Carotenoid bioavailability is higher from salads ingested with full-fat than with fat-reduced salad dressings as measured with electrochemical detection1,2,3

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Abstract

Background: The amount of dietary fat required for optimal bioavailability of carotenoids in plant matrices is not clearly defined.

Objective: The objective was to quantify the appearance of carotenoids in plasma chylomicrons after subjects ingested fresh vegetable salads with fat-free, reduced-fat, or full-fat salad dressings.

Design: The subjects (n = 7) each consumed 3 salads consisting of equivalent amounts of spinach, romaine lettuce, cherry tomatoes, and carrots with salad dressings containing 0, 6, or 28 g canola oil. The salads were consumed in random order separated by washout periods of ≥2 wk. Blood samples were collected hourly from 0 to 12 h. Chylomicrons were isolated by ultracentrifugation, and carotenoid absorption was analyzed by HPLC with coulometric array detection.

Results: After ingestion of the salads with fat-free salad dressing, the appearance of α-carotene, β-carotene, and lycopene in chylomicrons was negligible. After ingestion of the salads with reduced-fat salad dressing, the appearance of the carotenoids in plasma chylomicrons increased relative to that after ingestion of the salads with fat-free salad dressing ($P < 0.04$). Similarly, the appearance of the carotenoids in plasma chylomicrons was higher after the ingestion of salads with full-fat than with reduced-fat salad dressing ($P < 0.02$).

Conclusions: High-sensitivity HPLC with coulometric array detection enabled us to quantify the intestinal absorption of carotenoids ingested from a single vegetable salad. Essentially no absorption of carotenoids was observed when salads with fat-free salad dressing were consumed. A substantially greater absorption of carotenoids was observed when salads were consumed with full-fat than with reduced-fat salad dressing.

Dress Your Salad in Olive Oil to Get the Most Nutrients

A new study from Purdue University showed that olive oil might be the best choice of salad dressing when it comes to absorbing nutrients from the vegetables. It appears that monounsaturated fats provide the most efficient absorption of carotenoids, pigments with antioxidant activity present in vegetables and fruit.

Previous research has showed that carotenoids, such as beta-carotene were more bioavailable, in other words were more easily absorbed by the body when fat was present in the salad. Carotenoids are pigments that are responsible for the bright colors of fruit and vegetables and are associated with a variety of health benefits such as protection from cancer and heart disease and promotion of eye health.

For this study published in the journal Molecular Nutrition & Food Research, researchers gave 29 participants salad with either a saturated fat dressing, a monounsaturated fat dressing or a polyunsaturated fat dressing. Each salad was served with 3 grams, 8 grams or 20 grams of fat from dressing. The participants had their blood tested for absorption of fat-soluble carotenoids, compounds such as lutein, lycopene, beta-carotene and zeaxanthin.

While all fats promoted absorption of the carotenoids, the salad dressing that contained the monounsaturated fat (the main type of fatty acids in olive oil) promoted the equivalent carotenoid absorption at 3 grams of fat as it did 20 grams. In other words it required the least amount of fat to get the most carotenoid absorption, while saturated fat and polyunsaturated fat dressings required higher amounts of fat to get the same benefit. This makes monounsaturated fat such as olive oil, a great choice for those watching their fat or calorie intake.

It is important to note that the researchers used canola oil as their source of monounsaturated fat dressing. However, olive oil actually contains more monounsatured fat than canola oil, in fact olive oil has the highest amount of monounsaturated fat among commonly used cooking oils, but it is also a source of beneficial antioxidants as well, providing a double benefit.

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Molecular Nutrition and Food Research

Purdue University News Service

Fat-Free and Low-Fat Dressings Don't Unlock the True Potential of Salad

Jun 19, 2012 05:14 PM By Charles Poladian

In the case of salad dressings, some fat may be a good thing. Olive oil and canola oil- based dressings may help you get the most of your salad without ruining your diet.

Fat-free and low-fat salad dressings may not be as good for you as regular salad. It's not because the dressings are not as healthy as they claim but because they don't unlock the full nutrient potential of salads.

In the case of salad dressings, some fat may be a good thing. Olive oil and canola oil-based dressings may help you get the most of your salad without ruining your diet. The reason for this is that there are many nutrients in salads that are fat soluble nutrients that won't be absorbed by your body if you choose fat-free or low-fat dressings.

The study was led by Mario Ferruzzi, PhD, associate professor of food science at Purdue University. Researchers tested human absorption of carotenoids when using di erent types of fat-based dressings. The trial included 29 people being fed salad that was topped with either saturated, monounsaturated or polyunsaturated-based dressings and having blood samples taken to measure carotenoid levels. The salad dressings were topped with three, eight or 20 grams of fat from the dressing.

Carotenoids such as lutein, lycopene, beta-carotene and zeaxanthin can help reduce the risk of cardiovascular disease, cancer and macular degeneration. These nutrients dissolve in fat and when humans consume fat-free or low-fat dressings, there will be fewer calories consumed but also less carotenoids that can be absorbed by humans.

Certainly too much fat in dressing is a bad thing and that's why researchers factored in dosage. In the 29 participants, monounsaturated fat-based dressings equired the lowest dose of fat, three grams, to have the participants gain the most carotenoid absorption from the salad. Three grams of fat from the monounsaturated fat-based dressing absorbed as much carotenoids as 20 grams of fat.

Both the saturated fat-based, such as butter, and polyunsaturated-based, such as soybean oil, dressings required more fat to get more carotenoids from the salad.

While watching how many calories and how much fat you consume is important in daily diet choices, understanding nutrient absorption is just as important. With just a little bit of fat from using canola oil or olive oil-based dressings you'll be getting even more value from that salad thanks to all the nutrients you'll be absorbing.

Sources:
Molecular Nutrition and Food Research
Purdue University News Service

Study: No-fat, low-fat dressings don't get most nutrients out of salads

Jun 19, 2012

WEST LAFAYETTE, Ind. - The vegetables in salads are chock-full of important vitamins and nutrients, but you won't get much benefit without the right type and amount of salad dressing, a Purdue University study shows.

In a human trial, researchers fed subjects salads topped off with saturated, monounsaturated and polyunsaturated fat-based dressings and tested their blood for absorption of fat-soluble carotenoids – compounds such as lutein, lycopene, beta-carotene and zeaxanthin. Those carotenoids are associated with reduced risk of several chronic and degenerative diseases such as cancer, cardiovascular disease and macular degeneration.

The study, published early online in the journal Molecular Nutrition & Food Research, found that monounsaturated fat-rich dressings required the least amount of fat to get the most carotenoid absorption, while saturated fat and polyunsaturated fat dressings required higher amounts of fat to get the same benefit.

"If you want to utilize more from your fruits and vegetables, you have to pair them correctly with fat-based dressings," said Mario Ferruzzi, the study's lead author and a Purdue associate professor of food science. "If you have a salad with a fat-free dressing, there is a reduction in calories, but you lose some of the benefits of the vegetables."

In the test, 29 people were fed salads dressed with butter as a saturated fat, canola oil as a monounsaturated fat and corn oil as a polyunsaturated fat. Each salad was served with 3 grams, 8 grams or 20 grams of fat from dressing.

The soybean oil rich in polyunsaturated fat was the most dependent on dose. The more fat on the salad, the more carotenoids the subjects absorbed. The saturated fat butter was also dose-dependent, but to a lesser extent.

Monounsaturated fat-rich dressings, such as canola and olive oil-based dressings, promoted the equivalent carotenoid absorption at 3 grams of fat as it did 20 grams, suggesting that this lipid source may be a good choice for those craving lower fat options but still wanting to optimize absorption of health-promoting carotenoids from fresh vegetables.

"Even at the lower fat level, you can absorb a significant amount of carotenoids with monounsaturated fat-rich canola oil," Ferruzzi said. "Overall, pairing with fat matters. You can absorb significant amounts of carotenoids with saturated or polyunsaturated fats at low levels, but you would see more carotenoid absorption as you increase the amounts of those fats on a salad."

The findings build on a 2004 Iowa State University study that determined carotenoids were more bioavailable – absorbed by the intestines – when paired with full-fat dressing as opposed to low-fat or fat-free versions. Ferruzzi; Wayne Campbell, a Purdue professor of nutrition science; Shellen Goltz, a Purdue graduate student in food science; and their collaborators, Chureeporn Chitchumroonchokchai and Mark L. Failla at Ohio State University, are the first to study different types of fats in differing amounts in human subjects.

Ferruzzi and colleagues will next work on understanding how meal patterning affects nutrient absorption. He is trying to determine whether people absorb more nutrients if they eat vegetables at one time or if consumption is spread throughout the day.

The U.S. Department of Agriculture funded the research.

ABSTRACT

Meal Triacylglycerol Profile Modulates Postprandial Absorption of Carotenoids in Humans

Shellen R. Goltz, Wayne M. Campbell, Chureeporn Chitchumroonchokchai, Mark L. Failla, Mario G. Ferruzzi

Scope: Dietary lipids are considered to be primary potentiators of carotenoid absorption, yet the amount and source required to optimize bioavailability has not been systematically evaluated. The objective of this study was to examine the impact of both amount and source of triacylglycerols on postprandial absorption of carotenoids from vegetable salads.

Methods and results: Healthy subjects (n = 29) were randomized using a Latin square design (3x3) and consumed three identical salads with 3, 8 or 20 g of canola oil, soybean oil or butter. Blood was collected from 0–10 h and triacylglycerol-rich fractions (TRLs) were isolated by ultracentrifugation. Carotenoid contents of TRL fractions were analyzed by HPLC-DAD. Considering all lipid sources, 20 g of lipid promoted higher absorption compared to 3 and 8 g for all carotenoid species ($p < 0.05$), except for α-carotene ($p = 0.07$). The source of lipid had less impact on the absorption of carotenoids than amount of lipid. Pooling results from all lipid amounts, monounsaturated fatty acid rich canola oil trended toward enhancing absorption of lutein and α-carotene compared to saturated fatty acid rich butter ($p = 0.06$ and $p = 0.08$, respectively).

Conclusion: While both amount and source of co-consumed lipid affect carotenoid bioavailability from vegetables, amount appears to exert a stronger effect.

Dressing Your Salad to Boost Nutrients

If you want to get the biggest nutritional bang from your salad greens, be sure your dressing is made with a monounsaturated fat such as olive oil or canola oil. A new study from Purdue University found that salad dressings made with monounsaturated fat - canola oil was the one used in the study - enhanced absorption of the health-promoting carotenoids in salad vegetables. What's more, the monounsaturated-based dressing resulted in the same amount of carotenoid absorption whether it contained three grams of fat or 20 grams. Researchers at Purdue fed 29 study volunteers salads topped with saturated, monounsaturated and polyunsaturated dressings and then ran blood tests to see how well their subjects absorbed carotenoids including lutein, lycopene, beta-carotene and zeaxanthin. The investigators found that polyunsaturated or saturated fat-based dressings also boost carotenoid absorption, but amounts were dose-dependent. That is, to absorb more nutrients you have to use more dressing. If you use a fat-free dressing, you cut calories but also lose out on carotenoids.

My take? I'm not a big fan of salad dressing. Most of the time I use a small amount of olive oil (a monounsaturated fat) on my salads. If you check out some of the recipes for salad dressing on my website, you'll see that I don't recommend using much. This study shows that even with a little bit of the healthiest type of fat you get a bigger nutritional pay-off from your salad than you would if you used much more polyunsaturated or saturated fat. Olive oil has the highest percentage of heart-healthy monounsaturated fat of any edible oil, and quality olive oil also contains abundant antioxidants, substances that have been shown to provide cardiovascular and anti-cancer benefits. And, of course, quality olive oil tastes wonderful.

Get The Most Nutrition From Your Veggies

July 27, 200912:16 AM ET
Heard on Morning Edition

A recent study in the Journal of Food Science suggests that green beans, beets and garlic maintain their antioxidant levels even after most kinds of cooking.

If you want to get the biggest nutritional bang from your salad greens, be sure your dressing is made with a monounsaturated fat such as olive oil or canola oil. A new study from Purdue University found that salad dressings made with monounsaturated fat - canola oil was the one used in the study - enhanced absorption of the health-promoting carotenoids in salad vegetables. What's more, the monounsaturated-based dressing resulted in the same amount of carotenoid absorption whether it contained three grams of fat or 20 grams. Researchers at Purdue fed 29 study volunteers salads topped with saturated, monounsaturated and polyunsaturated dressings and then ran blood tests to see how well their subjects absorbed carotenoids including lutein, lycopene, beta-carotene and zeaxanthin. The investigators found that polyunsaturated or saturated fat-based dressings also boost carotenoid absorption, but amounts were dose-dependent. That is, to absorb more nutrients you have to use more dressing. If you use a fat-free dressing, you cut calories but also lose out on carotenoids.

