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Degradation of Vitamins And Probiotics Caused By Exposure to Heat, Water and Sunlight

(A Green Circle White Paper)

Heat, Water & Sunlight Degrade Some Nutritional Ingredients

Vitamins and probiotics (and other active ingredients) can be substantially affected by exposure to heat, water (or other liquids) and/or sunlight. The nutritional value (or level of potency) of such ingredients can degrade when exposed. Therefore, maintaining the viability (and consistency—commensurate with accurate label claims) of these nutritional components in food and beverage products, from the time of production to the time of consumption, can be challenging.

Over-Fortifying Is Not A Solution

While there is a risk of products providing a lower level of vitamin or other nutrients (versus the promises made on their labels) in some cases there is also a risk to consumers of actually consuming *more* of certain nutrients than they were aware of, or desired to consume. Knowing that there will be degradation, some manufacturers "over-fortify" products in order to exceed label claims by the time the products get to (or sit on) shelves. (Note: for "naturally occurring" vitamins—such as Vitamin C in orange juice—the FDA allows for meaningful variance, but for "fortified vitamins" added into products the level of vitamins contained in the product on the shelf must exceed label claims). As a result, Consumers sometimes ingest products with nutritional ingredient levels that actually exceed the claims made on labels. While doing so may be harmless in certain cases, consuming excessive doses of certain vitamins and other ingredients can be harmful and, at a minimum, consumers simply deserve accurate and honest labeling of the products they eat or drink. While the degree of "over-fortifying" of vitamins and other ingredients is limited so that levels remain below known "toxicity," the amount of over-fortification can be quite significant depending on the specific vitamin. For

instance, it is common practice to over-fortify the Vitamin C level of some products by 50% or even 100% or more. It is notable that levels for certain elements (such as Pantothenic Acid (B5) and Folic Acid (B9)) can be 190% and 250% respectively. If a manufacturer needs to over-fortify Folic Acid by 250% in order to try and land on the level claimed on the label, surely the variance or "inaccuracy" between the time of production, a month later on a store shelf, or six months later on a store shelf, must be very significant.

Application of Heat (Such as Pasteurization of Beverages) Destroys Vitamins and Probiotics

Food and beverage product manufacturers rely on a few main methods to extend product shelf life and/or avoid the need for expensive and restrictive cold channel distribution. Pasteurization has long been used as a common means of killing bacteria (and preventing the future growth of bacteria) in beverage products. Since the acceleration of the natural products movement in the last decade or two, chemical preservatives (such as sodium benzoate and potassium sorbate) have been excluded/removed from the formulations of many natural and/or organic products. Doing so makes it incumbent upon the manufacturer to utilize some other means of eliminating bacteria (otherwise known as a "kill step"). The most common methodology is to revert back to the application of extreme heat. New technologies such as High Pressure Processing (HPP) and, in some unique cases the use of microfiltration, have been used as a kill step (or, in some cases, to merely extend shelf life) but heat remains extremely common. And heat harms the potency and effectiveness of a variety of vitamins and other nutrients. Degradation generally starts to occur in foods or beverages exposed to heat of greater than 120 degrees Fahrenheit.

The temperatures utilized in kill steps on beverages range from extended periods at 160-175 degrees Fahrenheit (with certain tunnel pasteurization processes) to a more common level of around 190-200 degrees for hot filling, between 180-220 for aseptic packaging and also as hot as 240 degrees (or about thirty degrees hotter than boiling water) for some retort processes. These temperatures can dramatically alter the nutritional content of foods and beverages.

Vitamin C and Heat

Vitamin C begins to denature with exposure to temperatures as low as 86 degrees Fahrenheit, according to a study done by N.C. Igwemmar, S.A. Kolawole, I.A. Imran in the

International Journal of Scientific and Technology Research. The negative effects of heat increase significantly at 140 degrees and even more at 170 degrees Fahrenheit. In fact, pasteurization was blamed for the dramatic increase in infantile scurvy in the late 19th century as naturally occurring vitamin C in milk was destroyed through pasteurization.

