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INFORMATIVE NOTE

Oils and fats on food: is it possible to have a healthy diet?

R. Garcés[a], E. Martínez-Force[a], M. Venegas-Calerón[a] and J.J. Salas[a,*,✉]

*Secretary and Member of the Editorial Board of *Grasas y Aceites*,
Head of the Department of Biochemistry and Molecular Biology of Plant Products.
[a]Instituto de la Grasa (CSIC), Ctra. Utrera Km 1, Campus Universidad Pablo de Olvide, 41013, Sevilla, Spain.

✉Corresponding author: jjsalas@ig.csic.es

Oils and fats are an important part of our diet as components of many food formulations. Thus, they are retailed for domestic or hostelry uses and broadly used by food industry for the elaboration of margarines, ice cream, canned food, pre-cooked dishes, bakery, confectionary, chocolates, etc. Chemically, the main component of oils and fats are triacylglycerols (TAGs), which account for up to 95% of their total weight. They consisted of a molecule of glycerol esterified with three fatty acids, usually the saturated, palmitic and stearic, the monounsaturated oleic, and the polyunsaturated, linoleic or linolenic, all with 18 carbons excepting the palmitic which has 16 carbons. Out of those most common fatty acids, we can found other fatty acids present only in certain oils such as saturated medium chained fatty acids like lauric and myristic, which contain 12 and 14 carbons respectively.

The final use of each class of oil or fat would depend on its chemical and physical properties, relying mostly on their fatty acid composition, which will also determine their nutritional properties. High proportions of palmitic or stearic (saturated fatty acids) gives place to solid fats at room temperature. On the contrary, high levels of oleic, linoleic or linolenic acids decrease the melting point of the fats that would be liquid at room temperature. With regard to their effect on human health, the World Health Organization (WHO, 2003), pointed that; (i) myristic acid and palmitic acid increase the risk of developing cardiovascular diseases due they increase the levels of low density lipoprotein (LDL) associated cholesterol, (ii) lauric acid possible has the same negative effect; (iii) oleic, linoleic and linolenic acid reduces those levels, and (iv) stearic acid do not alter them. A more recent inform (WHO, 2010) reaffirmed in these data stating that “Individual saturated fatty acids have different effects on the concentration of plasma lipoprotein cholesterol fractions. For example, lauric, myristic and palmitic acids increase LDL cholesterol whereas stearic has no effect. There is convincing evidence that the best replacement of SFA (lauric, myristic and palmitic) is with polyunsaturated fatty acids that will decrease LDL cholesterol concentration and the total/HDL cholesterol ratio. A similar but lesser effect is achieved by replacing these SFA with monounsaturated fatty acids”.

Vegetable oils most commonly retailed (canola, soybean, sunflower or olive) are rich in unsaturated fatty acids and they all can be considered healthy provided they are consumed according to the individual energetic necessities, avoiding overweighting or obesity (EFSA, 2010). Among them, virgin extra olive oil stands out for its benefits for human health, due to the high content of oleic acid (EFSA, 2011), hydroxytyrosol and its derivatives (i.e. oleuropein and tyrosol), naturally occurring olive oil phenols (EFSA, 2012).

The elaboration of margarines, bakery or confectionary products requires fats with appropriate plasticity and solid content. So, higher contents of saturated fatty acids are necessary at expenses of linoleic and linolenic acids, which also increases oxidative stability of the final product (Jandacek, 2009). In the past, these products

ORCID ID: Garcés R http://orcid.org/0000-0003-2571-8644, Martínez-Force E http://orcid.org/0000-0001-5324-9537, Venegas-Calerón M http://orcid.org/0000-0002-1562-5025, Salas JJ http://orcid.org/0000-0002-0012-7963

were usually elaborated with fats of animal origin like lard or tallow. These are typically cholesterol-rising fats due their high levels of palmitic acid, the presence of myristic acid and the extra cholesterol input that involves their intake. The concern on the excessive consumption of animal fats and the reject of an important part of customers to lard by religious reasons made industry looks for an alternative. Thus, animal fats were progressively substituted by vegetable oils that were hydrogenated to make them plastic fats appropriate for the above mentioned applications. At that time, it was considered that hydrogenation was an easy and safe way to harder vegetable oils. This process consisted in converting unsaturated fatty acid chains into saturated ones by reaction with hydrogen at high temperature and pressure in the presence of a heterogeneous metal catalyst. This reaction involves the reversible binding of the fatty acids to the catalyst though the double bond which is then activated easing the addition of hydrogen to form a single bond product. However, since the binding is reversible, fatty acids can be released from the catalyst before reaction has occurred. In that case the fatty acid changes its initial conformation, the naturally occurring *cis*, to the more stable conformation *trans*. This is the reason why fatty acid *trans* isomers are present in all partially hydrogenated fats. At the day today, there is a broad agreement in the scientific community about the harmful effects of *trans* fatty acids on cardiovascular health. *Trans* fatty acids acts increasing the LDL-cholesterol (or "bad cholesterol") and depleting the cholesterol associated to high density lipoproteins (HDL) or "good cholesterol", provoking a double negative effect (WHO, 2003). Thus, from an epidemiologic point of view a positive correlation between the increase of the intake of partially hydrogenated oils and the incidence of cardiovascular disease and myocardial infarction have been observed in all countries in which has been studied. This is the case of Denmark, where the early ban of products containing more than 2% of *trans* fatty acids considerably affected the number of deceases caused by cardiovascular accident, which was reduced in 20 per 100,000 inhabitants and year, which means more than 1000 deceases less a year for the whole country (Restrepo *et al.* 2016). The increasing concern on the presence of chemically altered *trans* fatty acids in our diet ran parallel along the 90´s and 2000´s with an exponential expansion of the cultivation of the oil palm in Southwest Asia. Palm is the most productive oil crop in the planet, yielding fruits containing up to 60% of oil in their pulp. This oil is rich in palmitic acid (around 40%), having a distribution of saturated fatty acids in the TAGs different to that in other oil seeds. Palm oil as itself does not have many applications due to its strong red color and broad melting profile. Nevertheless, most of the palm oil is submitted to a process called fractionation, consisting in the separation of the TAGs richer in saturated fatty acids from those containing more unsaturated ones. This process involves crystallization plus pressure filtration, yielding solid fractions with higher contents of palmitic acid (up to 60%) called stearins, and liquid fractions named oleins (Lin, 2011). The irruption of large amounts of palm stearins in the market at a very competitive price made them the most adequate alternative to hydrogenated oils for food industry and so, they became in few years one of the main components of many food formulations elaborated along the world. Again, these formulations are those requiring plastic or solid fats for their functionality, which embrace a large amount of food products already enumerated above. Moreover, palm oleins started to be used instead of other liquid oils for applications like frying, pre-cooked dishes or canned food increasing the level of palmitate in all these formulations (Lin, 2011). The effects of such increase in the intake of palmitic acid have had negative effects on the health of customers. Thus, in a multi country study, in a scenario of increasing consumption of palm oil and derivatives the effect on cardiovascular mortality in general population was studied. The main conclusion was that for every additional kilogram of palm oil consumed per-capita annually, ischemic heart disease mortality rates increased by 68 deaths per 100,000 persons per year (Chen *et al*. 2011).

