Ascorbyl Palmitate

Handling/Processing

Identification of Petitioned Substance

Chemical Names:
Ascorbyl palmitate
2,3-didehydro-L-threo-hexono-1,4-lactone-6-palmitate
L- ascorbic acid 6-hexadeconoate
6-palmitoyl-3-keto-L-gulofuranolactone

IUPAC name:
[2-(4,5,-dihydroxy-3-oxofuran-2-yl)-2-hydroxyethyl] hexadeconoate

Other Names:
Vitamin C palmitate, ascorbic acid palmitate
Vitamin C ester
L-Ascorbyl palmitate, 1-ascorbyl palmitate
Ascorbyl monopalmate
Cetyl ascorbate
Ascorbylpalmitic acid
6-O-palmitoyl L-ascorbic acid
Ondascora
Quicifal

CAS Number:
137-66-6

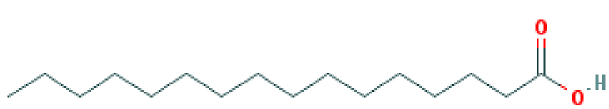
Other Codes:
800155 (U.S. EPA PC Code)
E 304 (European Union INS number)
205-305-4 (EINECS number)
CI7671040 (RTECS Code)

Characterization of Petitioned Substance

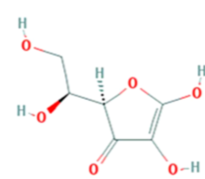
<u>**Composition of the Substance**</u>:

Ascorbyl palmitate is an antioxidant, antimutagenic, and antineoplastic compound (i.e., inhibits the development of neoplasms, controls growth of malignant cells) composed of carbon, hydrogen, and oxygen, $C_{22}H_{38}O_7$ (ChemIDplus Advanced, 2011). The main use of ascorbyl palmitate in processed foods is as a preservative, which capitalizes on the antioxidant functions of the compound. It is an ester of ascorbic acid (vitamin C) and palmitic acid and is assumed to by hydrolyzed back to these parts when metabolized by the body (Madhavi and Salunkhe, 1995; Akoh and Min, 2008). The molecular structures of palmitic acid, ascorbic acid, and ascorbyl palmitate are shown in Figure 1.

(A)



(B)



(C)

Figure 1. Molecular Structures
Ascorbyl Palmitate (A); Palmitic Acid (B); Ascorbic Acid (C)
Source: PubChem, 2011

Properties of the Substance:

Commercial preparations of ascorbyl palmitate are solid powders with a citrus-like odor and white to yellowish color (HSDB, 2011). Ascorbyl palmitate is an amphipathic compound meaning that it has both a hydrophobic (apolar) tail and a hydrophilic (polar) head and, therefore, is both lipophilic and water soluble (Meves et al., 2002). Ascorbyl palmitate is chosen over ascorbic acid as an ingredient in many foods due to its lipophilic (i.e., fat-soluble) property (Coppen, 1999). Physical and chemical properties of ascorbyl palmitate are provided in Table 1.

Table 1. Physicochemical Properties of Ascorbyl Palmitate

Property	Value[a]
Physical state	Solid
Appearance	White to yellow-white powder
Odor	Citrus-like
Molecular weight	414.533
Melting point (°C)	112
Solubility in water (mg/L at 25°C)	Slightly soluble, 7.44×10^{-2}
Solubility in other solvents	Soluble in alcohol, animal oil, vegetable oil
Vapor pressure (mm Hg at 25°C)	2.09×10^{-15}
Octanol/water partition coefficient (log K_{ow})	6.00
Henry's Law constant (atm-m^3/mol at 25°C)	1.40×10^{-7}

[a]Source: HSDB, 2011

Specific Uses of the Substance:

Ascorbyl palmitate is an antioxidant used as a food additive to prevent rancidity (the decomposition of fats and oils due to oxidation) and to preserve canned foods, frozen foods, and cured meats (HSDB, 2011). Additionally, ascorbyl palmitate is used to preserve a number of nonfood products such as pharmaceuticals, cosmetics, fragrances, and colorings (Ash and Ash, 2004). Ascorbyl palmitate is considered by some researchers to be a source of bioavailable vitamin C (Ash and Ash, 2004) and is readily available for purchase as a nutritional supplement. No information was identified to indicate that ascorbyl palmitate is added to processed foods for nutritional purposes.

In August 2011, a petition was filed for the inclusion of ascorbyl palmitate to the National List of Allowed and Prohibited Substances (hereafter referred to as the National List) at 7 CFR 205.605(b) as a synthetic nonagricultural substance in or on processed infant formula products labeled as "organic" or "made with organic (specified ingredients or food group(s))." Many infant formulas contain polyunsaturated chain fatty acids (PUFA) as some researchers believe they are essential for visual and cognitive development in infants (Gil et al., 2003; Simmer et al., 2008). However, these compounds are susceptible to oxidation and free radical formation, which can result in bad flavors and odors (Jacobsen, 2010). Adding antioxidant oils such as ascorbyl palmitate can help control oxidation of lipids like PUFA (Jacobsen, 2010).

Approved Legal Uses of the Substance:

The Food and Drug Administration (FDA) lists ascorbyl palmitate as a food additive that is generally recognized as safe (GRAS) for human consumption (21 CFR 182.3149) and for animal drugs, feeds, or other related products (21 CFR 582.3149) when used in accordance with good manufacturing or feeding practice (see Evaluation Question #4). The FDA standard of identity for margarine lists ascorbyl palmitate as an optional ingredient allowed as a preservative at up to 0.02% by weight of the finished product (21 CFR 166.110[b]).

FDA regulates infant formulas for sale in the U.S under 21 CFR 107. The regulation does not include specifications for the use of ascorbyl palmitate.

Ascorbyl palmitate can be used legally as a human dietary supplement, but it is not registered with the FDA for this use. The FDA does not regulate human dietary supplements in the same way as drugs or animal feed additives; generally, manufacturers do not need to register their products with FDA or get approval before producing and selling supplements for human consumption. The product manufacturer is responsible for ensuring the safety of the product. The FDA is responsible for taking action regarding an unsafe product after it reaches the market and to make sure the supplement's label is accurate and not misleading (FDA, 2005).

<u>Action of the Substance</u>:

The preservative action of ascorbyl palmitate is attributable to its antioxidant properties. Ascorbyl palmitate, along with other similar antioxidants like ascorbic acid, erythorbic acid, and sulfites, can function as an oxygen scavenger (Gunstone, 2001; Akoh and Min, 2008). This means it is a reducing agent that scavenges free oxygen atoms in a food, drink, oil, or other such product and donates a hydrogen atom thereby preventing oxidation of the product (Akoh and Min, 2008). A study by Lee et al. (1999) showed that ascorbyl palmitate was very effective at minimizing oxidation in oils, including soybean oil, cottonseed oil, corn oil, tallow, lard, and linoleic acid, through its action as a singlet oxygen quencher. Singlet oxygen quenchers prevent oxidation by reacting with the singlet oxygen molecule before it has a chance to oxidize the lipid, preventing free radicals or peroxides from being formed (Buettner and Schafer, 2002). Ascorbyl palmitate can also act as a chain-breaking antioxidant; however, this action is weak and dependant on the type of oil being oxidized (Gunstone, 2001). Chain-breaking antioxidants slow or stop oxidation after it has already started by intercepting peroxyl radicals that were formed when a lipid was oxidized. These peroxyl radications feed a chain of oxidation events, and so a chain-breaking antioxidant breaks the cycle of continued oxidation reactions (Buettner and Schafer, 2002).

Ascorbyl palmitate is most effective as a secondary or synergistic antioxidant (Gunstone, 2001; Eitenmiller and Lee, 2006) (see "Combinations of the Substance" below). Secondary antioxidants work by promoting the activity of a primary antioxidant (Eitenmiller and Lee, 2006). For example, ascorbyl palmitate works synergistically with antioxidant tocopherols by regenerating the tocopherols that are lost during the antioxidizing reactions (Gunstone, 2001).

