Chapter 5. Lauric oils as anti-microbial agents: Theory of effect, scientific rationale, and dietary application as adjunct nutritional support for HIV-infected individuals (only a portion of this chapter is excerpt).

INTRODUCTION

More than a decade and a half after the beginning of the AIDS epidemic there is still general agreement in the medical community that there "remains an urgent need for interventions" that include, in addition to an effective vaccine, safe and inexpensive drug therapies to treat individuals already infected with HIV-1. Such therapies should include effective adjunct nutritional support regimens.

Since the current research suggests that individuals infected with the HIV-1 virus progress more rapidly to AIDS when they have higher levels of the virus RNA, it is clear that alternative treatment modalities that help to lower the virus load would be useful. Although some of the recent studies (reported in 1996), using multiple drug cocktails, have been shown to lower viral load and look promising, the expense of such treatment is considerable (more that $15,000 per person per year). There are also concerns that there may be increased risk that such treatment might lead to drug-resistant viral strains. Thus, the potential benefit of regularly including in diets inexpensive and safe components that can help to lower the viral load, such as the lauric oils, represents a desirable nutritional support regimen for HIV-infected individuals worth investigating.

Medium-chain saturated fatty acids are well-known for their virucidal effects against viruses with lipid membranes as well as against numerous other pathogenic microorganisms. These antimicrobial fatty acids and their derivatives are essentially non-toxic to man; they are produced in vivo by humans when they ingest those foods that contain adequate levels of the appropriate medium-chain saturated fatty acids such as lauric acid.

In this chapter, a diet regimen that utilizes adequate sources of those anti-viral, anti-bacterial, and anti-protozoal monoglycerides and their fatty acid precursors that are found principally in lauric oils is proposed and described. The lauric oils such as coconut oil or palm kernel oil, both of which are GRAS, can provide a unique source of both antimicrobial lipids and needed calories. The scientific rationale for their use is reviewed and documented.


Information about the nutritional needs, and development of systems of nutritional support for individuals infected with the human immunodeficiency virus known as HIV-1 (or HIV+ for short) or those suffering from the frank acquired immune deficiency syndrome (AIDS), has been gradually increasing over the past several years. In part, recognition of the importance of this specialized nutrition information has come about because of the realization that nutrition plays a critical role in maintaining an efficiently functioning immune system.

The individual with HIV+/AIDS, whose immune system is already compromised by being HIV+ or who has progressed to a frank AIDS, is further disadvantaged by a diet that is inadequate in calories or a diet that has inappropriate balance of macro and micro nutrients. The individual with AIDS will become readily malnourished
as well as progressively more immune-compromised under circumstances with frequent bouts of infection such as those precipitated by opportunistic microorganisms, e.g., cytomegalovirus, candida, cryptosporidium.

A comprehensive review in 1990 by Raiten was directed at providing ".a scientific report on all aspects of nutrition and HIV-related disease for the use of health care providers." The review was prepared by the Life Sciences Research Office of the Federation of American Societies for Experimental Biology for the Center for Food Safety and Applied Nutrition of the Food and Drug Administration. Although the review included discussions of both conventional and unconventional diet therapies, information on antimicrobial lipids was not included.

b. Nutritional Interventions During HIV Infection.

Aron has reviewed the use of nutritional interventions in early HIV disease, latent stage HIV, and late stage HIV/AIDS. During early HIV infection there is an increase in resting energy expenditure (REE), a decrease in lean body mass, and altered triglyceride status. Recommendations during this early stage include increased energy intake with emphasis on avoidance of low or no-calorie foods and beverages. Also recommended is supplementation with certain vitamins and trace elements, as well as experimental fish oil supplementation.

During latent stage HIV infection there are further increases in REE as well as futile lipid cycling with difficulty maintaining body weight. Recommendations during this stage include the addition of enteral feeding supplementation using intact formulas (e.g., Ensure, Nutren, Replete, etc.) or special formulas (e.g., Impact, Peptamen) and various digestive aids.

Further metabolic disturbances during late stage HIV disease: AIDS include the problems of major lipid futile cycling with increased de novo lipogenesis, increased whole body fat oxidation, increased endogenous cholesterogenesis, increased free fatty acid production, greatly increased REE, decreased nitrogen balance, and increased hepatic gluconeogenesis. Further complications stem from multiple infections caused by opportunistic microorganisms (e.g., cytomegalovirus, candida, cryptosporidia). Nutritional intervention in this late stage disease has been focused on aggressive parenteral nutrition; an upper daily limit for lipids given parenterally has been set at 0.11 g/kg · h.

Aron(7) also notes that "the use of nutrient components for their pharmacologic properties rather than for their nutrient effects warrants investigation," and suggests the attractiveness of studying a "superlipid" composed of fish oil, medium chain triglyceride and phospholipid in AIDS patients who require TPN.

c. Current Published Dietary Recommendations for Individuals With HIV/AIDS.

Current published dietary regimens for individuals infected with HIV invariably address the concept of "eating right" as a means of improving immune status, since, as noted by Dwyer(8), "...conventional or standard treatments are relatively ineffective in halting the underlying immunodeficiency..." Different clinicians understand the meaning of "eating right" differently. For example, Dwyer et al consider the Dietary Guidelines for Americans an appropriate basic diet; Wickwire, on the other hand, points to the inappropriateness of such a diet for individuals with AIDS.

These two approaches are in diametric opposition with respect to the dietary fat. Dwyer et al(8) encourages a lower fat regimen, in part because of the anecdotal information about problems with fat digestion in AIDS patients, and in part because of the current anti-fat rhetoric from government agencies and certain consumer groups. Wickwire(9) recognizes the need for a higher fat regimen to provide additional caloric density to the diet.
d. Low Fat Dietary Regimens Are Not Appropriate for Individuals with HIV+/AIDS

With the exception of a few special diet booklets written for HIV+/AIDS patients, which recognize the need for "fats in moderation," writers of current foods and nutrition texts who use government and industry promoted recommendations either ignore the issue of fats or are rather uniform in their advocacy of the selection of low fat foods. However, these writers usually recommend high calorie diets. High calorie diets cannot be made palatable without using adequate levels of fat.

Automatic acceptance by health and nutrition professionals of U.S. government recommendations for lowering dietary fat consumption to 30% of energy (calories), and which are applied to all fats regardless of type, should be ignored by the individual who is HIV+positive or has progressed to AIDS as long as the fat in the diet is high lauric fat. Fats that should be avoided are those oils that are partially hydrogenated, and oils that are high in omega-6 oils without adequate levels of omega-3 fatty acids. It is important to maintain an appropriate omega-6/omega-3 balance, i.e. no less than 4:1 and no greater than 10:1.

RATIONALE FOR ADDING ANTIVIRAL LIPIDS TO DIETS

None of the clinicians from the mainstream nutrition/dietetics community seems to have recognized the added potential to be gained by use of antimicrobial lipids in the nutritional support treatment of HIV-infected individuals or patients who have progressed to AIDS. These antimicrobial fatty acids and their derivatives are essentially non-toxic to man; they are produced in vivo by humans when they ingest those commonly available foods that contain adequate levels of medium-chain fatty acids such as lauric acid. According to published research, lauric acid is one of the best "inactivating" fatty acids, and its monoglyceride is an even more effective antimicrobial than the fatty acid alone.

a. Antimicrobial Activity of Monolaurin, the Monoglyceride of Lauric Acid

Recognition of the antimicrobial activity of the monoglyceride of lauric acid (monolaurin) has been reported since 1966. The seminal work can be credited to Jon Kabara at Michigan State University(11). Some of the early work by Kabara that showed virucidal effects of monolaurin on enveloped RNA and DNA viruses was done with selected prototypes or recognized representative strains of enveloped human viruses; the envelope of these viruses is a lipid membrane. This early research was directed at the virucidal effects of monolaurin because there were concerns about viral contamination in foods and monolaurin was seen as having potential related benefits to food preservation.

Kabara and others have reported that certain fatty acids (e.g., medium-chain saturates) and their derivatives (e.g., monoglycerides) can have adverse effects on a variety of microorganisms. Those microorganisms that are inactivated by monolaurin include bacteria, yeast, fungi, and enveloped viruses (Table 1)(5)(11)(13)(19)(20)(21)(22)(23)(24)(25).
The medium-chain saturated fatty acids and their derivatives act by disrupting the lipid membranes of the organisms. In particular, enveloped viruses are inactivated in both human and bovine milk by added fatty acids (FAs) and monoglycerides (MGs) as well as by endogenous Fas and MGs(11). All three monoesters of lauric acid are shown to be active antimicrobials, i.e., -, -, and –MG. Additionally, it is reported that the antimicrobial effects of the Fas and MGs are additive and total concentration is critical for inactivating viruses.

Some of the viruses inactivated by the lauric acid monoglycerides, in addition to HIV, are the measles virus, herpes simplex virus-1 (HSV-1), vesicular stomatitis virus (VSV), visna virus, and cytomegalovirus (CMV). Many of the pathogenic organisms reported to be inactivated by these antimicrobial lipids are those known to be responsible for opportunistic infections in HIV-positive individuals. For example, concurrent infection with cytomegalovirus is recognized as a serious complication for HIV+ individuals. Thus, it would appear to be important to investigate the practical aspects and the potential benefit of an adjunct nutritional support regimen for HIV-infected individuals, which will utilize those dietary fats that are sources of known anti-viral, anti-microbial, and anti/protozoal monoglycerides and fatty acids.

The properties that determine the anti-infective action of these lipids are related to their structure; e.g., monoglycerides, free fatty acids. The monoglycerides are active, diglycerides and triglycerides are inactive. Of the saturated fatty acids, lauric acid has greater antiviral activity than either caprylic acid (C-8), capric acid (C-10) or myristic acid (C-14) for these viruses.

The action attributed to monolaurin is that of solubilizing the lipids and phospholipids in the envelope of the virus causing the disintegration of the virus envelope. In effect, it is reported that the fatty acids and monoglycerides produce their killing/inactivating effect by lysing the (lipid bilayer) plasma membrane. However, there is evidence from recent studies that one antimicrobial effect is related to its interference with signal transduction.

LAURIC ACID IN THE DIET: HISTORICAL AND CURRENT STATUS

a. What Is the Current Use of Lauric-rich Diets as Antiviral Modalities for Adjunct Nutrition Support in HIV?

Except for the use of commercially available enteral feeding supplements (e.g., Ensure-type liquids) that utilize medium-chain triglyceride (MCT) oils, and one enteral product (Impact®, Sandoz Nutrition) that contains palm kernel oil as part of its structured lipid, novel or unusual dietary treatments related to fats in the diet appear not to have been systematically investigated for HIV adjunct treatment, although there is a substantial research supporting their potential. At least one of the commercial lipid formulas (High MCT Supplement®, Corpak, Inc.) is based on coconut oil. This product is listed as an incomplete medical food in tables of enteral formulas and does not appear to have been utilized in treatment of AIDS patients.

The American Foundation for AIDS Research (AMFAR) did a preliminary review of the antiviral lipid monolaurin in 1987 but did not pursue this adjunct treatment modality (AMFAR office, personal communication 1994). Also in 1987, an alternative medical journal published an extensive discussion of the properties and clinical use of monolaurin. However, as noted above, the review by Raiten(6) did not indicate use of or knowledge of monolaurin.
Most dietary recommendations published for HIV+/AIDS patients are directed at prevention of weight loss. All the diets currently being formally recommended by the professional dietetic groups, government agencies, or organizations involved in support for individuals with AIDS are structured from foods that are missing lauric acid. Thus any benefit that might accrue to an individual who is HIV+ or has AIDS, from the substantial utilization of lauric acid-rich foods, is missing.

The potential benefits that can be derived from feeding antimicrobial lipids need to be investigated in humans on a systematic basis, the lauric oils need to be made more readily available in the general food supply, and the rationale for use of these lipids needs to be explained to the food and nutrition professionals as well as the medical and lay community.

b. Loss of lauric acid from the American diet

Increasingly, over the past 40 years, the American diet has undergone major changes. Many of these changes involve changes of fats and oils. There has been an increasing supply of the partially hydrogenated trans-containing vegetable oils and a decreasing amount of the lauric acid-containing fats and oils. As a result of these shifts in fats usage, there has been an increased consumption of trans fatty acids and linoleic acid and a decrease in the consumption of lauric acid. There has also been a decrease in some of the other antimicrobial fatty acids. This type of change in the diet has an important effect on the fatty acids the body has available for its metabolic activities.

The lipid coated (envelop) viruses are dependent on host lipids for their lipid constituents. Given this fact, it becomes important to evaluate the variability of the fatty acids in an individual patient’s diet, since such variability is reflected in the changes in the lipid membrane of the virus envelop, leads to the variability of glycoprotein expression, and plays a role in the aspects of mutation that interfere with successful vaccine development.

c. Lauric Acid Intake in Selected Asian Countries

Based on the per capita intake of coconut oil in 1985 as reported by Kaunitz, the per capita daily intake of lauric acid can be approximated. For those major producing countries such as the Philippines, Indonesia, and Sri Lanka, and consuming countries such as Singapore, the daily intakes of lauric acid were approximately 7.3 grams (Philippines), 4.9 grams (Sri Lanka), 4.7 grams (Indonesia), and 2.8 grams (Singapore). In India, intake of lauric acid from coconut oil in the coconut growing areas (e.g., Kerala) range from about 12 to 20 grams per day, whereas the average for the rest of the country is less than half a gram. An average high of approximately 68 grams of lauric acid is calculated from the coconut oil intake previously reported by Prior et al in 1981 for the Tokelau Islands. Other coconut producing countries may also have intakes of lauric acid in the same range.

d. Lauric Acid Intake in the U.S.

In the United States today, there is very little lauric acid in most of the foods. During the early part of the 20th Century and up until the late 1950s many people consumed heavy cream and high fat milk. These foods could have provided approximately 3 grams of lauric acid per day to many individuals. In addition, desiccated coconut was a popular food in homemade cakes, pies and cookies, as well as in commercial baked goods, and 1-2 tablespoons of desiccated coconut would have supplied 1-2 grams of lauric acid. Those foods made with the
coconut oil based shortenings would have provided additional amounts. Until two years ago, some of the commercially sold popcorn, at least in movie theaters, had coconut oil as the oil. This means that for those people lucky enough to consume this type of popcorn the possible lauric acid intake was 6 grams or more in a three(3) cup order.

Some infant formulas (but not all) have been good sources of lauric acid for infants. However, in the past 3-4 years there has been reformulation with a loss of a portion of coconut oil in these formulas, and a subsequent lowering of the lauric acid levels. Only one U.S. manufactured enteral formula contains lauric acid (e.g., Impact®); this is normally used in hospitals for enteral tube feeding; it is reported to be very effective in reversing severe weight loss in AIDS patients, but it is discontinued when the patients leave the hospital because it is not sufficiently palatable for continued oral use (D.P. Kotler, private communication, 1995) The more widely promoted enteral formulas (e.g., Ensure®, Nutren®) are not made with lauric oils, and, in fact, many are made with partially hydrogenated oils.

There are currently some candies sold in the US that are made with palm kernel oil, and a few specialty candies made with coconut oil and desiccated coconut. These can supply small amounts of lauric acid. Cookies such as macaroons, if made with desiccated coconut, are good sources of lauric acid, supplying as much as 6 grams of lauric acid per macaroon (Red Mill Farm's Jennies Macaroons is apparently the only brand in the U.S. that supplies this amount). However, these cookies make up a small portion of the cookie market. Most cookies in the United States are no longer made with coconut oil shortenings; however, there was a time when many U.S. cookies (e.g., Pepperidge Farm) were about 25% lauric acid.

Originally, one of the largest manufacturers of cream soups used coconut oil in the soup formulations. Many popular cracker manufacturers also used coconut oil as a spray coating. These products supplied a small amount of lauric acid on a daily basis for some people.

e. Probable Levels of Lauric Acid Required For Antimicrobial Effect

Based on the amount of lauric acid found in human milk, which is known to be effective in its role as an antimicrobial component for the infant, the percent of calories that would be appropriate can be determined. For example, human milk provides at least 3.5% of calories as lauric acid for the human infant. Mature human milk has been noted to have up to 12% of the total fat as lauric acid (approximately 6.6% of calories. The upper end of this range represents approximately twice the amount of calories as lauric acid (i.e., 7% of calories) as does the minimum.

When developing lauric-rich diets for adults, one can use this range as the starting point for calculating the amount of lauric fat to be consumed. Based on the upper end of the range, we see that this would entail providing an adult consuming 3000 kilocalories a day with 52 grams of coconut oil (approximately 24 grams of lauric acid). This could be accomplished by use, for example, of two 250 ml cans of a calorically dense enteral formula (e.g., Carnation Nutren 2.0) if that product was made with full coconut oil. As it is, that product is made with MCT oil and corn oil and provides no lauric acid.

Lauric acid-rich diets can be developed readily for infants and children. For infants, a formula made with coconut oil that supplies at least 7% of the calories as lauric acid would be needed. When infants progress to solid food, these foods can be enriched with added coconut oil. Cereals and strained baby foods make ideal bases for 2-5 gram additions coconut oil (0.5-1.0 teaspoons). This would add approximately 1-2 grams of lauric acid. Children can utilize the same protocol as outlined for adults with alterations in the portions of food depending on the caloric needs of the child.