In Europe, for a long time all these palm derived fractions were declared as vegetable oil or vegetable fat in all these food products. The new guidelines on labelling in the European Union (regulation 1169/2011) make obligatory the specific origin indication of oils and fats, avoiding generic designations. Therefore, customers started to notice that the vegetable fats they were eating, assumed as healthy in opposition to animal fat, were actually palm derivatives rich in palmitic acid that acts raising LDL cholesterol levels. Moreover, in the last years concerns on palm oil and fractions uses is being extended to the ecological impact of its production. Palm plantations have been growing in a non-sustainable way at expenses of extensive areas of tropical rainforest, importantly affecting the biodiversity in these areas and setting in serious risk of extinction some emblematic species like orangutan. The removal of these rainforest areas involves also the massive emissions of greenhouse gases like CO_2. Finally, recent surveys revealed that palm fractions used in many food formulations shows elevated levels of monochloropropanediols (MCPDs) and glycidyl esters (EFSA, 2016). These compounds are produced during oil refining in presence of a source of chlorine and have been demonstrated to have carcinogenic and genotoxic effects (Bakhiya *et al*., 2011), so their intake should be totally avoided. The content of these compounds in palm oil is often several times higher than in other vegetable oils. For example, 3-MCPD has been reported to be present in palm oil at concentrations that were 60-fold those found in olive oil (EFSA, 2016). The potential impact of these compounds on health summed to their difficult determination and control has become one of the main concerns caused by the massive consumption of palm oil.

One of the main targets of food lipid technology at the present days is finding a healthy alternative to palm oil and fractions, assuring a sustainable production and higher control on the production standards. In this regard, we have to consider that these fats should contain saturated fatty acids providing the appropriate physical and rheological properties of the fat. As mentioned above, among the most common saturated fatty acids only stearic acid does not have an effect on the blood cholesterol levels and so it is not an inductor of arteriosclerosis. The reason for this is that this fatty acid is efficiently converted to oleic acid by the liver (Grundy, 1994) and it is preferentially incorporated into polar lipids instead of cholesteryl esters or TAGs (Emke, 1994). Thus, the most plausible alternative to the use of animal fat, hydrogenated oils and palm oil is using vegetable fats based on stearic acid.

The best known vegetable sources of fats rich in stearate are butters coming from tropical trees like shea, sal, kokum or mango. Some of these species are not crops, but they are tall trees growing in the wild, which nuts are hand-harvested to process the oil by the means of craft methods. Therefore, the supply and the quality of these oils are irregular, reaching often high prices in the international market. Furthermore, after the breakthrough of modern biotechnology on the improvement of agriculture at the beginning of the 90´s many research projects have been involved in increasing the levels of stearic acid in conventional oil crops. This has been achieved by both classical techniques of mutagenesis and selection in soybean and sunflower, and by genetic engineering in rapeseed, cotton and soybean. All these projects have generated a number of publications and patents depicting the new lines of high stearic oil crops (Fernandez-Moya, 2005, Watkins, 2009), even in the case of palm (Parveez, 2000). These new fats rich in stearic can be used by food industry for the formulation of margarines, ice cream, bakery and confectionary products with low contents of myristic, palmitic and free of *trans* fatty acids. Within these, the high stearic sunflower oil is the only one ready for commercialization.

In conclusion, from the beginning of the industrial production food technologists have not been able to design formulations based on solid fats that at the time were compatible with a healthy diet. Nevertheless, the latest advances on food science and plant biotechnology have gave to us the appropriate tools to provide a realistic alternative to the saturated cholesterol-rising fats that have been predominant in many food formulations. Thus, new oil and fats rich in stearic acid are solid candidates to attend the demand of industry and customers for healthier fat-based products. Now, we are in a position to affirm that these oils can meet all requirements of industry without any chemical alteration, giving place to a new broad variety of healthy products that could satisfy all the customers' expectations for quality tasty products within a healthy diet.

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