.

Pelucchi C, Bosetti C, Negri E, Lipworth L, La Vecchia C. 2011. Olive oil and cancer risk: an update of epidemiological findings through 2010. Curr Pharm Des. 17:805–812.

Priven M, Baum J, Vieira E, Fung T, Herbold N. 2015. The influence of a factitious free-from food product label on consumer perceptions of healthfulness. J Acad Nutr Diet. 115:1808–1814.

Rydén L, Grant PJ, Anker SD, Berne C, Cosentino F, Danchin N, Deaton C, Escaned J, Hammes HP, Huikuri H, et al. 2013. ESC Guidelines on diabetes, pre-diabetes, and cardiovascular diseases developed in collaboration with the EASD: the Task Force on diabetes, pre-diabetes, and cardiovascular diseases of the European Society of Cardiology (ESC) and developed in collaboration with the European Association for the Study of Diabetes (EASD). Eur Heart J. 34:3035–3087.

Sambanthamurthi R, Sundram K, Tan Y. 2000. Chemistry and biochemistry of palm oil. Prog Lipid Res.39:507–558.

Sette S, Le Donne C, Piccinelli R, Arcella D, Turrini A, Leclercq C. INRAN-SCAI 2005-6 Study Group. 2011. The third Italian National Food Consumption Survey, INRAN-SCAI 2005-06-part 1: nutrient intakes in Italy. Nutr Metab Cardiovasc Dis. 21:922–932.

Sette S, Le Donne C, Piccinelli R, Mistura L, Ferrari M, Leclercq C. INRAN-SCAI 2005–06 study group. 2013. The third National Food Consumption Survey, INRAN-SCAI 2005-06: major dietary sources of nutrients in Italy. Int J Food Sci Nutr. 64:1014–1021.

SINU (Società Italiana di Nutrizione Umana). 2014. LARN – Livelli di Assunzione di Riferimento di Nutrienti ed energia per la popolazione italiana. IV Revisione. Milano: Società Italiana di Comunicazione Scientifica e Sanitaria (SICS). p. 1–655.

Stam J, Sauer PJ, Boehm G. 2013. Can we define an infant's need from the composition of human milk? Am J Clin Nutr. 98:521S–528S.

Sundram K, Hornstra G, von Houwelingen AC, Kester AD. 1992. Replacement of dietary fat with palm oil: effect on human serum lipids, lipoproteins and apolipoproteins. Br J Nutr. 68:677–692.

Uauy R, Castillo C. 2003. Lipid requirements of infants: implications for nutrient composition of fortified complementary foods. J Nutr. 133:2962S–2972S.

US Department of Health and Human Services. 2015. 2015–2020 Dietary Guidelines for Americans [cited 2016 Oct 13]. Available from: www.cnpp.usda.gov/2015-2020-dietary-guidelines-americans.

Vessby B, Uusitupa M, Hermansen K, Riccardi G, Rivellese AA, Tapsell LC, Nalsen C, Berglund L, Louheranta A, Rasmussen BM, et al. 2001. Substituting dietary saturated for monounsaturated fat impairs insulin sensitivity in healthy men and women: The KANWU study. Diabetologia. 44:312–319.

Virtanen JK, Mursu J, Tuomainen TP, Voutilainen S. 2014. Dietary fatty acids and risk of coronary heart disease in men: the Kuopio Ischemic Heart Disease Risk Factor Study. Arterioscler Thromb Vasc Biol. 34:2679–2687.

Voon PT, Ng TK, Lee VK, Nesaretnam K. 2011. Diets high in palmitic acid (16:0), lauric and myristic acids (12:0 + 14:0), or oleic acid (18:1) do not alter postprandial or fasting plasma homocysteine and inflammatory markers in healthy Malaysian adults. Am J Clin Nutr. 94:1451–1457.

Wang DD, Li Y, Chiuve SE, Stampfer MJ, Manson JE, Rimm EB, Willett WC, Hu FB. 2016a. Association of specific dietary fats with total and cause-specific mortality. JAMA Intern Med 176:1134–1145.

Wang Q, Afshin A, Yakoob MY, Singh GM, Rehm CD, Khatibzadeh S, Micha R, Shi P, Mozaffarian D. Global Burden of Diseases Nutrition and Chronic Diseases Expert Group (NutriCoDE). 2016b. Impact of nonoptimal intakes of saturated, polyunsaturated, and trans fat on global burdens of coronary heart disease. J Am Heart Assoc. 5:e002891.

WHO Joint FAO Expert Consultation. 2003. Diet, nutrition and the prevention of chronic diseases. World Health Organ Tech Rep Ser. 916:i–viii.