The Igwemmar study in the *International Journal of Scientific and Technology Research* looked at the effect of heat on different vegetables and measured the percentage of vitamin C lost at 5, 15 and 30 minutes while exposed to constant heat of 140 degrees (far less extreme than most pasteurization methods). The impact, as can be seen in the chart below, is material. As the authors say, "Vitamin C is water-soluble as such easily leached into the water and then degraded by heat."

Vegetable samples	% lost in 5 mins	% lost in15 mins	% lost in 30 mins
Pepper	11.76	35.28	64.71
Green Peas	10.59	33.33	58.28
Spinach	9.94	29.94	60.00
Pumpkin	12.43	37.43	62.43
Carrot	16.57	33.33	49.91

Vitamin-Fortified Beverages and Heat

A standard hot-fill process used for many well-known vitamin-fortified beverages typically heats the fluid to between 194 and 203 degrees Fahrenheit and then cools it to about 180 degrees before transfer to a bottle where cooling continues. The temperatures required to hot fill are widely believed to be very damaging to vitamins (and even more damaging to probiotics).

Other Nutrients and Heat

Vitamin C, Thiamine (B1) and Pantothenic Acid (B5) are all "sensitive" or "highly sensitive" to damage by heat. This is according to multiple sources including a whitepaper by Royal DSM, a global company active in health, nutrition and materials, a paper by rawfoods.com and other sources. Probiotic cultures are even more delicate and cannot live with extended exposure to temperatures above 120 degrees, as is the case with virtually all bacteria and yeast. For probiotics, the drinks must be taken to market through the cold channel at considerably higher cost or not at all. In fact, one popular

probiotic-fortified beverage was recently the subject of a class action lawsuit for false labeling claims since any naturally occurring probiotic cultures are all destroyed when that product is pasteurized in order to extend its shelf life. The manufacturer then "adds back" probiotic cultures, but the plaintiff in the lawsuit claims that doing so, and still calling the product a "kombucha" (or making other related claims) is misleading. This is according to an article in October, 2017 in *Bevnet* quoting from the lawsuit, filed in Ventura County California.

Probiotics

Within the last decade, probiotics have risen beyond specialty and niche markets to become a mainstream ingredient (Stephens, 2009). Ganeden's BC30 was the first strain of *Bacillus coagulans* for which safety data was published in a peer-reviewed journal (Endres et al., 2009) and was found to be generally recognized as safe (GRAS) status by an independent scientific panel (PR Newswire, 2009a). In 2012 GanedenBC30 became the first spore forming probiotic to receive a letter of no objection from the FDA after reviewing the GRAS dossier relating to the patented strain. In order to deliver health benefits, probiotic bacteria must overcome several challenges present in food processing. Furthermore, ensuring that probiotics remain viable throughout shelf life is a formidable challenge (Sanders et al., 2007). Although probiotics are prevalent in dairy products, many of the most commonly used strains do not have the ability to survive high heat processesing used in food manufacturing and cannot survive during extended storage at room temperature. While common strains of probiotic bacteria (e.g. lactic acid bacteria) survive mild temperatures used during fermentation, they are inactivated by greater temperatures used in food processes such as baking, pasteurization, and extrusion. A recent report by ConsumerLab.com showed varied results of probiotic survivability among several supplements. Most products tested contained various strains of *Lactobacillus* and *Bifidobacterium* species; some products contained the amount of probiotic claimed on the label while others fell short (Consumerlab.com, 2009).

