United States Department of Agriculture
Agricultural Marketing Service | National Organic Program
Document Cover Sheet
https://www.ams.usda.gov/rules-regulations/organic/petitioned-substances

Document Type:

☐ **National List Petition or Petition Update**

A petition is a request to amend the USDA National Organic Program's National List of Allowed and Prohibited Substances (National List).

Any person may submit a petition to have a substance evaluated by the National Organic Standards Board (7 CFR 205.607(a)).

Guidelines for submitting a petition are available in the NOP Handbook as NOP 3011, National List Petition Guidelines.

Petitions are posted for the public on the NOP website for Petitioned Substances.

☒ **Technical Report**

A technical report is developed in response to a petition to amend the National List. Reports are also developed to assist in the review of substances that are already on the National List.

Technical reports are completed by third-party contractors and are available to the public on the NOP website for Petitioned Substances.

Contractor names and dates completed are available in the report.

Cornstarch

Handling/Processing

Identification of Petitioned Substance

Chemical Names:
Amylum; amylose & amylopectin; IUPAC: 5-[(5-{[3,4-dihydroxy-6-(hydroxymethyl)-5-methoxyoxan-2-yl]oxy}-6-({[3,4-dihydroxy-6-(hydroxymethyl)-5-methoxyoxan-2-yl]oxy}methyl)-3,4-dihydroxyoxan-2-yl)oxy]-6-(hydroxymethyl)-2-methyloxane-3,4-diol

Other Names:
Corn starch; cornstarch (native); glycogen, maize starch; native cornstarch; starch, corn; starch, maize; unmodified cornstarch; cornflour (UK)

Trade Names:
Argo®; Clabber Girl®; Keoflo; Maisita, Maizena®, Novation®

CAS Numbers:
9005-25-8 (Generic starch, all sources)
977050-51-3 (Cornstarch)
977050-52-4 (Cornstarch, Waxy)

Other Codes:
EC 232-679-6
SMILES:
COC1C(O)C(O)C(OCC2OC(OC3C(O)C(O)C(C)OC3CO)C(O)C(O)C2OC2OC(CO)C(OC)C(O)C2O)OC1CO
InChI Identifier: 1S/C27H48O20/c1-8-13(31)14(32)23(11(6-30)42-8)46-27-20(38)17(35)24(47-26-19(37)16(34)22(40-3)10(5-29)44-26)12(45-27)7-41-25-18(36)15(33)21(39-2)9(4-28)43-25/h8-38H,4-7H2,1-3H3
InChI Key: YJISHJVIRFPGGN-UHFFFAOYSA-N

Summary of Petitioned Use

This full scope technical report provides information to the National Organic Standards Board (NOSB) to support the sunset review of cornstarch (native), listed at 7 CFR 205.606(e). This report focuses on uses of cornstarch (native) in organic processing and handling, as a nonorganically produced agricultural product allowed as ingredients in or on processed products labeled as "organic," per the substance's annotation. Substances listed at § 205.606 may be used in products labelled as "organic" when not commercially available in organic form.[1]

Native cornstarch was included on the original National List of Allowed and Prohibited Substances (hereafter referred to as the "National List") with the first publication of the National Organic Program (NOP) Final Rule (65 FR 80548, December 21, 2000). The NOSB recommended that cornstarch be added to the National List of allowed nonorganic ingredients on November 1, 1995 (NOSB, 1995a).

The only technical review for cornstarch was conducted by the Technical Advisory Panel in September 1995 (NOSB, 1995b). At a meeting on April 28, 2004, the NOP informed the NOSB that they had received a petition to remove nonorganic cornstarch from the National List (NOSB, 2004a). However, we found no record of the NOSB having reviewed the petition (NOSB, 2004b). As of July 2024, the USDA reported that the petition to remove cornstarch from the National List was not available (NOP, 2024b). The NOSB has recommended renewing the listing for cornstarch in 2005, 2010, 2015, and 2020 (NOSB, 2005, 2010, 2015, 2020).

Cornstarch (native) is listed at § 205.606(e). As stated previously, materials listed at 205.606 may be used in processed products labelled as "organic" only when the product is not commercially available in organic form. Like all agricultural substances, cornstarch (native) is also allowed in products in the

[1] The term "commercially available" is defined as: "The ability to obtain a production input in an appropriate form, quality, or quantity to fulfill an essential function in a system of organic production or handling, as determined by the certifying agent in the course of reviewing the organic plan" (7 CFR 205.2).

"made with organic [specified ingredients]" category if it has been produced without the use of excluded methods, sewage sludge, or ionizing radiation [§§ 205.105(e-g); 205.301(c); §§ 205.301(f)(1-3)]. Native cornstarch has no additional annotation that limits its use.

Starch produced by the corn wet milling process that is simply dried without further processing is called common, regular, or unmodified cornstarch (CRA, 2006). These have been traditionally referred to as "native" cornstarch (Thomas & Atwell, 1999). Cornstarch can be further modified through chemical means to enhance its properties, creating "modified" cornstarch (see *Specific Uses of the Substance* below). However, corn varieties have now been genetically modified to alter their characteristics, and have the functionality of modified cornstarch without further chemical processing (CRA, 2006). Starches from such genetically modified corn varieties allow processors to use fewer chemicals in the manufacturing process and claim "native" labeling in addition to their unique functionality and use in food (CRA, 2006).

Cornstarch derivatives that have been modified by further chemical processes are outside the scope of this technical report. Unless otherwise specified for context and comparison, "cornstarch" used in this technical report refers only to cornstarch that is not produced from varieties using excluded methods and have not been chemically modified.

Characterization of Petitioned Substance

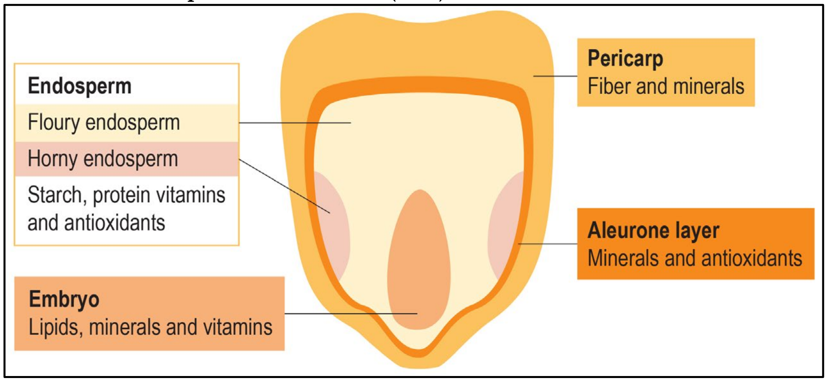
Composition of the Substance:

Cornstarch is composed of both amylose and amylopectin molecules isolated from the endosperm of corn (*Zea mays*) (Igoe, 2011). Both are large polymers made up of long chains of sugar (glucose) molecules linked together (Hamaker et al., 2019; Starch Europe, 2019). Amylose is connected in linear or near-linear chains, while amylopectin is substantially branched (Hamaker et al., 2019). The proportions of amylose and amylopectin in cornstarch vary based on the corn variety grown, specific processes at various steps in the milling process, and subsequent filtration steps or other mechanical and physical treatments used to prepare the product for specific applications (Eckhoff & Watson, 2009; Galliard, 1987; P. J. White, 2001). Unmodified starches are defined as any granular starch that has been isolated from the original plant source but has not undergone subsequent chemical modification (Thomas & Atwell, 1999). Unmodified starches can be treated by pH adjustment or small quantities of chemicals or adjuvants—such as enzymes—to help them perform more effectively for certain specific applications (CRA, 2006). Such treatments are discussed further in *Evaluation Question #1B* below. The genetic makeup of corn can also be changed through the use of genetic engineering techniques (CRA, 2006). The use of excluded methods in corn production is discussed further in *Evaluation Question #1F* below. Unless specifically referred to as such, cornstarch derived from corn that has been genetically modified to alter the chemical composition of the starch or that has been chemically modified is outside the scope of this Technical Review, even if such starches meet the standard of identity to be labelled "native" or "unmodified."

Source or Origin of the Substance:

Corn is the largest commercial source of starch in the world (Hamaker et al., 2019). Worldwide, corn accounts for about 80% of starch production (Johnson, 2000). About 95% of all starch manufactured in the U.S. comes from corn (P. J. White, 2001). Most cornstarch in the U.S. is manufactured through the wet milling process (Whistler & Daniel, 2000). The endosperm of the corn kernel (see *Figure 1*) contains the highest concentration of cornstarch, making up about 75% of the kernel by weight (Eckhoff & Watson, 2009; Hong et al., 2024; P. J. White, 2001). Breeders have, through various means, selected different varieties to be high in amylopectin (CIRF, 1964; CRA, 2006; Johnson, 2000; P. J. White, 2001). Classically bred waxy corn varieties originated in China and were first introduced to the U.S. in 1908 (CIRF, 1964). As corn breeding increased yields of corn during most of the 20th century, the starch percentage also increased, with a reported 0.3% increase in starch content per decade in varieties grown in Iowa. Protein content declined over the same period (Duvick, 2005).

Figure 1: Corn kernel. Adapted from Hou et al. (2022) and licensed under Creative Commons by 4.0.

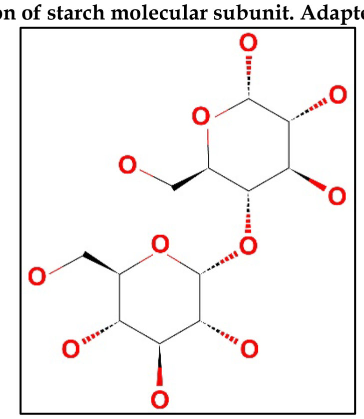


The endosperm is divided between the floury endosperm, which is composed entirely of starch, and the horny endosperm, which contains starch, protein, vitamins, and antioxidants (Hou et al., 2022). Corn is hydrolyzed using synthetic chemicals and naturally occurring enzymes and separated into various derivatives, one of which is corn starch (Johnson, 2000; Whistler & Daniel, 2000). Corn wet milling is described in greater detail in *Evaluation Question #1B* below.

Properties of the Substance:

While starches can be complex polymeric structures, they are all carbohydrates made from amylose and amylopectin. The starch molecule is composed of glucose subunits (see *Figure 2*) connected in either a linear or branched pattern.

Figure 2: Representation of starch molecular subunit. Adapted from US NLM (2024).



Cornstarch is a stable solid, granular white-to-slightly yellowish powder with a bland odor and taste that is soluble in water (*Table 1*). Like other unmodified food starches the particle sizes can vary as powders, as intact granules, and as flakes or coarse particles if pregelatinized (Food Chemicals Codex, 2014). Granules are polygonal, round, and when extracted from high-amylose corn, irregular in shape (Thomas & Atwell, 1999). Starch granules vary in diameter by plant, with cornstarch ranging between 5 and 30 µm (Thomas & Atwell, 1999). Most granules fall in the range of 10-25 µm (Galliard, 1987). These granule sizes are mid-range when compared to other starch sources. Rice starch tends to have the smallest granules, with particle sizes of 1-3 µm (Thomas & Atwell, 1999). Potato starch has the largest particle sizes, with granules of up to 100 µm (Galliard, 1987; Thomas & Atwell, 1999).

Table 1: Properties of cornstarch

Property	Value
Physical state and appearance	Solid, granular powder (Chemistry Connection, 2015; Scholar Chemistry, 2009)
Odor	Bland odor (Scholar Chemistry, 2009)
Taste	Bland taste; will not mask flavors and aromas (Ingredion, 2023)
Color	White to slightly yellowish white (Chemistry Connection, 2015; Ingredion, 2022; Scholar Chemistry, 2009)
Molecular weight	504.4 g/mol (Amylose monomer); 828.7 g/mol (Amylopectin monomer)

Property	Value
	(US NLM, 2024)
Specific gravity	1.45 g/mL @ 20°C (Scholar Chemistry, 2009)
pH	~5-7 (Chemistry Connection, 2015)
Solubility	Starch granules begin to swell and gelatinize in water at temperatures between 45° and 80°C (113°-176°F). Insoluble in alcohol, ether, and chloroform (Food Chemicals Codex, 2014)
pKa	11.76 (TMIC, 2024)
pKb	-3.6 (TMIC, 2024)
Boiling point	NA
Melting point	NA
Critical temperature	NA
Vapor pressure	0.0±0.6 mmHg @ 25°C (Royal Society of Chemistry, 2024)
Stability	Stable under normal conditions and uses (Scholar Chemistry, 2009)
Reactivity	No dangerous reactions are known under conditions of normal use (Chemistry Connection, 2015)

<u>Specific Uses of the Substance:</u>

Starches

Generally speaking, starches are the most widely used polysaccharide for food applications (Stephen & Phillips, 2006). They are primarily used in food for the following technical and functional effects (Pomeranz, 1991):

- thickeners (sauces, soups, pie fillings)
- colloidal stabilizers (salad dressings)
- moisture retention (cake toppings)
- gel-forming agents (gum confections)
- binders (ice cream cones and wafers)
- coating and glazing agents (candies and nuts)

Native cornstarch

According to comments provided by the Organic Trade Association to the NOSB in 2020, nonorganic cornstarch is used (Organic Trade Association, 2015, 2020):

- as a thickener in macaroni products, tortillas, baking mixes, and baked goods
- as a processing aid in the manufacture of confections
- to build viscosity to maintain fruit distribution in fruit preparations
- in dressings, sauces, cereals, snacks, frozen entrees, breakfast products, nutritional supplements, and jellybeans
- as a molding medium for gummy bears and other fruit snacks

Cornstarch is used in many different foods for diverse reasons (Hong et al., 2024; Mason, 2009; Mohamed, 2020; Thomas & Atwell, 1999). However, native cornstarch has limited uses (J. BeMiller & Huber, 2011). This is because unmodified starches (such as native cornstarch) tend to have a narrow range of tolerance between undercooking and overprocessing, and products that contain them often have poor retail shelf stability (Mason, 2009; Moore et al., 1984). The food industry has replaced native cornstarch with modified cornstarch in many applications (J. BeMiller & Huber, 2011). Modified cornstarch can be different from native cornstarch in the following ways (Mason, 2009):

- better retained viscosity in processing conditions involving heat, acid, and shear by crosslinking
- improved emulsification (dispersion in a liquid), increased stability, reduced viscosity, and improved film-forming by dextrinization
- the ability to form a broader range of gels of varying thickness before cooking and by using various solvents
- improved stability, increased gel temperature, and reduced viscosity through ionizing radiation

While cornstarch itself generally does not impart flavor, it is used as an ancillary ingredient in formulated flavors (FEMA, 2011). Starches are regarded as non-flavor adjuvants by flavor manufacturers (FEMA, 2011). Because it has a bland taste, cornstarch used as a carrier for flavors will not mask flavors and aromas (Ingredion, 2023). Cornstarch has no leavening effect, but is used in baking powder as a filler, standardizing agent, and stabilizer that prevents the leavening agents from reacting with each other prematurely (Neeharika et al., 2020). While pure cornstarch alone has no vitamins or minerals, it offers an inexpensive carrier that facilitates micronutrient uptakes (Deladino et al., 2016; Lay Ma et al., 2011).

Native cornstarch is still used as a dusting powder for jelly-type confections, chewing gum, and marshmallows (J. BeMiller & Huber, 2011; Mason, 2009). Native starches are sometimes used in dry mixes for foods eaten shortly after preparation, such as gravies or pudding (Mason, 2009). They may also be added to salt for moisture control (J. BeMiller & Huber, 2011).

Native cornstarch lots that fail to meet food-grade specifications can be chemically modified and marketed for many industrial uses (Ellis et al., 1998; Hong et al., 2024). Non-food applications include textiles, paper manufacturing, ink and dye thickeners, ore refining, and ceramics (J. BeMiller & Huber, 2011; Ellis et al., 1998; Hong et al., 2024).

Approved Legal Uses of the Substance:

FDA

Unlike food additive safety determinations, which are made by the FDA, GRAS determinations can be made by non-governmental experts (Gaynor & Cianci, 2006). In 2016, the FDA published an updated Final Rule on GRAS substances, which amended the rule so that the GRAS notification program was voluntary (81 FR 54960-55055). The notification program provides a mechanism for a company (or a person) to notify the FDA that a substance is GRAS.

Under a contract between the FDA and the Life Sciences Research Office (LSRO), the Select Committee on GRAS Substances (SCOGS; consultants working under the FDA-LSRO contract) reviewed cornstarch, high amylose cornstarch, and waxy maize starch along with starches derived from arrowroot, milo, potato, rice tapioca, and wheat, as well as pregelatinized starch as food ingredients (LSRO, 1979). The FDA recognizes cornstarch and waxy cornstarch as GRAS for several uses (see *Table 2*, below) (US FDA, 2024b). These include uses as an anticaking agent, a drying agent, an adjuvant to flavors, and as a carrier. Waxy cornstarch and cornstarch are recognized for their GRAS use as stabilizers, thickeners, and texturizers. The FDA has also affirmed GRAS status for use in cotton (21 CFR 182.70) and paper packaging (§ CFR 182.90) in contact with food.

Table 2: Food uses of cornstarch. Adapted from (US FDA, 2024b)

Use	Limitations	Notes
Anticaking agent or free flow agent	None	
Drying agent	None	
Flavoring agent or adjuvant	None	
Formulation aid	None	
Humectant	None	
Non-nutritive sweetener	None	
Nutritive sweetener	None	
Solvent or vehicle	None	
Stabilizer or thickener	None	Waxy cornstarch as well as cornstarch
Texturizer	None	Waxy cornstarch as well as cornstarch

Action of the Substance:

Starch is a carbohydrate polymer that has limited water solubility at low temperatures but is almost completely water soluble at higher temperatures (see *Table 1*, above). Starch granules swell in water when hydrogen bonds of the complex carbohydrate structure are broken and new bonds with free water molecules are formed, particularly with exposed hydroxyl groups of amylose and amylopectin (Quiroga Ledezma, 2018). As such, cornstarch is stable in water and acts like a hydrocolloid that solidifies into a gel as it cools.[2]

[2] A stable mixture of a solid substance in water.

Combinations of the Substance:

Cornstarch may be combined with other starches, such as those derived from:

- potato (Bello-Pérez et al., 2001; Fonseca-Florido et al., 2017; Obanni & Bemiller, 1997; Waterschoot et al., 2015)
- cassava (tapioca) (Karam et al., 2005, 2006; Obanni & Bemiller, 1997; Seibel & Hu, 1994; Waterschoot et al., 2015)
- banana (Bello-Pérez et al., 2001)
- wheat (Obanni & Bemiller, 1997)
- rice (Waterschoot et al., 2015)
- yam (Karam et al., 2005, 2006)
- sweet potato (Waterschoot et al., 2015)
- and barley (Waterschoot et al., 2015)

By blending starches, manufacturers combine their desirable properties (Waterschoot et al., 2015).

Impurities

Cornstarch may contain sulfites (Grotheer et al., 2005). Residual sulfites from the wet-milling process may be present in food grade native cornstarch at levels of up to 50 ppm, measured as sulfur dioxide (Food Chemicals Codex, 2014). The sulfite levels in cornstarch are considered low to moderate when compared with other foods with added sulfites (Ekstein & Warshaw, 2024). Sulfites act as an antimicrobial in the cornstarch wet milling process (NOSB, 1995b; S. L. Taylor et al., 2013). The concentration of sulfur dioxide and related chemical species can be reduced by washing and drying, ion exchange, and evaporation, in order to meet the tolerance levels (CRA, 2000).

Status

Historic Use:

Starchy foods derived from seeds, tubers, and roots have always been a part of the human diet (Schwartz & Whistler, 2009). Isolated starch produced from wheat in ancient Egypt and Rome appears in the literature from the classical era (Schwartz & Whistler, 2009). Wheat and potatoes were the main sources of starches used in food prior to the invention of the corn wet milling process (Schwartz & Whistler, 2009).

Corn wet milling was invented in the mid-19th century (Jones, 1841). The Colgate Corporation built the first corn wet mills in Jersey City, NJ, and Columbus OH, in 1844 (CIRF, 1964; CRA, 2006). In 1849, Thomas Kingsford and others converted a wheat starch production facility in Oswego, NY, to produce cornstarch using an alkaline steeping process (Schwartz & Whistler, 2009). Millers were slow to adopt corn wet milling, but by 1900, corn was the principal source of starch made in the U.S. (Schwartz & Whistler, 2009).

Cornstarch was one of the items on the omnibus petition considered by the NOSB in the October 1995 meeting, which indicates that some processors were using nonorganic cornstarch at the time (NOSB, 1995a). By 2005, researchers reported that organic cornstarch had the highest premium price above conventional cornstarch (450%) of all items included in the USDA Thrifty Food Plan (C. Brown & Sperow, 2005).[3]

[3] The USDA's Thrifty Food Plan outlines nutrient dense foods and beverages, their amounts, and associated costs that can be purchased on a limited budget to support a healthy diet through nutritious meals and snacks at home: https://www.fns.usda.gov/research/cnpp/usda-food-plans.

Organic Foods Production Act, USDA Final Rule:

OFPA (1990) does not include any reference to nonorganic cornstarch, specifically. OFPA states (7 U.S.C. 6510):

> (a) In General.—For a handling operation to be certified under this title, each person on such a handling operation shall not, with respect to any agricultural product covered by this title—
>
> > …(4) add any ingredients that are not organically produced in accordance with this title and the applicable organic certification program, unless such ingredients are included on the National List and represent not more than 5 percent of the weight of the total finished product (excluding salt and water).

For processing and handling purposes, USDA organic regulations include nonorganic cornstarch on the National List [7 CFR 205.606(e)] The annotation for materials on this section of the National List specifies that nonorganic cornstarch is only for use as "…ingredients in or on processed products labeled as "organic," only in accordance with any restrictions specified in this section, and only when the product is not commercially available in organic form." Cornstarch (native) was originally included in the first publication of the NOP Final Rule (65 FR 80548, December 21, 2000).

International:

Non-organic cornstarch is allowed under some other international organic standards. However, it is not permitted under the European Economic Community (EEC) organic standards.

Canadian Organic Regime (COR) (CAN/CGSB-32.310 and 32.311)

The Canadian General Standards Board (CGSB) Organic Production systems - General principles and management standards allows for the use of up to 5% "ingredients classified as food additives" and "ingredients not classified as food additives" listed in Tables 6.3 and 6.4 respectively of the Permitted Substances List (PSL) in foods that are labeled as organic [CGSB 32.310-2020 §9.2.1(a)]. The ingredients are subject to the requirements specified in the annotations and restrictions specified in the PSL, and cannot be made from genetically engineered sources, intentionally used nanotechnology, or irradiation as defined in the standard [CGSB 32.310-2020 §9.2.1(a)]. Starch from waxy maize must be derived using substances listed in Table 6.3 Extraction solvents and precipitation aids, Starch may be modified using physical or enzymatic methods, but not by chemicals. Cornstarch may contain substances that are plant-derived or listed in Tables 6.3, 6.4 or 6.4 (CGSB 32.311-2020).

European Economic Community (EEC) Council Regulation (EC No. 2018/848 and 2021/1165)

Previously, starch from waxy corn was allowed under the European Union organic standards. However, the European Union repealed and replaced the organic legislation at 834/2007 with EC No. 2018/848. The new legislation placed more limitations and restrictions on the use of non-organic agricultural ingredients in organic processed products. The regulations to implement most of the legislation—including the Annexes of allowed inputs and non-organic food ingredients—are in EC No. 2021/1165. Food additives, including carriers, are found in Annex V, Part A, Section A1. Non-organic agricultural ingredients are listed in Annex V, Part B. Cornstarch is not included on either of these lists.

Japanese Agricultural Standard (JAS) for Organic Processed Foods

The Japanese Agricultural Standards have a provision to allow nonorganic agricultural ingredients "only if it is difficult to obtain the same type of organic products of plant origin, organic livestock products, or organic processed foods as the ingredients being used . . ." (JAS 1606 Japanese Agricultural Standard for Organic Processed Foods §5.1). Plant products that are the same kind as organic agricultural products used as ingredients are excluded, as are ingredients that have been irradiated or have been produced using recombinant DNA technology [JAS 1606 Japanese Agricultural Standard for Organic Processed Foods §5.1(b)].

Codex Alimentarius Commission—Guidelines for the Production, Processing, Labelling and Marketing of Organically Produced Foods (GL 32-1999)

The Codex Alimentarius Guidelines states that "Member countries are required to establish a 95% minimum of organic agricultural products in organic processed foods. Competent authorities of member states can allow non-organic agricultural ingredients that are not derived from genetically modified sources. Exporters are subject to the importing country's standards" (FAO/WHO Joint Standards Programme, 2013).

IFOAM-Organics International

The IFOAM—Organics International Standards do not include nonorganic native cornstarch as an allowed nonorganic ingredient in Annex V (IFOAM, 2014). The current IFOAM Standards provide for the use of nonorganic agricultural ingredients under the following conditions (IFOAM, 2014):

> "All ingredients used in organic processed products shall be organically produced except for those additives and processing aids that appear in Appendix 4. In cases where an ingredient of organic origin is commercially unavailable in sufficient quality or quantity, operators may use nonorganic raw materials, provided that:
>
> a. they are not genetically engineered or contain nanomaterials and
> b. the current lack of availability in that region is officially recognized or prior permission from the control body is obtained.
> c. the requirements in section 8.1.3 shall be met."

Evaluation Questions for Substances to be used in Organic Handling

Classification of the substance:

Evaluation Question #1(A): Describe if the substance is extracted from naturally occurring plant, animal, or mineral sources.

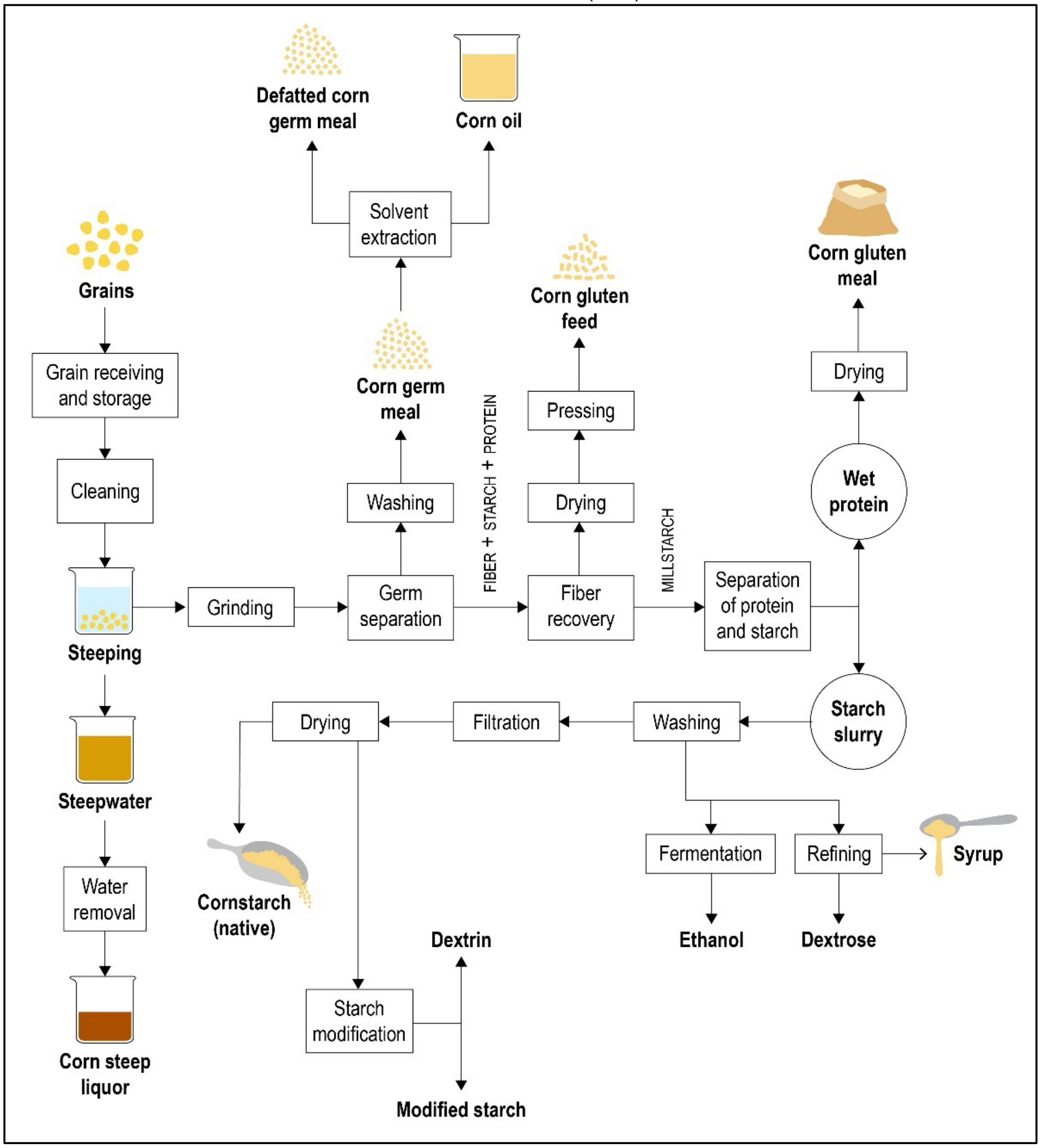
The substance is extracted from the crop plant, corn (*Zea mays*) (Johnson, 2000; Whistler & Daniel, 2000; P. J. White, 2001). Most corn is genetically modified [see *Evaluation Question #1(F)*, below].

Evaluation Question #1(B): Describe the most prevalent processes used to manufacture or formulate the petitioned substance. Include any chemical changes that may occur during manufacture or formulation of the substance.

Corn wet milling process

Corn wet milling is the prevailing process used to manufacture cornstarch (see *Figure 3*, below) (CIRF, 1964; CRA, 2006; Johnson, 2000; Rausch et al., 2019; P. J. White, 2001). According to Johnson (2000), the wet milling process is the most efficient means of isolating starch from the endosperm. The scale of wet milling operations increased with the invention of a continuous steeping process (Randall et al., 1978). Starch and germ are the most valuable products of the wet milling process (Johnson, 2000).

Figure 3: Corn wet milling process. Adapted from Santana & Meireles (2023) licensed under CC By 4.0 and Brown & Van Meer (1978).



1. The corn wet milling process begins by removing the kernels from the cobs, cleaning and removing broken kernels that can significantly reduce starch yield (Johnson, 2000; Rausch et al., 2019).
2. Optionally, the kernels may be pretreated with lactic acid to optimize separation, increase the effectiveness of sulfur dioxide, and prevent mineral scale deposition on the equipment (D. S. Jackson & Shandera, 1995).
3. The kernels are then steeped in a solution of 0.10% sulfur dioxide (SO_2) and water at 48-52°C (118-126°F), typically for 30-40 hours (BeMiller & Huber, 2011) (Eckhoff & Watson, 2009; D. S. Jackson & Shandera, 1995; Johnson, 2000; Rausch et al., 2019).

Sulfur dioxide aids in dissolving the protein matrix to release the starch, while also inhibiting spoilage organisms, thereby maximizing starch yield (J. BeMiller & Huber, 2011; D. S. Jackson & Shandera, 1995).

Sulfur dioxide was initially added as an antimicrobial agent to control putrefactive organisms. The 1995 Technical Advisory Panel report, *Cornstarch*, identified the function of sulfur dioxide as a "temporary" preservative to avoid putrefaction of soaked corn (NOSB, 1995b). However, manufacturers also use sulfur dioxide in the steep water to optimize starch yields and purity (D. S. Jackson & Shandera, 1995). According to Jackson & Shandera (1995), the use of sulfur dioxide has become indispensable in the wet milling process. The use of enzymes in recent years has reduced (but not eliminated) the need for sulfur dioxide [see *Enzyme wet milling (E-milling)*, below].

Because of the negative environmental and human health effects of sulfites, researchers have explored ways to reduce or eliminate the amount of SO_2 used in the wet milling process. They have studied adding various other acids to the steepwater, such as lactic, acetic, hydrochloric, phosphoric, oxalic, and sulfuric acid, with lactic acid and acetic acid giving the highest yields (approximately 2,000 ppm (0.2%) of SO_2 in the steepwater) in conjunction with potassium metabisulfite (K_2SO_4) and sodium metabisulfite (Na_2SO_4) instead of SO_2 gas (Yang et al., 2005). Researchers have also sought to eliminate SO_2 by using mechanical and enzymatic processes (Johnston & Singh, 2004; Ramírez et al., 2009).

4. Optionally, lactic acid can be added along with sulfur dioxide to reduce the pH, resulting in increased yields, more homogenous particle size, and higher gelatinization temperatures through prolonged steeping (Pérez et al., 2001). Manufacturers may use enzymes in the steeping process, which can reduce the amount of SO_2 needed to inhibit microbial activity to approximately 600 ppm (Ramírez et al., 2009).
5. After steeping, the softened grains are ground, and then mechanically and physically separated into two streams through screening, centrifuging, hydrocloning, and washing (Rausch et al., 2019). Vacuum filtration may be used in some older systems (D. S. