



## The Dietary and Therapeutic Aspects of Coconut Oil

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Coconut is grown in over 90 countries and is consumed by over one billion people. Despite this, the share of coconut oil in the world market is only about 3%. Since it is considered as a traditional product in most countries where it is grown, there has been no systematic and deliberate program to develop it. Coconut oil can be developed for many uses, from diet, to functional food, to therapeutic applications. However, it must be developed appropriately as a product specific for those applications.

Many claims have been made for coconut oil, ranging from its favorable nutritional and functional properties to its curative effects. The challenge for us is to produce the scientific research that will support these claims. However, this is a wide range of effects and so we should select the strategic studies that will answer the key questions. Coconut oil is a versatile product. It has uses as food (as part of coconut-based dishes), as cooking oil, as functional food or dietary supplement, as a component of pharmaceutical preparations, and as an active ingredient in a pharmaceutical product. We should strategize the research that will be needed to support coconut product development. There are three parts to the development of this strategy. First, we should understand each coconut oil product and its market. Second, we should identify the concerns and research needs of each product. Third, we should choose the right type of study and focus our research efforts to yield maximum benefit and impact.

### Address concerns regarding coconut oil

Despite the improving image of coconut oil in the health food market, there remain a number of issues that must be addressed regarding the fear of saturated fat and cholesterol. These fears are constantly reinforced

by the nutritional labelling guidelines that require the declaration of the saturated fat content right next to the trans-fats content and the strong anti-cholesterol bias of the food and medical industries. In ways both implicit and explicit, the message is that saturated fat and cholesterol are both undesirable. The suggestion that saturated fat and trans-fat are both harmful adds insult to injury because trans-fats were originally produced by the food industry to mimic the desirable qualities of saturated fat without resorting to the use of saturated fat.

Ansel Keys' Seven Countries Study in 1986 was the paradigm-setting paper which proposed the link between saturated fatty acids, cholesterol and coronary heart disease. This study, which was started in the 1960s, was published in 1986 with the objective of providing the scientific basis for Dietary Guidelines for Americans which had its first edition in 1980. In this paper, Keys claimed proof for his saturated fat-cholesterol-heart disease hypothesis using an alleged correlation between amount of calories from saturated fat (y-axis) and the incidence of coronary heart disease (CHD) (x-axis) (Fig. 1a). This is an alleged correlation because Keys controversially did not utilize all of the data that he had gathered from the entire study which actually involved 15-countries. He was accused of cherry-picking his data to support his desired conclusions, an accusation which he never satisfactorily answered. Secondly, the principle that a correlation does not prove causation was ignored and the saturated fat-cholesterol-heart disease paradigm has dominated the scientific and popular mindset for the past 30 years. Interestingly, one can draw an almost identical graph if one plots the latitudes of the towns included in the Seven Country Study with incidence of CHD (Fig. 1b) In other words, a



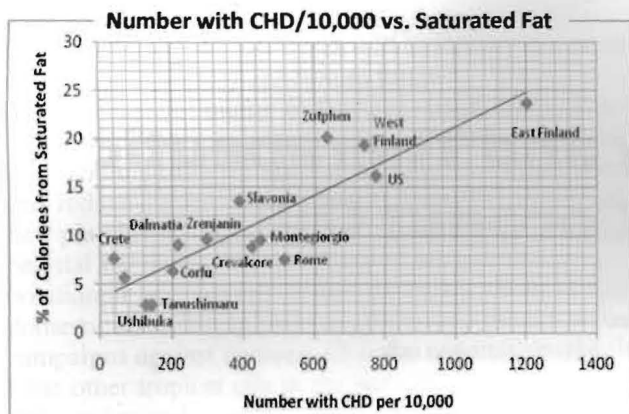


Figure 1a. Keys plot from the Seven Country Study which is meant to show the relationship between amount of intake of saturated fat and incidence of coronary heart disease. In principle, a simple correlation does not constitute a causal relationship.

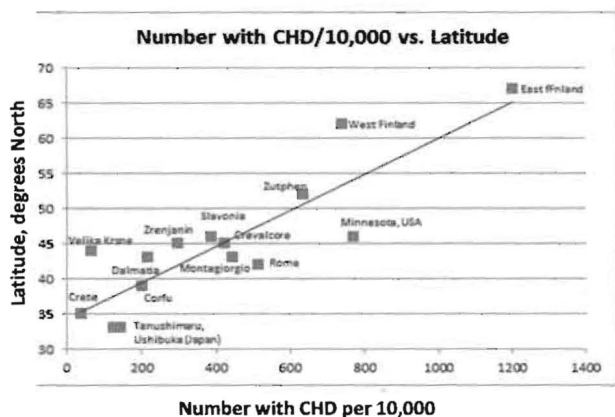


Figure 1b. If one plots the latitudes of the towns included in the Seven Country Study, one also obtains a very similar plot. Following are the approximate latitudes ( $^{\circ}$ N) of the towns: East & West Finland: 61; Zutphen: 52; Minnesota: 46; Crevalcore: 44; Corfu: 42; Rome: 41; Dalmatia: 40; Slavonia: 40; Crete: 35; Tanushimaru: 33.

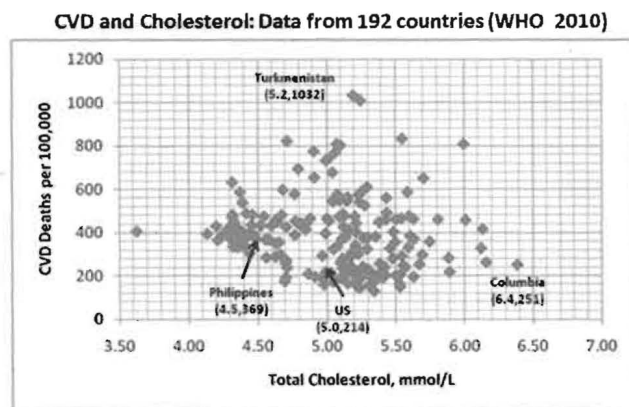


Figure 1c. CVD deaths per 100,000 population plotted against total cholesterol (mmol/L) (WHO 2010).

very plausible explanation for the Keys result is that people in high latitude countries tend to lack vitamin D due to lower sunlight and this increases the incidence of CHD. Finally, 2010 data from the World Health Organization (WHO) show that there is no correlation between cholesterol and heart disease (Fig. 1c).

Despite the strong anti-cholesterol position of Ancel Keys, it is quite surprising that early on in his career, he published at least three papers where he concluded that cholesterol is not associated with heart disease. In 1952, Keys published a paper in the journal *Circulation* where he concluded that the “cholesterol content of human diets is unimportant in human atherosclerosis.” In another paper published in 1952 in the *Journal of Gerontology*, Keys showed that serum cholesterol in healthy people normally increases with age, from about 180 at age 20, to over 250 at age 65. This observation was corroborated by a number of other researchers. In a third paper published in 1955, Keys reiterated his earlier conclusions that in healthy individuals, there is a natural increase in serum cholesterol with age and that cholesterol in the diet did not have a detrimental effect on health. It is relevant at this point to mention that a number of papers on French, U.S., and Japanese subjects support the observations that old people with high cholesterol are healthier than those with low cholesterol. It is most curious then that Keys did a turn-around and started linking cholesterol with heart disease. There is no record of him ever publishing an admission that the conclusions in his early papers were in error.

In 1980, the U.S. Department of Agriculture and the U.S. Department of Health and Human Services published the first edition of the Dietary Guidelines for Americans that was largely consistent with the saturated fat-cholesterol-heart disease paradigm. From the first edition, the recommendation regarding saturated fat and cholesterol did not change substantially: “avoid too much fat, saturated fat, and cholesterol”. In later editions, the Dietary Guidelines recommended to replace saturated fat with polyunsaturated fat. Following the lead of the U.S., many health agencies all over the world adopted the U.S. recommendation to limit saturated fat and cholesterol and to replace saturated fat with polyunsaturated fat. Even WHO gives a similar recommendation to “limit energy intake from total fats and shift fat consumption away from saturated fats to unsaturated fats and towards the elimination of trans-fatty acids”. As a result, coconut oil has been on the retreat for much of the past 30 years.

After 30 years and seven editions, is there evidence for the success of the Dietary Guidelines? Ironically, the data from the U.S. Centers for Disease Control (CDC) and the U.S. National Institutes of Health (NIH)

show that the obesity in the US has been on the increase and this increase started in 1980, coincident with the promulgation of the Dietary Guidelines in 1980 (Fig. 2a). In fact, global obesity has been increasing mimicking that of the U.S. (Fig. 2b).

But not all scientists have been in agreement with the Dietary Guidelines. In a statistical analysis of U.S. macronutrient data, Cohen and co-workers (2015) highlighted their disagreement in the title of their paper declaring that: "Americans have been following dietary guidelines, coincident with the rise in obesity." Utilizing a systematic review and meta-analysis of randomized control trials (RCTs) published prior to 1983, which examined the relationship between dietary fat, serum cholesterol and the development of CHD, Harcombe and co-workers (2015) concluded that U.S. and British health authorities introduced their dietary recommendations in the absence of supporting evidence from RCTs. In other words, there was insufficient support for the Dietary Guidelines.

To explain the contradicting conclusions regarding cholesterol is the hypothesis that the real problem may be oxidized cholesterol and oxidized LDL. It has been shown that oxidized polyunsaturated fatty acids, oxidized cholesterol and oxidized LDL are harmful. However, using standard clinical procedures, one cannot distinguish oxidized from non-oxidized cholesterol (this can be done using mass spectrometry). Thus, cholesterol gets all the blame when the problem may be oxidation of PUFA oils which are more widely used in the modern Western diet.

The fear of saturated fat and cholesterol inevitably makes people doubt the healthful properties of coconut oil. This fear, however, is unfounded: all of the studies that have been done on the health effects of coconut on populations have uniformly concluded that coconut oil does not cause heart disease. A comparative study on four Polynesian populations was conducted in 1973. The Pukapukans and the Tokelauans who continued to live on their traditional high coconut diet, and the Maoris and Rorotongans who had migrated to New Zealand and who were already consuming Western food. Prior found that the Pukapukans and Tokelauans had lower

### Incidence of Obesity in US, 1971-2006

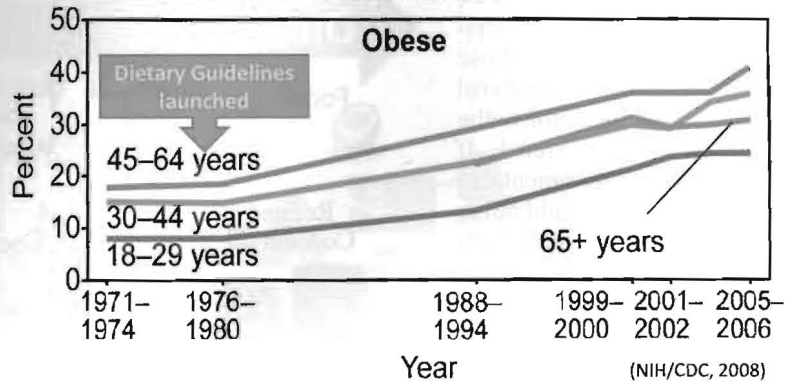


Figure 2a. The incidence of obesity in the U.S. was stable until 1980 when the USDA and the HHS launched the Dietary Guidelines. Today, with 7 editions of the Dietary Guidelines, obesity in the U.S. is at an all-time high.

### Past and projected future overweight rates in selected OECD countries

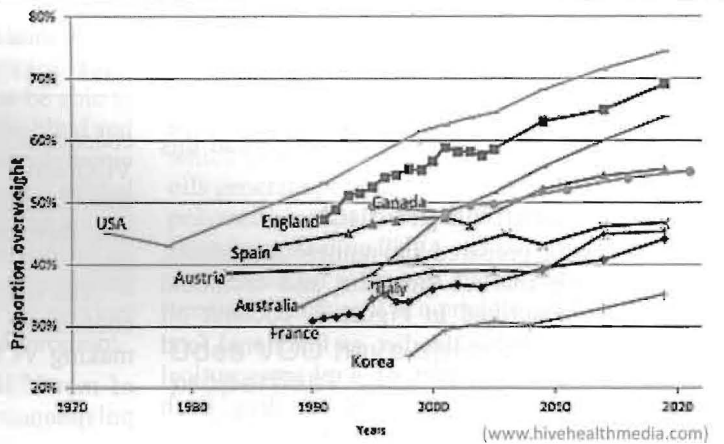


Figure 2b. Many other countries have adopted the Dietary Guidelines for Americans. Obesity has been on the rise globally.

hypertension than their Westernized relatives. A study on two coconut-consuming populations – Indians from Kerala and Indonesians from West Sumatra showed no link between coconut and heart disease.

Ironically, many health researchers in the West are oblivious to the importance of coconut oil in the diet especially of people in the tropics and the unique fatty acid profile of coconut oil is often ignored in assessments of saturated fat. For example, in the Cochrane Database of Systematic Reviews of 2015, a reduction in saturated fat intake was recommended to avoid cardiovascular disease without a single citation of a study on coconut oil (Cochrane 2015). Coconut oil is the equivalent of the Black Swan effect. The Black Swan effect is a metaphor that describes a psychological bias that blinds people to see only familiar phenomena and ignore unfamiliar ones. Coconut oil is largely unfamiliar to Western nutritionists

and MDs.

Finally, there is one evolutionary principle that must be considered by those who believe that cholesterol is harmful. Cholesterol is the chief mammalian sterol. If cholesterol were detrimental to health, mammals would never have evolved with such high reliance on this compound. The anti-cholesterol lobby is anti-Darwinian. Today, despite mounting evidence that the saturated fat-cholesterol-heart disease paradigm is in error, many health agencies continue to advise against saturated fat in favor of polyunsaturated fat and carbohydrates. Mark Twain, the American author and humorist, famously said: "It's easier to fool people than to convince them that they have been fooled." He could have very well had this failed paradigm in mind.

### Define the coconut oil product

Coconut oil can be prepared into numerous products, each with its own market situation and technical requirements. As described in Figure 3, coconut oil can be consumed as food in the diet, as functional food or dietary supplement, as part of a pharmaceutical formulation, or as the active ingredient in a drug. Each application must meet the requirements relevant to the product and so a specific strategy should be developed for each type of product. There are four general types of coconut oil products: refined coconut oil, virgin coconut oil, MCT oil, and monolaurin and tricaprylidene.

#### a. Refined coconut oil

Refined coconut oil represents the biggest market. Refined coconut oil is used as cooking oil and in the preparation of food products. The specifications for refined coconut oil are defined in Codex and the main distinguishing feature is the fatty acid composition. There are active efforts to develop varieties which are high in lauric acid and this will stretch the fatty acid profile of coconut. Since coconut oil competes with lard and other vegetable oils in the cooking oil market, we must develop an appropriate strategy for coconut oil as a healthy cooking oil.

#### b. Virgin coconut oil

Codex gives the official definition of virgin oils. There are only two main virgin oils in the global market: virgin

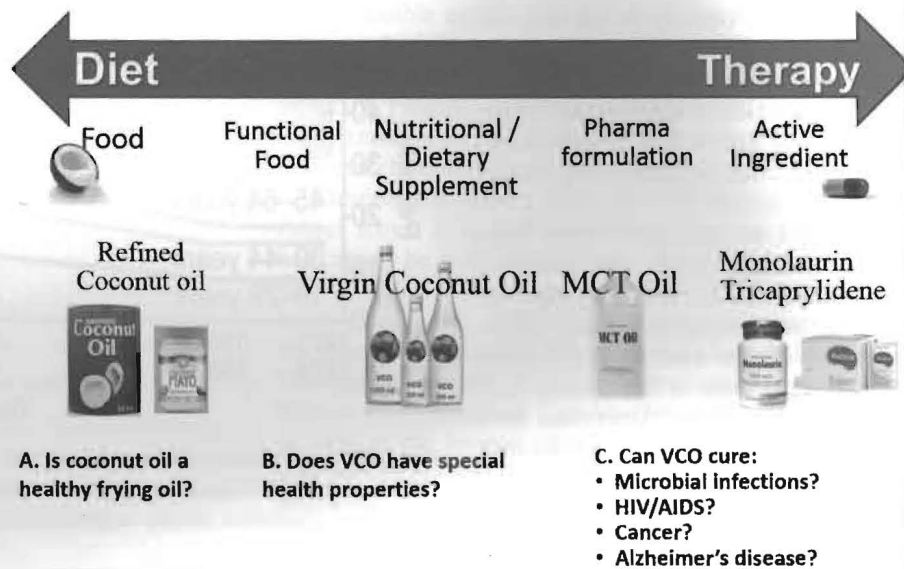


Figure 3. Range of applications of coconut oil with the corresponding coconut oil products. Listed at the bottom of the figure are some key questions that can guide the research that can be done on the coconut oil product.

coconut oil (VCO) and virgin olive oil (VOO). Because VCO and VOO have different fatty acid profiles, these should be considered as complementary healthy virgin oils; there should be no competition between these two oils.

The fatty acid composition of VCO is the same as coconut oil. However, there are at least 4 methods of making VCO and each type of VCO differs in terms of mouth feel, as well as minor constituents, such as polyphenols and gums. There is internal competition among VCO manufacturers on claims regarding which type of VCO is best and this has caused some confusion among consumers. This internal competition will not help the VCO industry as a whole. The more important issue for VCO is product quality and customer satisfaction.

