

**National Organic Standards Board
Handling Subcommittee
Petitioned Material Proposal
Phosphoric acid - Annotation Change
July 26, 2022**

Summary of [Petition](#)

This document reviews the petitioned annotation change of phosphoric acid, which is currently on the National List at §205.605(b): Phosphoric acid - cleaning of food-contact surfaces and equipment only.

Introduction:

In 2019, Kemin Food Technologies petitioned the United States Department of Agriculture (USDA) National Organic Standards Board (NOSB) to amend the existing annotation of phosphoric acid on the National List to include use as a synthetic substance for organic processing and handling ([USDA 2019](#), [USDA 2020a](#), [USDA 2020b](#)). This new petition requests the expansion of the use of phosphoric acid “as an acidifier to adjust pH of an extraction solvent to extract antioxidants or other target molecules from *lamiaceae* plants, provided the amount of acid used shall not exceed the minimum needed to lower pH to 2.5” (USDA 2020b).

Relevant Background:

In 2002, Aquatic Seaplants Limited petitioned the NOSB to expand the approved use of phosphoric acid within the National List to include production of organic aquatic plant extracts (USDA 2002). A technical report on phosphoric acid for organic processing was submitted in 2003 (USDA 2003). In 2004 the NOP contacted the petitioner and stated that phosphoric acid did not need to be petitioned for use in plant extraction “because its use as a pH adjuster in aquatic plant extracts is currently not prohibited through the inclusion of “aquatic plant extracts” in section 205.601(j)(1) of the National Organic Standards” (NOP 2013). In 2013 the NOP sent a memorandum to the National Organic Standards Board (NOSB) requesting a review on the use of phosphoric acid in plant extracts to ensure that this use is consistent with the context to the National List (NOP 2013). The petitioner subsequently withdrew the petition in January 2014.

Use:

Phosphoric acid is used in organic handling and processing as a cleaning agent for “food contact surfaces and equipment,” as described in 7 CFR 205.605(b). Phosphoric acid has been approved for pH adjustment of some soil amendments (liquid fish products and squid byproducts) and as an equipment cleaner in both organic crop and livestock production. (7 CFR 205.601 and §205.603).

In addition to its appearance at 7 CFR 205.605, phosphoric acid has been used as an ingredient in plant extractions (USDA 2002, USDA 2019, USDA 2020a, USDA 2020b). When used in this manner, phosphoric acid acts as an acidifying agent and stabilizer to facilitate more efficient extraction of target compounds (Yoon et al. 2020). The purpose of the annotation would be to allow use to extract target molecules, including but not limited to antioxidants, from various plant species of the *lamiaceae* family. In order to prepare the proper extraction solvent, tap water pH will be adjusted to lower pH.

The petitioner states, “This adjustment is critical to successful extraction because such low pH inhibits enzymatic oxidation that would otherwise destroy the target molecules. Regarding use of the extract, as consumer preferences begin to change and shift away from chemically sounding ingredients, consumers are looking to purchase and consume foods made with ingredients that come from natural sources. For food manufacturers, this means finding replacements for traditionally used synthetic ingredients, such as plant-based molecules. The petition is intended to be limited to extracting target molecules from

plants of the *lamiaceae* family. The extracted target molecules may be subsequently blended with appropriate carriers for help in proper dispersal across the surface of finished food products. Application depends on the finished food matrix as different extracts have hydrophilic or lipophilic properties.”

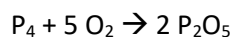
In addition to organic applications, phosphoric acid is a widely-used substance in conventional agriculture, with approximately 90% of wet process phosphoric acid used in the production of fertilizers (Shriver and Atkins 2008). Phosphoric acid has uses in food and beverage processing as a pH adjuster, flavor ingredient, and processing agent in dairy products (Wolke 2002, Gilmour 2019). Phosphoric acid is also a precursor to synthetic phosphates, which have a variety of uses including as fertilizers, surfactants, and detergents (Shriver and Atkins 2008). [TR 163-179]

Manufacture:

Phosphoric acid is produced through two methods, the wet process, and the thermal process (EPA 1995, Gilmour 2019, Haghani and Daneshpazhuh 2020). Historically, the end-point use for the phosphoric acid was determined by its production method. High purity, technical and food grade phosphoric acid was produced by the thermal process (EPA 1995, Gilmour 2019). Lower purity phosphoric acid, primarily used in animal feed and fertilizer applications, was produced by the wet process (EPA 1995, Shriver and Atkins 2008, Gilmour 2019). Due to the expensive nature of the thermal process, there has been continued development of purification methods for wet process phosphoric acid, which now serve as the predominant method for the production of technical and food grade phosphoric acid (Gilmour 2019).