<u>Combinations of the Substance</u>:

Ascorbyl palmitate is rarely used on its own as an antioxidant agent (Coppen, 1999). As mentioned under "Action of the Substance," it is often combined with tocopherols—natural antioxidants that are commercially available in synthetic forms (Coppen, 1999; Lee et al., 1999; Akoh and Min, 2008). Synthetic tocopherols are currently included on the National List as a nonagricultural ingredient allowed in or on processed products labeled as "organic" or "made with organic (specified ingredients or food group(s))" provided that they are derived from vegetable oil and only when rosemary extracts are not a suitable alternative (21 CFR 205.605(b)).

Ascorbyl palmitate is often added to oils containing compounds like the polyunsaturated fatty acids docosahexaenoic acid (DHA), arachidonic acid (ARA), and docosapentaenoic acid (DPA), because it prevents oxidation and related adverse effects on the nutritional quality, odor, and flavor of the oil (Bartee et al., 2007; Jacobsen, 2010). DHA algal oil and ARA single cell oil have been petitioned to be added to the National List.

Ascorbyl palmitate is petitioned for addition to infant formula, which contains a number of nutrients (protein, calcium, iron, thiamin, biotin, phosphorus, magnesium, zinc, riboflavin, niacin, pantothenic acid, iodine, copper, potassium, and vitamins A, C, D, E, B_6 and B_{12}) included on the National List through the listing of "nutrient vitamins and minerals, in accordance with 21 CFR 104.20, "Nutritional Quality Guidelines For Foods" (7 CFR 205.605). The NOP recently published a proposed rule that would amend and correct the National List cross-reference to the FDA regulation 21 CFR 104.20, and specify that certain nutrients are allowed in non-milk based infant formulas as required by 21 CFR 107.100 (USDA, 2012).

Mixtures of food ingredients including carbohydrates, proteins, fats, and stabilizers are expected to be included in infant formula and other foods to which ascorbyl palmitate is added. These ingredients will vary significantly with the type of product and manufacturer.

Ascorbyl palmitate is lipid soluble, but is not highly soluble; so it is often combined with solubilizing agents such as monoglyceride (Coppen, 1999). Monoglycerides are included on the National List as a nonagricultural ingredient allowed in or on processed products labeled as "organic" or "made with organic (specified ingredients or food group(s))" with the specification that they are for use only in drum drying of food (21 CFR 205.605(b)).

Status

Historic Use:

The antioxidant properties of ascorbyl palmitate were identified by American chemist and food scientist Lloyd A. Hall (1874–1971), who discovered that fatty and oily foods became rancid due to oxidation processes (Carey, 2006; Mabunda, 1994). In addition to identifying ascorbyl palmitate as an antioxidant, Hall is credited with developing methods to use antioxidants like ascorbyl palmitate, citric acid, lecithin, and propyl gallate to treat foods and prevent oxidation (Carey, 2006; Mabunda, 1994). Hall's discoveries were reported in a patent issued on March 22, 1949 (U.S. Patent 2,464,927).

The standard of identity for margarine, in which ascorbyl palmitate is currently listed as an optional ingredient allowed as a preservative at up to 0.02% by weight of the finished product (21 CFR 166.110), was first promulgated in 1977 and last amended in 1998. It is unclear whether ascorbyl palmitate was included in the initially written standard or added during a subsequent amendment.

OFPA, USDA Final Rule:

Ascorbyl palmitate is not allowed as an ingredient in organic production or handling (7 CFR 205.105). Ascorbyl palmitate is not currently listed under 7 CFR 205.605(b) as a synthetic substance allowed in or on processed products labeled as "organic" or "made with organic (specified ingredients or food group(s))."

International:

The Codex Alimentarius Commission of the Joint FAO/WHO Food Standards Programme, to which the United States is a member, does not list ascorbyl palmitate as an allowed substance for organically-produced foods. Ascorbic acid is listed as an approved food additive for organically-produced foods (Codex Alimentarius Commission, 2001). Minerals (including trace elements), vitamins, essential fatty and amino acids, and other nitrogen compounds are permitted for use as food additives in organic processed foods only when their use is legally required in the food products in which they are incorporated (CODEX Alimentarius Commission, 2001). The Codex world-wide standard for infant formula that ascorbyl palmitate is an antioxidant allowed in all types of infant formulas up to a maximum level of 1 mg per 100 mL of consumption-ready product, either singly or in combination with mixed tocopherol concentrate. A minimum required level is not established (Codex Alimentarius Commission, 1981).

The International Federation of Organic Agriculture Movements (IFOAM) does not list ascorbyl palmitate within its "Norms for Organic Production and Processing" (IFOAM, 2006). However, the IFOAM Norms state that, "Minerals (including trace elements), vitamins and similar isolated ingredients shall not be used unless their use is legally required or where severe dietary or nutritional deficiency can be demonstrated" (IFOAM, 2006). IFOAM does, however, list ascorbic acid as an approved food additive (IFOAM, 2006).

The East African Organic Product Standard and the Pacific Organic Standard were both created using the IFOAM and Codex guidelines as models; both standards do not list ascorbyl palmitate but do list ascorbic acid as an allowed additive in organic food processing (East African Community, 2007; Secretariat of the Pacific Community, 2008).

The Canadian Organic Production Systems Permitted Substances List does not include ascorbyl palmitate (CGSB, 2011). However, "non-synthetic sources of vitamins" and "synthetic sources of vitamin C (ascorbic acid)"can be used in crop production. Nonsynthetic ascorbic acid is allowed as a food additive; synthetic ascorbic acid is allowed as a food additive in fruits and vegetables only if nonsynthetic forms are not commercially available (CGSB, 2011). Canadian Food and Drug Regulations do not require infant formula to contain ascorbyl palmitate under Section B.25.054. Additionally, Section B.25.062 states that no food can be labeled or advertised for consumption by infants if it contains a food additive with the exception of those listed in the regulation; ascorbyl palmitate and oils to which ascorbyl palmitate have been added are exceptions (Health Canada, 2011).

The European Economic Community (EEC) Council Regulation does not list ascorbyl palmitate as an additive allowable in organic foods (Commission of the European Communities, 2008). The regulation does list ascorbic acid as a permitted food additive in processed organic meats. While minerals (trace elements included), vitamins, amino acids, and micronutrients are allowed in the processing of organic food, they are only authorized if their use is legally required in the foodstuffs in which they are incorporated (Commission of the European Communities, 2008). For example, European Commission Directive 2006/141/EC states that infant formula may contain ascorbyl palmitate as a formulation for vitamin C in order to satisfy the requirements on vitamins as specified in other sections of the directive (Commission of the European Communities, 2006).

The Japanese Agricultural Standard for Organic Processed Foods does not list ascorbyl palmitate, but does list ascorbic acid as a food additive allowed in processed foods of plant origin only (JMAFF, 2006).

Evaluation Questions for Substances to be used in Organic Handling

<u>Evaluation Question #1:</u> Describe the most prevalent processes used to manufacture or formulate the petitioned substance. Further, describe any chemical change that may occur during manufacture or formulation of the petitioned substance when this substance is extracted from naturally occurring plant, animal, or mineral sources (7 U.S.C. § 6502 (21)).

Ascorbyl palmitate is typically manufactured through industrial-scale chemical reactions (Humeau et al., 1995; Pokorny et al., 2001), and these processes have been described in sources related to the food applications of ascorbyl palmitate. In the most prevalent manufacturing process, ascorbic acid is esterified with sulfuric acid (H_2SO_4), and the product of that reaction is esterified with palmitic acid (Pokorny et al., 2001). This process is typically achieved by combining equal molar concentrations of ascorbic acid and palmitic acid in a sulfuric acid solution and leaving it at room temperature for 16–24 hours (Madhavi et al., 1996). The resulting ascorbyl palmitate is recovered and purified through a recrystallization process (Pokorny et al., 2001). There are many patented processes for the chemical synthesis of ascorbyl palmitate. These processes follow the general acid-catalyzed esterification process described above, but use solvents other than sulfuric acid, (e.g., dimethylformamide, dimethyl sulfoxide, or hydrogen fluoride) (Humeau et al., 1995).

Humeau et al. (1995) describe a lipase-catalyzed enzymatic synthesis for preparation of ascorbyl palmitate in which *Candida antartica* lipase is used as the enzyme catalyst to convert ascorbic acid and palmitic acid to ascorbyl palmitate. Similar processes have been described with other enzyme catalysts including *Rhizomucor miehei*, *Pseudomonas cepacia*, and *C. rugosa*, which are isolated from porcine pancreas, and *Bacillus stearothermophilus* SB-1, isolated from bacteria (Bradoo et al., 1999). Enzymatic synthesis processes can achieve greater regioselectivity compared with acid-catalyzed esterification (i.e., results in more of the desired derivative, so less intensive purification is needed); however, they generally result in a lower overall product yield (Humeau et al., 1995). No information was found to indicate the relative amount of ascorbyl palmitate that is industrially manufactured using enzymatic synthesis processes instead of acid esterification.

For cosmetic formulations, ascorbyl palmitate has been prepared by condensing palmitoyl chloride and ascorbic acid, using pyridine as a dehydrochlorinating agent. It can also be formed by reacting ascorbic acid and palmitic acid as already described (HSDB, 2011).

Evaluation Question #2: Is the substance synthetic? Discuss whether the petitioned substance is formulated or manufactured by a chemical process, or created by naturally occurring biological processes (7 U.S.C. § 6502 (21)).

Ascorbyl palmitate is a synthetic antioxidant (Coppen, 1999; Akoh and Min, 2008). As discussed above, ascorbyl palmitate can be derived through various chemical reactions, most predominantly the esterification of ascorbic acid and palmitic acid (see Evaluation Question #1) (Humeau et al., 1995; Madhavi et al., 1996; Pokorny et al., 2001; HSDB, 2011).

Some authors (e.g., Lee et al., 1999; Coppen, 1995; Humeau et al., 1995) consider ascorbyl palmitate to be a natural antioxidant when enzymatically produced from natural ascorbic acid and natural palmitic acid. However, ascorbyl palmitate and the enzymatic reaction through which it is produced are not found in nature.

While ascorbic acid is naturally occurring and can be isolated from plant sources (Coppen, 1999), the ascorbic acid used in the production of ascorbyl palmitate is typically synthetically derived from glucose (Pokorny, 2001). The Reichstein and Grussner process for synthesizing ascorbic acid from glucose was developed in 1934, and almost all current industrial processes for ascorbic acid production are variations of this technique (Chotani et al., 2000). Alternatively, ascorbic acid can be industrially produced through biosynthetic methods, such as isolation from rosehips or fermentation of microalgae or genetically modified bacteria or fungi (DVC Inc., 1999).

Evaluation Question #3: Provide a list of non-synthetic or natural source(s) of the petitioned substance (7 CFR § 205.600 (b) (1)).

As previously discussed, ascorbyl palmitate is manufactured by chemical processes. It is not created by naturally-occurring biological processes (see Evaluation Question #1).

Evaluation Question #4: Specify whether the petitioned substance is categorized as generally recognized as safe (GRAS) when used according to FDA's good manufacturing practices (7 CFR § 205.600 (b)(5)). If not categorized as GRAS, describe the regulatory status. What is the technical function of the substance?

FDA lists ascorbyl palmitate as a chemical preservative that is GRAS for human consumption when used in accordance with good manufacturing practice (21 CFR 182.3149) and for animal drugs, feeds, or other related products when used in accordance with good manufacturing or feeding practice (21 CFR 582.3149). A review of ascorbyl palmitate along with L-ascorbic acid, sodium L-ascorbic acid, calcium L-ascorbate, erythorbic acid (D-isoascorbic acid), and sodium erythorbate (sodium D-isoascorbate) was completed in 1979 by the Select Committee on GRAS Substances (SCOGS) (U.S. FDA, 2006). The Committee concluded that there was "no available information" on the listed substances "that demonstrates, or suggests reasonable grounds to suspect, a hazard to the public when they are used as food ingredients at levels that are now current or that might reasonably be expected in the future" (U.S. FDA, 2006).

Evaluation Question #5: Describe whether the primary function/purpose of the petitioned substance is a preservative. If so, provide a detailed description of its mechanism as a preservative (7 CFR § 205.600 (b)(4)).

The primary function of ascorbyl palmitate is as a preservative. As previously discussed, ascorbyl palmitate is added to foods in order to counteract the naturally-occurring oxidation of lipids within the food, thereby preventing development of off-flavors or bad odors that would otherwise occur over time (Jacobsen, 2010). Ascorbyl palmitate is also used to preserve a number of nonfood products such as pharmaceuticals, cosmetics, fragrances, and colorings (Ash and Ash, 2004). Ascorbyl palmitate counteracts oxidation of oils in these products in the same way that it does in food products. In cosmetics, such as lotions, skin foundations, and topical skin care products, ascorbyl palmitate is also used as an anti-aging ingredient as some believe it stimulates growth of fibroblasts that produce collagen and elastin (Perricone, 2007).

Evaluation Question #6: Describe whether the petitioned substance will be used primarily to recreate or improve flavors, colors, textures, or nutritive values lost in processing (except when required by law) and how the substance recreates or improves any of these food/feed characteristics (7 CFR § 205.600 (b)(4)).

No information was found to suggest that ascorbyl palmitate is used to recreate or improve flavors, colors, textures, or nutritive values that are lost in processing. Ascorbyl palmitate is used as a preservative, which includes the prevention of off-flavors or bad odors during the shelf life of the product.

Evaluation Question #7: Describe any effect or potential effect on the nutritional quality of the food or feed when the petitioned substance is used (7 CFR § 205.600 (b)(3)).

Ascorbyl palmitate is a fat-soluble source of vitamin C that is a powerful antioxidant. Because it is fat-soluble, ascorbyl palmitate is better absorbed by the body and its excess can be stored in the body's cell membranes until it is needed. On the other hand, excess ascorbic acid, a water-soluble form of vitamin C, is flushed from the body (excreted in urine) (Naidu, 2003). When ascorbyl palmitate is metabolized, it breaks down into nutritionally-available forms of ascorbic acid and palmitic acid (Madhavi and Salunkhe, 1995; Akoh and Min, 2008). While ascorbic acid is an essential vitamin (vitamin C), it remains inconclusive whether or not the body actually utilizes ascorbic acid that is metabolized from ascorbyl palmitate (Akoh and Min, 2008). No other information was found on the potential effects of ascorbyl palmitate on the nutritional quality of the food to which it is added.

Evaluation Question #8: List any reported residues of heavy metals or other contaminants in excess of FDA tolerances that are present or have been reported in the petitioned substance (7 CFR § 205.600 (b)(5)).

No reports of excessive levels of heavy metals or other dangerous contaminants in ascorbyl palmitate have been identified. No substances listed on FDA's Action Levels for Poisonous or Deleterious Substances in Human Food have been reported as contaminants of concern in ascorbyl palmitate. The requirements for ascorbyl palmitate in the 7th edition of the "Food Chemicals Codex" specify that it contain no more than 2 mg/kg lead (U.S. Pharmacopeia, 2010).

Evaluation Question #9: Discuss and summarize findings on whether the manufacture and use of the petitioned substance may be harmful to the environment or biodiversity (7 U.S.C. § 6517 (c) (1) (A) (i) and 7 U.S.C. § 6517 (c) (2) (A) (i)).

The acid esterification method of ascorbyl palmitate synthesis is energy intensive and involves significant post-processing (e.g., crystallization recovery, purification) to isolate the desired product. Less processing is required when enzyme-catalyzed synthesis processes are used (Bradoo et al., 1999). No other information was found that indicated that ascorbic palmitate manufacture or use might be harmful to the environment of biodiversity.

Evaluation Question #10: Describe and summarize any reported effects upon human health from use of the petitioned substance (7 U.S.C. § 6517 (c) (1) (A) (i), 7 U.S.C. § 6517 (c) (2) (A) (i)) and 7 U.S.C. § 6518 (m) (4)).

No reports of harmful effects on human health resulting from the use of ascorbyl palmitate as a food additive and preservative were found. As stated in response to Evaluation Question #4, ascorbyl palmitate is a chemical preservative that is affirmed as GRAS by FDA (21 CFR 182.3149). Ascorbyl palmitate shows low acute oral toxicity in laboratory animals and is not a dermal irritant or sensitizer (Andersen, 1999). In 2004, the European Food Safety Authority Scientific Panel on Dietetic Products, Nutrition and Allergies released an opinion on the tolerable upper intake level of vitamin C, defined as L-ascorbic acid along with its calcium, potassium, and sodium salts and L-ascorbyl-6-palmitate. The Panel concluded that there is insufficient data to establish a tolerable upper intake level, noting that "average dietary intakes do not represent a cause for concern" (EFSA, 2004).

Ascorbic acid and its derivatives have been shown to be cytotoxic, resulting in antimutagenic and antimetastatic action (Naidu, 2003). Because ascorbyl palmitate is lipophilic, it can cross the blood-brain barrier and has been shown to inhibit proliferation of brain tumor cells. It is more effective than ascorbic acid at inhibiting leukemia cell grown in mice (Naidu, 2003).

In cosmetics, such as lotions, skin foundations, and topical skin care products, ascorbyl palmitate is sometimes used as an anti-aging ingredient as some believe it protects the skin tissues from oxidation due to sunlight (Perricone, 2007). However, other research has shown that ascorbyl palmitate may have negative effects on skin, as antioxidant action during exposure to ultraviolet radiation can cause damage such as lipid peroxidation and cytotoxicity (Meves et al., 2002).

As mentioned in the response to Evaluation Question #7, ascorbyl palmitate is metabolized into nutritionally-available forms of ascorbic acid and palmitic acid (Madhavi and Salunkhe, 1995; Akoh and Min, 2008). While ascorbic acid is an essential vitamin, it cannot be determined whether ascorbyl palmitate provides added health benefits in contributing to the body's bioavailable vitamin C (Akoh and Min, 2008).

Evaluation Information #11: Provide a list of organic agricultural products that could be alternatives for the petitioned substance (7 CFR § 205.600 (b)(1)).

Ascorbyl palmitate is a fat-soluble antioxidant and therefore a useful preservative in foods and cosmetics with appreciable oil or fat content (Coppen, 1999). Nonorganic nonagricultural alternatives exist, such as synthetic BHA and BHT (Coppen, 1999), but information on organic, agricultural alternatives is limited. Other organic agricultural fat-soluble antioxidants which may be potential alternative preservatives include, but are not limited to, alpha-tocopherol (vitamin E), beta-carotene, alpha-lipoic and dihydrolipoic acids, and ubiquinone. Beta-carotene is a naturally-occurring substance that can be isolated from vegetables such as carrots (Banerjee, 2008). Alpha-lipoic acid, dihydrolipoic acid, and ubiquinone are also naturally-occurring substances biosynthesized by animals and humans (Packer et al., 1995; Frei et al., 1990). Like ascorbyl palmitate, ubiquinone and dihydrolipoic acid can function as synergistic antioxidants to regenerate tocopherols (Banerjee, 2008). No information was found to indicate whether or not these other fat-soluble antioxidants have been tested as alternatives to ascorbyl palmitate as preservatives in food or cosmetics, or are readily available for commercial use in processed foods.

Tocopherols are used as preservatives in many processed food uses similar to the uses of ascorbyl palmitate (Coppen, 1999). While tocopherols are naturally found in plants and animals, most commercially available tocopherols are synthetic (Coppen, 1999). Tocopherols derived from vegetable oils are classified under 21 CFR 205.605(b) as synthetic, nonagricultural substances allowed for use as an ingredient in or on processed products labeled as "organic" or "made with organic (specified ingredients or food group(s))" when rosemary extracts are not a suitable alternative. Rosemary extracts contain the antioxidants carnosol and carnosic acid, so can be used as a preservative in products like oils, fats, starch-based bakery items (i.e., cakes, cookies, pastries), processed meats, pastas, egg products, and dehydrated or powdered milks, soups, broths, and potatoes (EFSA, 2008). According to the petitioner, rosemary extracts are not considered suitable for use in infant formulas because carnosic acid is a possible abortifacient (i.e., a substance that induces abortion) and has unknown side effects in infants.

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