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Dietary fat is necessary for absorption of vitamins, nutrients and phytochemicals from fruits and vegetables

Wednesday, July 28, 2004
by Mike Adams, the Health Ranger

A fascinating new study published by the American Journal of Clinical Nutrition shows that dietary fat is necessary for the absorption of nutrients from fruits and vegetables. In the study, people who consumed salads with fat-free salad dressing absorbed far less of the helpful phytonutrients and vitamins from spinach, lettuce, tomatoes and carrots than those who consumed their salads with a salad dressing containing fat.
This is interesting research, but not necessarily all that surprising. We've known for a long time that healthy fats are a critical part of a healthy diet, and that avoiding fats actually causes chronic disease. The key is in choosing the right kind of fats for your diet and making sure you don't overdo the fats, because fats have a very high caloric density and can add far more calories to your meal than you might expect.

In this study, the focus was on eating salads with either fat-free salad dressing or regular salad dressing containing fat in the form of canola oil. However, these findings apply to far more than just eating salads. Every meal that you consume should contain healthy fats, even if only in small portions. What are the healthy fats? Canola oil is what I consider a neutral fat, meaning it's not necessarily a bad fat, but neither is it considered one of the healthier fats. The healthy fats include extra-virgin olive oil, flax seed oil, and fats from plant sources such as nuts, seeds, avocados, and coconuts. These healthy fats should be consumed with every meal. Failure to include these fats in a meal will result in many of the nutrients consumed during the meal not being absorbed by the body. That's because many nutrients are fat-soluble nutrients. Beta carotene, Vitamin D, and Vitamin E are three such nutrients that require fat in order to be absorbed and used by the human body, but there are many other nutrients that also need fats for human metabolism.

It doesn't take much fat, by the way, to aid the absorption of these important vitamins and nutrients. Eating just 5 or 10 nuts, or one-fourth of an avocado, provides plenty of dietary fat for transporting these nutrients and aiding their absorption. On another note, it's interesting to remember that for decades the American Heart Association insisted that heart patients should avoid nearly all dietary fat. This was during the low-fat craze of the 1980's and 1990's, when people were running scared from all dietary sources of fat and instead consuming massive quantities of sugar and refined carbohydrates.

We now know that this advice from the American Heart Association was, in effect, causing extreme nutritional deficiencies and actually reducing the life span of heart patients rather than helping them. Such is the case with information from many so-called disease organizations, such as the American Heart Association and the American Diabetes Association. Personally, I wouldn't listen to nutritional advice from any association that is so politically motivated and receives funding from pharmaceutical companies, as both of those organizations do.

The other thing to keep in mind with this finding is that if you are supplementing your diet with nutritional supplements or superfoods like the ones I frequently recommend, it's a good idea to do so in combination with a few nuts, seeds, or a tablespoon of flax oil or olive oil. One tablespoon of flax oil will give you about 100 calories, so keep that in mind in terms of keeping your total daily calorie intake under control. By consuming fats as you take these nutritional supplements, you will multiply the effectiveness of the phytonutrients found in those supplements, thereby giving your body far greater nutritional help from the very same capsules and pills.

In other words, if you take superfood supplements without fat, you're not getting the same benefit as taking the same supplements with a little bit of fat. So keep some nuts handy, as I always do, and eat a few nuts with each meal. I highly recommend macadamias, cashews, pecans, peanuts, and almonds, and all nuts should be purchased and consumed in their raw form, without absolutely no added salt or flavors, and with no roasting or cooking. Raw nuts are the healthiest way to go, and will provide you with all sorts of additional beneficial nutrients that go beyond what you're getting in your food.

One more bit of advice about all of this -- if you're thinking that you should start eating your salads with salad dressing because of this new research, be sure to double-check the kind of fat that is in your salad dressing. Most of the cheaper salad dressings are made with soybean oil, and there's nothing necessarily wrong with soybean oil, but it is not the healthiest oil you can choose. It is used by the food manufacturing industry primarily because it's cheap -- it's a cheap source of calories, and it tastes the same as any other fat to most people. But canola oil is better than soybean oil, and olive oil is better yet.

You can also count on any salad dressing you find at national restaurant chains or fast food restaurants to be made with the cheapest oils possible, which would include soybean oil and partially hydrogenated oils, which of course, should be avoided at all costs.

Is It True That Our Bodies Can't Absorb Vitamins Without Fat?

By David L. Katz, MD
From the April 2010 issue of O, The Oprah Magazine

Q: Is it true that our bodies can't absorb vitamins without fat?

A: Two kinds of vitamins—B-complex and C—are water-soluble and easily absorbed. But the rest of the vitamins are fat-soluble, meaning their absorption is enhanced by dietary fat. These are vitamin A (found in carrots and sweet potatoes), vitamin D (found in fish), vitamin K (found in leafy greens), and vitamin E (found in almonds). So the next time you eat foods rich in these vitamins, consider adding a little healthy fat to the dish. Even full-fat salad dressings can be a good choice if they're made at home using heart-healthy oils like olive or canola. But skip store-bought dressings, which are often loaded with cream (not a healthy fat source) or high-fructose corn syrup.

David L. Katz, MD, is director of the Yale-Griffin Prevention Research Center and president of the nonprofit Turn the Tide Foundation.

The bioavailability bugaboo1,2

By Maret G Traber
1From the Linus Pauling Institute and the Department of Nutrition and Food Management, Oregon State University, Corvallis, and the Department of Internal Medicine, the University of California, Davis.

It is no longer sufficient for nutritionists to prevent deficiency symptoms; they are now charged with defining nutrient intakes for optimal health (1). In this context, the term "chronic disease" is invoked frequently and epidemiologic data are touted to show that diets high in fruit and vegetables are beneficial for reducing the risk of heart disease and cancer. But when single dietary components are tested in intervention trials, the results are sometimes extraordinarily promising, eg, the 77% decrease in second heart attacks in patients with coronary disease given vitamin E (2); sometimes extraordinarily disastrous, eg, the 18% increase in lung cancer in smokers given β-carotene supplements (3); or simply equivocal (4). As Block (5) pointed out, clinical trials are designed to test drug efficacy, not long-term nutrient intakes. If so, what is the appropriate method for the nutritionist?

Traditionally, the reversal of deficiency symptoms was used to assess nutrient requirements. As we became more skilled in biochemistry and molecular biology, the precise physiologic roles of nutrients became the standard for setting requirements—quantities that optimize specific physiologic functions. This approach is most likely to be successful for answering the question, How much of a nutrient is needed for optimal health? Here enters the major problem of, What is the bioavailability of a nutrient?

Bioavailability is defined as the plasma concentration of a water-soluble drug given orally compared with the concentration when the drug is given intravenously. The transfer of this concept from pharmacology to nutrition has been successful, at least in the case of vitamin C, a water-soluble nutrient (6). But, for fat-soluble nutrients, bioavailability is difficult to assess because the nutrient cannot be given intravenously, so relative bioavailability (the change in plasma concentration in response to a test meal) is often measured.

Part of the difficulty of assessing the bioavailability of fat-soluble nutrients is the complexity of the absorption process. Fat-soluble nutrients must be solubilized in micelles, a process that depends on adequate bile and pancreatic secretions. Subsequently, the micelles transfer their contents to the intestinal cells, where these nutrients are packaged in chylomicrons, secreted into the lymph, and transported to the liver. Once the chylomicron remnant arrives at the liver, most fat-soluble nutrients then depend on liver mechanisms for disposition. Vitamins A and E provide contrasting examples of nutrients with protein-mediated fates. The retinol binding protein binds retinol, is secreted into the plasma, and acts as a plasma carrier protein. In contrast, the α-tocopherol transfer protein (α-TTP) binds and transfers α-tocopherol within the hepatocyte, but facilitates α-tocopherol secretion only from the liver for transport in plasma lipoproteins; α-TTP itself is not found in plasma. This makes estimation of the relative bioavailability of α-tocopherol more difficult because plasma α-tocopherol concentrations depend on plasma lipid concentrations.

But what about those fat-soluble nutrients that do not have transfer proteins? How are "beneficial" plasma concentrations achieved? Again, vitamin E provides an interesting example. Humans with a genetic defect in α-TTP have severe vitamin E deficiency—extremely low plasma and tissue vitamin E concentrations and progressive peripheral neuropathy (7, 8). When given supplements containing α-tocopherol in amounts 100 times the recommended dietary allowance of vitamin E, these people can maintain normal plasma and tissue α-tocopherol concentrations and the neurologic symptoms are reversed or halted. If supplementation is discontinued, the plasma concentrations of these individuals decrease within days to deficient levels—a phenomenon never seen in healthy subjects. These findings imply that, in the absence of α-TTP, the vitamin E "default pathway," and perhaps that of

other fat-soluble nutrients, is rapid plasma removal and biliary excretion. These data also suggest that continued intake of large amounts of other fat-soluble nutrients will allow plasma concentrations to remain elevated.

It is obvious that fat-soluble nutrients require some fat for absorption and that nature does not incorporate fat-soluble nutrients into foods without fat. However, that does not limit food manufacturers (eg, manufacturers of vitamin E–enriched fat-free mayonnaise or vitamin D–enriched fat-free milk) or plant geneticists [eg, those working with β-carotene–enriched rice (9)] from increasing the food contents of fat-soluble nutrients without adding fat. Roodenburg et al (10) attempted to study the question of how much fat is necessary. They studied the relative bioavailability of some carotenoids and vitamin E in humans and reported that lutein esters, but not other fat-soluble nutrients, are dependent on a higher fat content (36 g compared with 3 g) of a hot meal for increased relative bioavailability. Subjects consumed low-fat breakfasts and lunches and high- or low-fat dinners that were varied by changing the fat contents of experimental spreads. In this split-plot design, 1 group received a placebo-containing spread during the two 7-d experimental periods of high or low fat consumption, whereas the other 3 groups received spreads supplemented with α-tocopherol, α- and β-carotenes, or lutein esters. When these fat-soluble nutrients were dissolved in fat and consumed as part of a hot meal, the effect of 3 g fat was equal to that of 36 g on plasma concentrations of α-tocopherol and α- or β-carotenes. Lutein bioavailability, however, was improved with high fat intakes. Lutein was provided as lutein esters, which likely required hydrolysis mediated by lipases (11). Perhaps the additional fat intake stimulated pancreatic lipase secretion and improved hydrolysis of the lutein esters. An interesting addition to the study would have been to include α-tocopheryl acetate, a form commonly used in vitamin E supplements or as a food fortificant, because it too must be hydrolyzed before absorption.

We are still left with the question of how much fat is necessary for absorption of fat-soluble nutrients not dissolved in 3 g fat eaten as a spread, but naturally present as a component of food or added during its manufacture, perhaps without fat. We also face the quandary of fat-soluble nutrient interactions. Roodenburg et al (10) administered the fat-soluble nutrients individually, yet these nutrients are usually found in combination. Worse yet, lutein and carotenes appear to adversely affect each other's absorbability (12). Diet composition is also a factor. The nutrient intake of one fat-soluble nutrient does not dictate the intakes of the others—a low-fat diet, high in fruit and vegetables, increases carotenoid intakes but decreases α-tocopherol intakes (13, 14). Study of bioavailability and nutrient interactions also needs to be extended to include flavonoids and other phytochemicals because concentrations necessary to produce favorable effects of these nutrients in tissue culture may not be achievable in vivo.

Thus far we have considered variables in foods, but variability in the individual consuming the foods adds to the bioavailability problem. Plasma concentrations of fat-soluble nutrients carried in lipoproteins also depend on plasma lipoprotein concentrations. Thus, a subject with a high plasma lipid concentration has the ability to transport more of the fat-soluble nutrient and as a result will have a higher plasma concentration, but is that nutrient available to tissues? And what about the subjects' routine food choices? Does a person who usually consumes several servings of fruit and vegetables respond to a test meal differently from one who avoids these foods?

Does the size of a nutrient dose matter? Does diet composition or meal frequency matter? Does the food matrix in which the nutrient is bound materially affect the nutrient's bioavailability? And if so, as seems likely, what happens if the food is puréed, juiced, cooked, or both cooked and mashed? This bioavailability problem seems to leave us with endless unanswered questions and a tremendous amount of work to do. However, bioavailability of specific nutrients is a cornerstone to determining the amount of any given nutrient for optimal health.

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