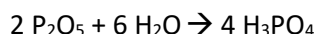
Thermal process

The thermal process is broken down into three major steps: combustion, hydration, and demisting (collection) (EPA 1995, Gilmour 2019). In the combustion step, elemental yellow phosphorus (P_4) is reacted with oxygen gas, which oxidizes the phosphorous from its 0 to V oxidation state, as shown below in Equation 6 (EPA 1995, Gilmour 2019). The heat of combustion for phosphorus is highly endothermic and the reaction must be carried out at high temperatures (1650 – 2760 °C) (EPA 1995, Gilmour 2019).



Equation 6

Once the elemental phosphorus is oxidized to P_2O_5 , it undergoes the hydration process to form orthophosphoric acid, as shown below in Equation 7 (EPA 1995, Gilmour 2019). In this process P_2O_5 is generally reacted with water, although in some cases dilute solutions of phosphoric acid are used instead of water alone (EPA 1995). Once phosphoric acid has been produced, it is isolated in the demisting process. In this step, phosphoric acid is collected as a mist with high-pressure drop demisters. The thermal process produces phosphoric acid with P_2O_5 concentrations between 54 and 62%, which are sufficiently pure for use in technical and food grade applications (EPA 1995, Gilmour 2019).



Equation 7

Wet Process

The wet process produces phosphoric acid from naturally occurring phosphate mineral sources (fluorapatite $[\text{Ca}_{10}(\text{PO}_4)_6\text{F}_2]$ and hydroxyapatite $[\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2]$) (EPA 1995, Shriver and Atkins 2008, Gilmour 2019, Haghani and Daneshpazhuh 2020). Once mined, these minerals are converted to phosphoric acid in four main steps, as outlined in Figure 5 below (Gilmour 2019). The phosphate rock is prepped in the initial step by being milled and ground to increase its surface area (EPA 1995, Haghani and Daneshpazhuh 2020).

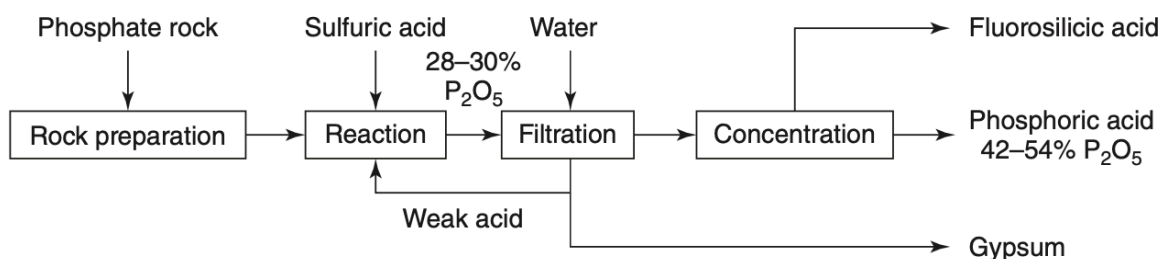
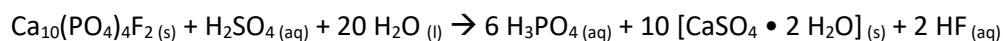


Figure 5

Once milled, the mineral phosphates are reacted with a strong mineral acid and converted to phosphoric acid, as shown in Equation 8 below (EPA 1995, Shriver and Atkins 2008, Gilmour 2019, Haghani and Daneshpazhuh 2020). While sulfuric acid is shown in both Figure 5 and Equation 8, other strong mineral acids (e.g., nitric acid $[\text{HNO}_3]$ and hydrochloric acid $[\text{HCl}]$) may also be used (Jin et al. 2014, Haghani and Daneshpazhuh 2020). However, most commercial processes use sulfuric acid because it provides higher phosphoric acid yields, lower costs, and a solid form of calcium (Al-Fariss et al. 1992, EPA 1995, Shriver and Atkins 2008, Gilmour 2019). The specific reaction conditions dictate the type of calcium sulfate hydrate ($\text{CaSO}_4 \cdot n \text{H}_2\text{O}$) formed, with lower temperatures favoring the formation of gypsum ($\text{CaSO}_4 \cdot 2 \text{H}_2\text{O}$), as shown in Equation 8 (EPA 1995). The prevalence of fluorapatite among mineral phosphates also produces hydrofluoric acid (HF), as shown below in Equation 8.



Equation 8

The gypsum formed during the reaction with the mineral acid is removed via filtration. Once removed, the gypsum solids undergo several aqueous wash cycles to remove residual phosphoric acid from the solid surface, producing phosphoric acid yields of 99.9% (EPA 1995, Gilmour 2019). As shown previously in Figure 5, the aqueous gypsum washes are sent back to the reaction vessel to aid in the conversion of mineral phosphates (EPA 1995, Gilmour 2019). The presence of mineral silicon in the initial composition reacts with hydrofluoric acid to produce less reactive forms of silicon tetrafluoride (SiF_4) and SiF_6^{2-} ions, some of which are removed as solids with the gypsum (Gilmour 2019).

The phosphoric acid isolated following the filtration process is dilute, with P_2O_5 concentrations between 26 – 30% (EPA 1995, Gilmour 2019). Vacuum evaporation is used to remove water and concentrate the phosphoric acid to 42 – 54% P_2O_5 (Gilmour 2019). Activated silica or clay is added during the concentration process to react with residual hydrofluoric acid. Silicon tetrafluoride isolated from the concentration step is hydrolyzed to fluorosilicic acid (H_2SiF_6), as shown in Figure 5 (Gilmour 2019).

Mineral impurities, including heavy metal contaminants, remain in phosphoric acid produced via the wet process, which have historically limited its use to agricultural fertilizer applications (EPA 1995, Shriver and Atkins 2008, Gilmour 2019, Haghani and Daneshpazhuh 2020). Wet process phosphoric acid results in concentrations between 42 and 54% P₂O₅, which is largely unsuitable for technical applications (Gilmour 2019). The elemental phosphorous used in the thermal process can be purified via sublimation, resulting in no carry-over of heavy metal contaminants so that thermal phosphoric acid can be used in technical and food applications (Shriver and Atkins 2008). However, the thermal process is much more expensive and energy intensive than the wet process (~2000 °C vs ~80 °C) (EPA 1995, Gilmour 2019).

Wet process purification methods

Wet process phosphoric acid is commonly purified by crystallization or solvent extraction (Gilmour 2019). Crystallization is a common purification technique, which is based on the differing solubilities of pure and impure mixtures, with pure substances selectively crystallizing at reduced temperatures (Pavia et al. 1995). When phosphoric acid is concentrated to 61% P₂O₅ or higher, it selectively forms hemihydrate crystals (H₃PO₄ • ½ H₂O) when cooled to 8 – 12 °C (Gilmour 2019). The crystals are removed from the mixture and can be melted to undergo additional recrystallization cycles to improve purity, with each cycle yielding a 10 to 100 times increase in purity (Gilmour 2019).

Solvent extraction is another traditional purification method based on solubility. In solvent extraction, the target compound migrates between immiscible phases (usually aqueous [polar] and organic [nonpolar]) based on solubility (Pavia et al. 1995). The selectivity of phosphoric acid does not differ greatly compared to its impurities, requiring additional purification steps. Prior to solvent extraction, concentrated phosphoric acid undergoes precipitation with calcium or barium salts to remove sulfate (SO₄²⁻), sodium salts to remove fluorosilicates, and sulfides to remove arsenic (Shlewitt and Alibrahim 2008, Gilmour 2019, Haghani and Daneshpazhuh 2020). Phosphoric acid extractions are performed in one or more extraction columns with many possible organic solvents, including alcohols, ethers, ketones, amines, and kerosene blends (Shlewitt and Alibrahim 2008, Jin et al. 2014, Gilmour 2019). Following extraction with an organic solvent, phosphoric acid is recovered with water. Residual organic solvents are removed via evaporation during the concentration of the recovered phosphoric acid from the aqueous solution (Shlewitt and Alibrahim 2008, Gilmour 2019). Solvent extraction of wet process phosphoric acid improves the purity of the substance from 42-54% P₂O₅ in the raw form to up to 97% P₂O₅ (Gilmour 2019). [TR 376-482]

International Acceptance:

[Canadian General Standards Board Permitted Substances List](#)

Phosphoric acid is listed in the Organic Production Systems Permitted Substances List as an approved substance for pH adjustment of “fish meal, fish powder, fish wastes, hydrolysate, emulsions and solubles” that are used for “soil amendments and crop nutrition.” Phosphoric acid is also listed as a “cleaner, disinfectant and sanitizer permitted on organic product contact surfaces for which a removal event is mandatory [for use] on dairy equipment.” [TR 345-351]

[European Economic Community \(EEC\) Council Regulation, EC No. 834/2007 and 889/2008](#)

Phosphoric acid is not listed in EC No. 834/2007 or EC No. 889/2008. [TR 357-358]

[CODEX Alimentarius Commission, Guidelines for the Production, Processing, Labelling and Marketing of Organically Produced Foods \(CXG 32-1999\)](#)

Phosphoric acid is not listed in the CODEX. [TR 353-355]

[International Federation of Organic Agriculture Movements \(IFOAM\) Norms](#)

Phosphoric acid is listed in the IFOAM NORMS for organic production and processing as an “equipment cleanser and equipment disinfectant only for dairy equipment,” and as a “substance for pest and disease control and disinfection in livestock housing and equipment [for] dairy equipment.” [TR 364-367]

[Japan Agricultural Standard \(JAS\) for Organic Production](#)

Phosphoric acid is not listed in the JAS. [TR 360-361]

Summary of Review:

The Handling Subcommittee submitted a proposal to the full Board at the Spring 2022 meeting in response to the petition. At that time, the Subcommittee’s review and discussion were centered around the petitioner’s assertion of essentiality. The Subcommittee took note of the presence of other similarly functional acids on the National List that can be used to prepare extraction solvents. According to the petitioner, phosphoric acid’s strength as an acid will assist in the creation of processed goods that meet consumer expectations. Phosphoric acid is allowed for use in crops to adjust pH in liquid fish products and squid byproducts. Phosphoric acid was in consideration for use in the extraction of aquatic plant extracts, but the submission was withdrawn by the petitioner. The Subcommittee discussed the low negative impact on the environment and human health, and noted that given the functionality of the petitioned use, it is unlikely that phosphoric acid will be present in final food products in significant amounts. The Handling Subcommittee challenged the need for an additional synthetic substance especially for use in food.

At the Spring 2022 meeting, the Board voted to send the proposal back to Subcommittee to further evaluate and better understand the intended use of phosphoric acid. The Subcommittee asked the petitioner some additional questions.

The questions and subsequent answers provided by the petitioner (in italics) are below:

1. Is this an accurate process flow?

- a. Tap water + phosphoric acid = extraction solvent with low pH
- b. PA extraction solvent + *lamiaceae* plants -> antioxidants and other target molecules of the *lamiaceae* plants
- c. Extracted antioxidants and other target molecules + organic carrier oil -> added as ingredient in finished product

The process flow detailed in your response is mostly correct. However, one minor change to Section 1(c) is that the carrier is unlikely to be an oil. After extraction, the plant extract could be used without a carrier, or could be used with a water-soluble carrier including but not limited to water or organic ethanol. It is also possible for the lamiaceae plant extracts to be combined with a dry carrier, including but not limited to something like organic rice flour, and then added as a dry ingredient to the finished food.

2. What are some examples of finished products this extract would be used as an ingredient in? And why is this ingredient needed to be added to the finished product? Is this for food preservation?

Finished products incorporating this extract would be any multi-ingredient product certified as organic under USDA NOP federal regulatory program.

Lipid oxidation, a chain reaction that occurs in the presence of oxygen and lipid molecules, is responsible for deterioration in food quality and can lead to possible off-flavors or off-odors.

Oxidation can be affected by processing, packaging, storage methods, or even ingredients within a food product. Fortunately, though, antioxidants are common food ingredients today used to help prevent oxidation and thereby preserve freshness to help ensure consumers have the most appealing and fresh food. Multiple synthetic antioxidants have commonly been used throughout history, but data has shown similar effects can come from the power of plants. These plant-based antioxidants are acceptable to consumers. Consumers not only expect a product to taste fresh through its shelf life, but also demand use of ingredients they feel good about, including those that are plant-based and organic compliant. Consumers have a wide range of expectations, meaning food ingredient manufacturers must offer a wide range of product solutions, including the antioxidants or other target molecules mentioned in this petition.

3. Is this to support the production of organic rosemary extract or other organic extracts?

The intent behind his petition was not to support production of organic rosemary extract. The current need is for an extraction solvent to process spearmint. However, as many plants from the lamiaceae family contain additional beneficial molecules that might not have been discovered yet, the need to extract these new molecules may arise in the future. That being said, Kemin is not currently aware of any such additional molecule having been affirmed GRAS for its intended use, and therefore a GRAS affirmation would be required before any additional plant extract could be applied to an organically certified food. Thus, while Kemin believes phosphoric acid could be used to aid in the extraction of any target molecule from the lamiaceae family, the current request could be limited to extraction of only antioxidants from spearmint if such amendment was more acceptable to the NOSB Handling Subcommittee.

Most of the public comments during the Spring 2022 meeting were not supportive of the listing based on lack of knowledge and understanding of the intended use of phosphoric acid especially in relation to the finished product. The petitioner confirmed that phosphoric acid is solely to be used to aid extraction (i.e., processing aid). By definition a processing aid is either "...removed in some manner from the food..." or "...is present in the finished food but at insignificant levels...". This addresses some stakeholder comments about whether phosphoric acid will be present in the finished product. It would appear this would not be the case given this will be used as a processing aid (§205.2 Definitions).

The extraction ingredient (mainly spearmint extract) will be added to various finished foods to prevent oxidation. Additionally, as stated throughout the TR and the petition, phosphoric acid is a stronger acid compared to other acids resulting in lower usage rates. There are other acids on the National List, which are all "weaker acids", which would require higher rates to achieve the desired pH adjustment. Based on this the petitioner states it is not feasible to use these alternatives. This was also brought up by stakeholders, in which it was noted that there are already various organic mint family extracts on the market. There are about a dozen companies in the Organic Integrity Database (OID) with spearmint extracts listed as organic products. The Subcommittee is looking for additional information on the topic of essentiality given that there are already organic spearmint extracts available produced without the use of phosphoric acid. It seems like the acids already on the National List are "feasible" but not preferred. Is this an accurate assumption?

The Subcommittee discussed how the expanded annotation could potentially increase use of organic rosemary extracts and therefore reduce the use of tocopherols (another synthetic on the National List). However, this doesn't seem to be the intended use. Again, it appears that other acids currently listed could also be used for this purpose, which brings us back to the same question of essentiality.

Lastly, public commenters also noted the impact on the environment during the manufacturing process. The Subcommittee discussed this along with the other concerns expressed in the Spring 2022 public comments outlined above.

Overall, the Subcommittee is mostly concerned about expanding the use of a synthetic substance on the National List when it appears to not be essential (i.e., according to the OID, organic spearmint extracts are currently being produced).

Category 1: Classification

1. Substance is for: **Handling** **Livestock**

2. For HANDLING and LIVESTOCK use:
 - a. Is the substance **Agricultural** or **Non-Agricultural**?
Describe reasoning for this decision using NOP 5033-2 as a guide:

Phosphoric acid is currently listed on the National List at §205.605(b).

- b. If the substance is **Non-agricultural**, is the substance **Non-synthetic** or **Synthetic**?
Is the substance formulated or manufactured by a process that chemically changes a substance extracted from naturally occurring plant, animal, or mineral sources? [OFPA §6502(21)] If so, describe, using NOP 5033-1 as a guide:

Phosphoric acid is currently listed on the National List at §205.605(b).

3. For **LIVESTOCK**: Reference to appropriate OFPA category
Is the substance used in production, and does it contain an active synthetic ingredient in the following categories: [§6517(c)(1)(B)(i)]; copper and sulfur compounds; toxins derived from bacteria; pheromones, soaps, horticultural oils, fish emulsions, treated seed, vitamins and minerals; livestock parasiticides and medicines and production aids including netting, tree wraps and seals, insect traps, sticky barriers, row covers, and equipment cleansers; or (ii) is used in production and contains synthetic inert ingredients that are not classified by the Administrator of the Environmental Protection Agency as inerts of toxicological concern?

N/A

Category 2: Adverse Impacts

1. What is the potential for the substance to have detrimental chemical interactions with other materials used in organic farming systems? [§6518(m)(1)]

The petition states “Phosphoric acid itself combines readily with many other chemicals and no known detrimental interactions within organic farming systems is known.” Additionally, this material is already listed twice on the National List, therefore the potential for detrimental chemical reactions seems unlikely.

2. What is the toxicity and mode of action of the substance and of its breakdown products or any contaminants, and their persistence and areas of concentration in the environment?
[§6518(m)(2)]

The petition states “In the process of phytochemical extraction, phosphoric acid combines with water to form an acidified extraction solution. Phosphoric acid in its original form will break down quickly in the environment, so there are no toxicity issues directly related to its breakdown products. In this process, phosphoric acid will be partially neutralized by the plant components, and after extraction, the matrix has a pH of about 5.0-6.0. Consequently, the phosphoric acid will no longer exist in its acid form and the resulting liquid will not be corrosive. Therefore, while raw and concentrated phosphoric acid might be toxic to aquatic environments, the process mitigates contaminant persistence and/or concentration in the environment.”

The TR states that due to the low concentration in the extraction application, as well as the prevalence of phosphates throughout biology, the likelihood of toxicity and concentration in the environment are low.

3. Describe the probability of environmental contamination during manufacture, use, misuse, or disposal of such substance? [§6518(m)(3)]

When used as petitioned, phosphoric acid is used in low concentrations (1 – 3%), and is a source of phosphates for incorporation to biomolecules. The low concentration in extraction applications and the prevalence of phosphates throughout biology make phosphoric acid from plant extractions unlikely to be harmful to the environment or biodiversity.

However, the production of phosphoric acid does have the potential to be harmful to the environment. The thermal process for producing phosphoric acid is energy intensive and requires high temperatures. The high energy requirements of the thermal process may contribute to atmospheric CO₂ levels if the energy is produced from fossil fuels. The thermal process also requires the treatment of combustion gases by scrubbers, cyclonic separators, mist eliminators, and electrostatic precipitators to prevent the release of phosphoric acid to the environment (EPA 1995, Gilmour 2019). The small size (< 3 μm diameter) makes these phosphoric acid and phosphorus oxide (P₂O₅) particles difficult to capture, and contributes their release to the atmosphere at levels of “< 25 mg P₂O₅ per dry standard cubic meter of stack gas” (Gilmour 2019).

Wet process phosphoric acid is produced from chemical changes to mined mineral phosphates. There may be initial harm to the environment and biodiversity in the mining process. Once the minerals are isolated, hydrofluoric acid presents the most likely source of environmental harm (Shriver and Atkins 2008). Hydrofluoric acid is removed as a solid or as fluorosilicic acid by reaction with silica sources. These include natural silicates present within the initial mineral, as well as activated silica and clay added during the manufacturing process (Shriver and Atkins 2008, Gilmour 2019). Additionally, scrubbers are used to remove gaseous fluorine compounds from concentration steps to prevent their release to the environment (EPA 1995).

In addition to the hazards from fluorine compounds, the gypsum produced may pose a hazard to the environment. Isolated gypsum may be used for other commercial applications if it is sufficiently pure (Gilmour 2019). In other cases, gypsum is left in gypsum stacks, or pumped out to sea (Gilmour 2019). However, the gypsum may also contain silicon fluorides, acids, and other impurities from the initial mineral source, which has resulted in its designation as a hazardous substance by the EPA in 40 CFR 261.4. [TR 566-594]

4. Discuss the effect of the substance on human health. [§6517 (c)(1)(A)(i); §6517 (c)(2)(A)(i); §6518(m)(4)].

Concentrated phosphoric acid is corrosive and can result in burning and irritation of the eyes and skin on contact (Flomenbaum et al. 2002, NJDHSS 2004, Gilmour 2019). Phosphoric acid can desiccate epithelial cells, resulting in the drying and cracking of skin where long-term exposure occurs (Flomenbaum et al. 2002, NJDHSS 2004). Inhalation of phosphoric acid may result in irritation to the nose, lungs, and throat and may induce coughing and wheezing (NJDHSS 2004, Gilmour 2019). Ingestion of phosphoric acid may damage gastric and esophageal mucus linings (Flomenbaum et al. 2002).

Phosphoric acid is frequently used in food processing and production and is a common component of food and beverages (Wolke 2002). As described in Equations 2 – 4 in the “Composition of the Substance” section, phosphoric acid is the source of several phosphates, which are important components of biomolecules (e.g., ATP, DNA, etc.) (Shriver and Atkins 2008, Timberlake 2016, Gilmour 2019). When used as petitioned, phosphoric acid is used in low concentrations (1 – 3%), making it unlikely to be harmful to human health (Gilmour 2019). [TR 599-611]

5. Discuss any effects the substance may have on biological and chemical interactions in the agroecosystem, including the physiological effects of the substance on soil organisms (including the salt index and solubility of the soil), crops and livestock. [§6518(m)(5)]

The petition states, “When stored, used and disposed of appropriately, phosphoric acid use during phytochemical extraction will have no negative interactions with soil organisms, crops, or livestock.”

Additionally phosphoric acid is allowed at §205.601(j)(8) as a pH adjuster which makes the likelihood that phosphoric acid has negative physiological effects on soil organisms, crops, and livestock unlikely.

6. Are there any adverse impacts on biodiversity? (§205.200)

As previously stated, due to the low concentration in the extraction application, as well as the prevalence of phosphates throughout biology, there does not appear to be an adverse impact on biodiversity.

Category 3: Alternatives/Compatibility

1. Are there alternatives to using the substance? Evaluate alternative practices as well as non-synthetic and synthetic available materials. [§6518(m)(6)]

There are alternative methods to extract target molecules from plant material. One of the simplest ways to improve solvent extraction processes is to increase the solvent temperature (Pavia et al. 1995, Silberberg 2003). Increased temperature improves the solvation of most solids and liquids by disrupting the intermolecular forces that prevent the target molecule from entering the solution (Silberberg 2003).

Supercritical carbon dioxide extraction offers an alternative to acidic extractions. This extraction method uses temperatures and pressures that push the solvent beyond its critical point, so that it no longer exists as a liquid or gas (Silberberg 2003, Babovic et al. 2010). Carbon dioxide is the most common supercritical fluid used in extraction applications due to its low cost and the low temperatures and pressures required to reach supercritical conditions (31.1 °C and 7.38 MPa) (Babovic et al. 2010). The selectivity of supercritical fluids can be modulated by changing its temperature and pressure to target different classes of molecules.

Subcritical extractions offer another alternative to acidic extractions. In such applications, the solvent remains in liquid form, although conditions may approach the critical point of the solvent (Ibañez et al. 2003). As with supercritical fluid extractions, the selectivity of the subcritical extractions can be manipulated by modifying temperature and pressure. Subcritical water extractions have been successful in the extraction of essential oils and antioxidants (Ibañez et al. 2003). However, some antioxidants and other compounds are sensitive to decomposition, and may not survive increased solvent temperatures or the high-pressure conditions needed in supercritical and subcritical extractions (Ibañez et al. 2003). [TR 616-634]

Many natural and currently allowed synthetic acids offer an alternative to phosphoric acid for plant extractions, such as acetic acid, citric acid, gibberellic acid, lactic acid, and tartaric acid (NOP 2016c). Polyprotic carboxylic acids (for example, ascorbic acid, citric acid, etc.) are also able to chelate positively charged species, facilitating improved extraction (Albuquerque et al. 2005).

However, the strength of the acid is important in determining the effectiveness in the extraction of the target molecules. Carboxylic acids are weaker acids than phosphoric acids ($pK_a \sim 5$ vs 2.15) meaning that they may be less effective in extracting some molecules, including anthocyanin antioxidants (Silberberg 2003, Nicoué et al. 2007, Timberlake 2016). The target molecule and plant structure determine the optimal solvent conditions, although phosphoric acid solutions have been reported to be among the most effective for antioxidant extractions (Nicoué et al. 2007). [TR 640-650]

Alternatives to phosphoric acid are naturally acidic agricultural substances, including wine and vinegar. Both mixtures include natural acids that can provide an acidic extraction solution. However, as described in Evaluation Question 12, carboxylic acids are weaker than phosphoric acid and may be less effective in the extraction of some target molecules. Additionally, the complex mixture of compounds in wine and vinegar would make purification of the plant extracts more difficult. [TR 655-659]

Category 4: Additional criteria for synthetic substances used in Handling (does not apply to nonsynthetic or agricultural substances used in organic handling):

Describe how the petitioned substance meets or fails to meet each numbered criterion.

1. The substance cannot be produced from a natural source and there are no organic substitutes; (§205.600(b)(1))

Phosphoric acid is a synthetic substance that does not exist in nature. Therefore, there are no natural sources of phosphoric acid. [TR 500-501]

2. The substance's manufacture, use, and disposal do not have adverse effects on the environment and are done in a manner compatible with organic handling; (§205.600(b)(2))

The petition states, "There are many environmental consequences from the manufacture, misuse, and disposal of phosphates in general and these cannot be separated out for phosphoric acid in particular. In figures from world phosphorus consumption in 1980, about 90% of phosphate consumption is for fertilizer, while 4.5% is for all detergents including other cleaners such as trisodium phosphate. There are extreme environmental impacts from mining of phosphate ore which occurs in many parts of the world. Worker safety is of prime concern in the wet-process acid and elemental phosphorous used in

the thermal process because of high acidity, heat released upon neutralization and toxic gases released. Plants will be equipped with proper safety procedures and equipment to deal with these issues.

The issues of phosphate pollution from disposal are discussed above, but in general the dilution of phosphoric acid will minimize disposal problems in the food processing or livestock facility.”

The TR, as previously stated, indicates that the use of phosphoric acid is relatively benign regarding its impact on the environment. However, it does state that thermal production process is energy intensive and uses high temperatures, which could contribute to CO₂ levels if the energy is produced from fossil fuels. That said, as stated previously, due to the expensive nature of the thermal process, there has been continued development of purification methods for wet process phosphoric acid, which now serve as the predominant method for the production of technical and food grade phosphoric acid (Gilmour 2019).

3. The nutritional quality of the food is maintained when the substance is used, and the substance, itself, or its breakdown products do not have an adverse effect on human health as defined by applicable Federal regulations; (§205.600(b)(3))

When used as petitioned, phosphoric acid will be used in the extraction of target molecules from plant material. The extraction of antioxidants and other compounds from the initial plant material will reduce the nutritional quality of the material from which they are extracted. However, the purpose of plant extracts is to improve the quality of other products to which they are added (Nicoué et al. 2007, Proestos 2020). Phosphoric acid is a source of phosphates, which are important nutrients in human health, and can be found in many biomolecules, including ATP and DNA (Shriver and Atkins 2008, Timberlake 2016, Gilmour 2019). However, phosphoric acid is typically used in low concentrations (1 – 3%) in extraction processes and is unlikely to contribute directly to improved nutritional quality. [TR 540-547]

4. The substance's primary use is not as a preservative or to recreate or improve flavors, colors, textures, or nutritive value lost during processing, except where the replacement of nutrients is required by law; (§205.600(b)(4))

When used as petitioned, the primary function of phosphoric acid is to improve the extraction of target molecules, not to act as a preservative. However, in some cases, the addition of phosphoric acid stabilizes target molecules from decomposition, as described above in the “Action of the Substance” section, thus the ingredient (e.g., *lamiaceae* plant extracts such as spearmint extract) will act as an antioxidant in the finished food product.

Phosphoric acid is also used as an equipment sanitizer in organic agriculture in 7 CFR 205.605 and §205.603. The low pH of phosphoric acid solutions makes it an antimicrobial substance, as high acid content is not tolerated by microorganisms (Winniczuk and Parish 1997, Prado et al. 2015). The antimicrobial nature of phosphoric acid may result in some preservative characteristics if incorporated into food and beverage products (Winniczuk and Parish 1997). [TR 518-526]

When used as petitioned, the primary function of phosphoric acid is to improve the extraction of target molecules, not to improve or recreate flavors in processed food products. However, phosphoric acid has been used as a flavoring agent in conventional food and beverage production, as described above in the “Specific Uses of the Substance” and “Historical Use” sections. [TR 532-535]

5. The substance is listed as generally recognized as safe (GRAS) by the Food and Drug Administration (FDA) when used in accordance with FDA's good manufacturing practices (GMP) and contains no residues of heavy metals or other contaminants in excess of tolerances set by FDA; (§205.600(b)(5))

As described in the "Approved Legal Uses of the Substance" section, the FDA has designated phosphoric acid generally recognized as safe (GRAS) for several uses. Phosphoric acid is listed as a "multiple purpose GRAS food substance" in 21 CFR 182. 1073, and as a GRAS "general purpose food additive" in §582.1073. Additionally, the FDA lists phosphoric acid as a substance used in the production of the GRAS substances monobasic ammonium phosphate in §184.1141, dibasic ammonium phosphate in §184.1141, magnesium phosphate in §184.1366, and hydrogen peroxide in §184.1366. [TR 507-512]

6. The substance is essential for the handling of organically produced agricultural products. (§205.600(b)(6))

The petition states, "Since effective extraction is a critical step in the ability to use biomolecules, the ultimate benefit of the applicable organic management program, and since phosphoric acid appears among the best and safest pH adjusters, this material seems compatible with an organic production and processing system."

However, as discussed above in the Summary of Review section, the Handling Subcommittee questions the essentiality of phosphoric acid as a pH adjuster as there are already acids on the National List that perform this function and there are organic spearmint extracts (and other *lamiaceae* plant extracts) commercially available (determined via a search of the OID).

7. In balancing the responses to the criteria in Categories 2, 3 and 4, is the substance compatible with a system of sustainable agriculture [§6518(m)(7)] and compatible with organic handling? (see NOSB Recommendation, [Compatibility with Organic Production and Handling, April 2004](#))

Based on essentiality, availability of alternatives, as well as potential negative environmental impacts during manufacturing, the Handling Subcommittee finds that phosphoric acid is not compatible with a system of sustainable agriculture,

Questions to stakeholders:

1. Is expanding the use of phosphoric acid as petitioned necessary given that there are currently organic spearmint extracts (and likely other extracts from the *lamiaceae* plant family) commercially available?

National List Motion:

Motion to amend the annotation of phosphoric acid to (underlined verbiage is the proposed addition) "cleaning of food-contact surfaces and equipment, and as an acidifier to adjust pH of an extraction solvent to extract antioxidants or other target molecules from *lamiaceae* plants, provided the amount of acid used shall not exceed the minimum needed to lower pH to 2.5." at 205.605(b).

Motion by: Kyla Smith

Seconded by: Dilip Nandwani

Yes: 0 No: 6 Abstain: 0 Recuse: 0 Absent: 2