#### c. Coconut-based synthetic products

Coconut oil can be hydrolyzed into its constituent fatty acids, and then re-synthesized into different products. MCT oil is a commercially-available oil containing mainly C8 (caprylic) and C10 (capric). It is recommended as a medical supplement and used by athletes for "clean and quick energy". Other structured lipids have been prepared for specific purposes. Monolaurin and tricaprylidene are synthetic products which use specific fatty acids only, such as lauric acid (C12) and caprylic acid (C8), respectively. These are special-purpose coco fatty acid products.

#### Choose the right type of study

The type of study should match the application that is being targeted, as well as the type of coconut product

that will be used. Figure 3 lists some questions that we can use to guide our research direction. Figure 4 presents a pictorial guide to the range of research that we should do for coconut oil.

The spectrum of health-related research for coconut oil covers in silico (computer) research and statistical and epidemiological research and meta-analysis; in vitro experiments, such as physico-chemical measurements, biochemical, enzyme, and molecular biology studies; in vivo experiments covers the range of studies from cells and stem cells, animal, nutritional and human observational studies, clinical case studies, and human clinical trials from phase II to IV. While the objective is to be able to come up with clinical studies which are double blind and placebo controlled in design, there should be a dynamic process whereby the needed in silico, in vitro and animal in vivo experiments are conducted to support the human studies. There should be a dynamic dialogue among all of these studies which can deepen our understanding with each iteration. In addition, research on product quality should also be included in the overall program.

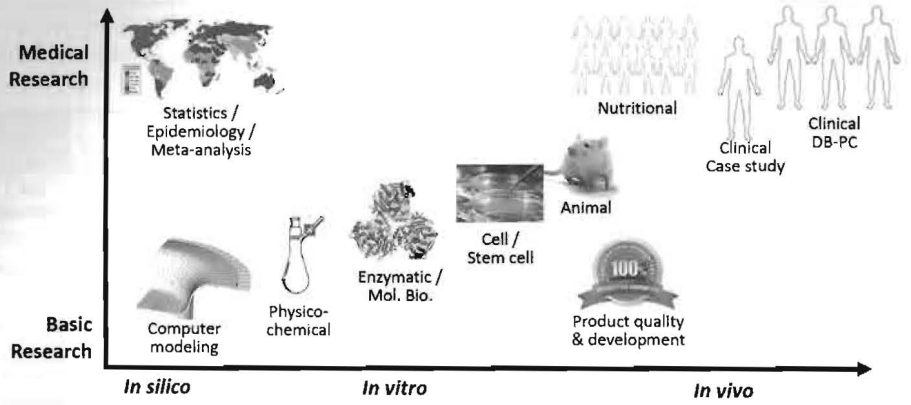


Figure 4. Illustration of the range of researches that we should do to establish the scientific basis for to support health claims for coconut oil products. (note: Clinical DB-PC refers to clinical studies which are double blind-placebo controlled)

**Is coconut oil a healthy frying oil?**

One of the strongest selling points of coconut oil

against other vegetable oils, which are all PUFA oils, is its higher stability towards oxidation under frying conditions. For the purposes of cooking, a more stable saturated oil like coconut oil is far superior to PUFA oils, which includes virtually all other vegetable oils. PUFA oils generate peroxides and free radicals which produce polymeric and polar materials which are ingested by the consumer. Heating PUFA oils also produces carcinogens. So coconut oil is the best choice for a stable cooking oil precisely because it is a predominantly

**Does VCO have special health properties?**

In order to understand the health effects of coconut oil,

Figure 5. Some important physiological processes of fat metabolism.

**2 Fatty Acid Absorption**

**3 Fatty Acid Transport**

**4 Fatty Acid Oxidation**

**1 Fat Digestion**

**5 Ketone body formation**

**6 Modulatory activity**

**7 Gut microbial modulatory activity**



k - including the two who developed AIDS and were recovering. The single AIDS fatality lost 6 k. The other three who failed to gain weight had decreasing viral and rising CD4 counts at the end of the six month period. This initial trial confirmed the anecdotal reports that coconut oil has an anti-viral effect and can beneficially reduce the viral load of HIV patients. The positive anti-viral action was seen not only with monolaurin acid but with coconut oil itself. This study on HIV/AIDS gave very promising preliminary results, but a larger clinical trial needs to be designed and carried out.

VCO may have special use in cancer therapy as an alternative energy source to glucose. Otto Warburg hypothesized that tumor cells generate energy exclusively by non-oxidative breakdown of glucose (glycolysis). In contrast, normal non-tumor cells can generate energy from glucose, as well as from alternative sources of energy such as ketone bodies. Because VCO is able to form ketone bodies, it has been shown experimentally to be effective for the treatment of certain cancers. Normal cells which can metabolize ketone bodies survive, but cancer cells which cannot metabolize ketone bodies die out. This has been shown in *in vitro*, *in vivo* animal and human studies and should be further pursued so that it can be adopted as standard of care.

Alzheimer's disease is a rising global disease that is yet to find a cure. Anecdotal reports on VCO have claimed effective management of Alzheimer's disease even at advanced stages. Ketone bodies, as well as the polyphenols in VCO, have been identified as the active agents. Coconut oil co-treatment also attenuated amyloid beta-induced mitochondrial alterations. On the other hand, Hertz and co-workers showed that low doses of ketone bodies can potentially have therapeutic effect in Alzheimer's disease by enabling ketone bodies to supply a fraction of needed ATP to compensate for the deficiency in glucose metabolism in Alzheimer's patients. Animal and clinical studies are currently being carried out to study the efficacy of VCO in the management of this dreaded disease. Compared to other vegetable oils such as olive oil, palm oil and canola oil, much fewer clinical studies have been conducted on VCO. For example, a check of the website [www.clinicaltrials.gov](http://www.clinicaltrials.gov) last March 2015 yielded a list of 24 clinical studies on VCO, compared with 190 for olive oil and VOO, 55 for palm oil, and 49 for canola oil. It is clear that more clinical studies on coconut oil are needed.

### Strategy for coconut oil

It is clear that, with the right strategy, coconut still has great potential for further development. However, the research effort has to be raised and new elements have to be added. The research output has to be at the level that is acceptable in the best international journals. The new elements of nutrigenomics and meta-analysis

have to be added. Nutrigenomics is the study of the effects of food on gene expression and metabolism. It aims to identify and analyze molecular-level interactions of diet on the metabolism and health of individual as influenced by genetic variations. It can be used to compare the metabolism of MCT and VCO versus LCT and PUFA, and understand the effects of VCO on diabetes, obesity, cancer, and other diseases. It never occurred to the Ansel Keys to consider the differences in the genetic make-up of the subjects that were involved in the Seven Countries Study. We now know that the various races and individuals metabolise fats differently depending on the haplotype of their mitochondrial DNA (mtDNA). This results in variations in bioenergetics among people which influence lipid metabolism. If the Seven Country Study were to be repeated today, a wider genetic sample and genetic analysis will have to be considered. Consistent with this, in many Asian countries, adult levels of cholesterol are often less than 200 mg dl<sup>-1</sup>, whereas in Europe and the USA they are greater than 200 mg dL<sup>-1</sup>.

A number of papers have pointed out the importance of considering genetics when assessing the nutrition outcomes of different individuals and populations. In addition, the role of gut microflora also plays an important role in the physiological response of individuals and populations to diet. Clearly, the Seven Countries Study cannot be considered today to have valid wide-ranging conclusions and the singular focus on cholesterol as a biomarker for heart disease is mistaken.

Another methodology of importance is meta-analysis. Meta-analysis is a statistical technique for combining the findings from independent studies. Individual trials may fail to show a statistically significant result. However, when the results from several studies are combined using meta-analysis, significant conclusions may be drawn. A methodology of systematic review is at the heart of meta-analysis. The quality of the design and execution of each study is assessed. A systematic review can provide a valid statistical estimate aggregated over all the included studies. Meta-analysis is now an important part of evidence-based medicine. A coconut research matrix (Fig. 6) is recommended as a guide for the research on coconut oil. Research projects can be classified according the level of research (from basic research to medical research), and whether the research is *in silico*, *in vitro*, or *in vivo* (animal or human).

In September 2015, Credit Suisse, an institution that is normally associated with banking and financial investment, came out with a book entitled: "Fat: The New Health Paradigm". This book presented the emerging ideas regarding fat and is significant because it represents the shifting views of the usually conservative banking community towards fat, which in some ways is

more progressive than that of the regulatory agencies. The Credit Suisse book ended with an assessment of the expected changes in health perception of the major vegetable oils. It concluded that soybean oil, canola oil and sunflower oil will suffer a lower health perception; olive oil and palm oil will remain unchanged in terms of health perception; and only coconut oil will enjoy a rise in health perception. While this is indeed very good news for coconut oil, it also urges the coconut industry to raise the level of research in order that it can meet the expectations of a more health-conscious society.

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