For more on probiotics, visit the Ganeden site at:

https://www.ganedenprobiotics.com/images/uploads/white_paper_pdfs/beyond_the_dairy_case.pdf

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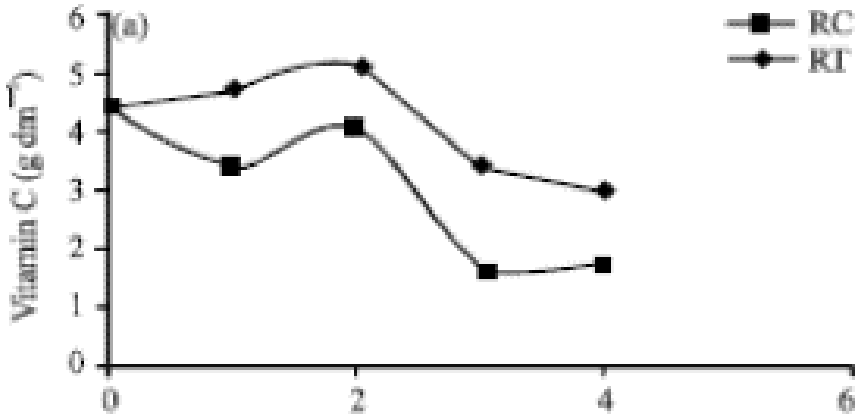
Sitting In Water Causes Oxidation That Also Reduces Potency

Oxidation in water causes water-soluble vitamins and probiotics to degrade over time. Just as nails rust in damp air and apples turn brown when cut open, water soluble vitamins and probiotics degrade when exposed to water and oxygen. This happens naturally in the atmosphere but putting the vitamins or probiotics in a water medium facilitates and speeds up the process—sometimes quite significantly.

Vitamin C, also known as ascorbic acid, is an example of a water-soluble vitamin and is common in natural fruits and as a supplement. Vitamin C has been widely studied and in one study shown to degrade by about 50% over 4 weeks in the juice of different fruits. ("The Effect of Storage Method on the Vitamin C Content in Some Tropical Fruit Juices, by V.O. Ajibola, O.A. Babatunde and S. Suleiman.) The chart below shows the concentration of vitamin C in the juice of an orange at 4 degrees Celsius and at room temperature over the course of four weeks. One can see the decrease in concentration over that relatively short time frame ranges from about 50% to 35%.

Concentration of Vitamin C in fresh orange juice from 0 to 4 weeks

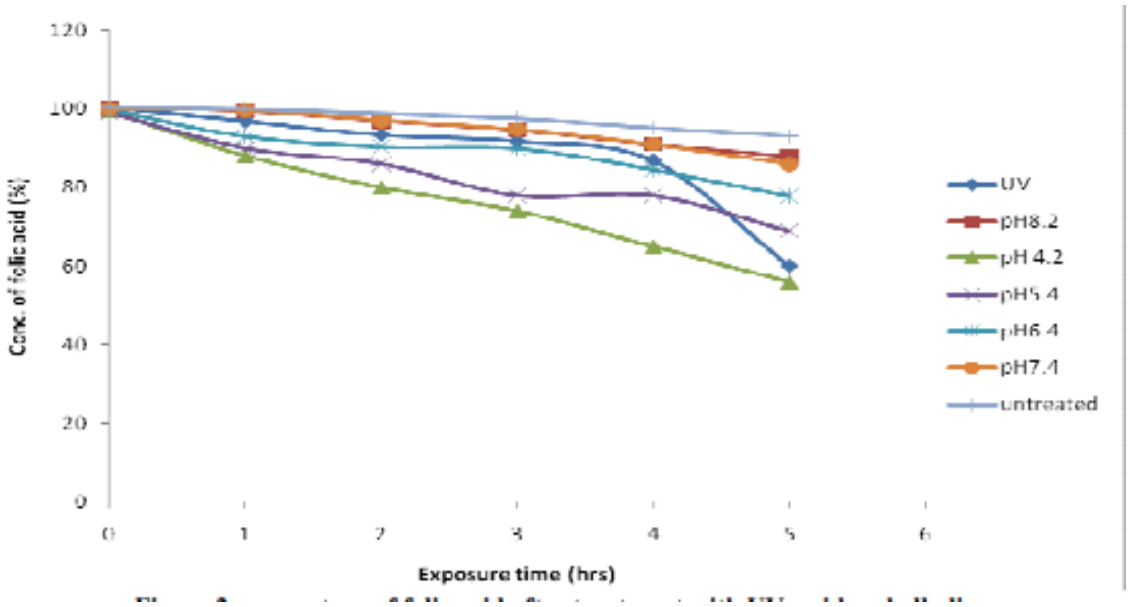


Source: Ajibola et al.

The effects of oxidation are similar on other water-soluble vitamins like Thiamin (Vitamin B1), Riboflavin (vitamin B2) Niacin (vitamin B3) Pyridoxine (B6) Folic Acid (B9) Cobalamin (B12) Biotin (B7) and Pantothenic Acid (B9). For example, S. Yakubu and J. Muazu showed that Folic Acid was shown to degrade by just over 15% after *just six hours* in a pH solution of 6.4 (see chart below from Pelagia Research Library and Der Pharmacia

Sinica). For a point of reference, Avanija Reddy, DMD, MPH et al. of the American Dental Association (ADA) show that some vitamin-fortified beverages have pH levels between 2.9 and 3.3, depending on the flavor. Acidity (low pH) causes faster degradation than pH neutral water. Again, the effect of a typical hydration beverage on a delicate active ingredient like Folic Acid is quite significant. The timing and extent of degradation varies depending on the molecules and the variables like pH, time and so on, but the net effect of showing a reduced concentration in a water solution is the same.

Percentage of Folic Acid after Treatment with UV, Acid and Alkali



Source: Effects of Variables on Degradation of Folic Acid, S. Yakubu and J. Muazu

For probiotics, the effects are similar. Probiotics are bacteria and yeast colonies that are believed to have beneficial effects on digestion and other areas. A study by A. Talwalkar and K. Kailasapathy shows that oxygen proves toxic for probiotic yogurts as noted, "The presence of such an oxygenic environment in yogurt throughout its manufacture and storage is thus believed to negatively affect the extended survival of probiotic bacteria such as L. acidophilus and Bifidobacterium spp. (Dave and Shah 1997a, 1997b, 1997c)."

Water has oxygen and facilitates oxidation, and "Exposure to oxygen has been suggested as one of the reasons for loss in viability of probiotics. This is due to the formation of

reactive oxygen species (ROS), such as superoxide, hydroxyl, and hydrogen peroxide from incomplete reduction of oxygen, which can cause damage by reacting with proteins, lipids, and DNA," according to a paper by O.D. Amund in *NRC Research Press*. The production and bottling of probiotics products causes damage and oxidative stress to the probiotics cultures. Heat can cause massive destruction of such cultures.

Degradation Testing and Validation

Consumer Labs, an independent consumer testing company, tests the label claims of vitamin and supplement makers. In their most recent diagnosis of vitamin C supplements, the three that failed their label claims all did it with over-concentration. There was too much vitamin C. There is a common conception that consuming "too much" water-soluble vitamins is harmless, but that is not correct. Folic Acid is a common, overly-consumed vitamin that can cause other issues like diarrhea, nausea, heartburn and abdominal cramps, according to the Mayo Clinic.

THE DAMAGE BY SUNLIGHT

Many vitamins are sensitive to the effect of UV light and, therefore, sunlight, according to consulting firm Packaging Gateway. The vitamins most affected include vitamin A, B2, B6, B12 and B9 (Folic Acid). Indeed, sport drinks and enhanced waters often opt for the clear PET bottle for branding and cost effectiveness. Exposure to sunlight (in addition to extreme heat) is likely to further impact vitamin degradation in these products, which are unlikely to contain the nutrients they claim to have by the time the consumer is drinking them.

The ultimate question is not what is on the label, but "what *is in the bottle.*" Having "enough" of an ingredient (so as to exceed the level in a label claim) is not necessarily acceptable if there is "too much" of the ingredient (as a function of the product having been "over-fortified"). Consumers deserve to get accurate information about what they're ingesting. For us, these findings give rise to two ideas: 1. Whenever possible, nutrition should be derived from the consumption of whole foods; 2. New technologies that generate shelf stability or extend shelf life without the application of extreme heat may be important and interesting for more than their ability to simply lower costs or broaden distribution.

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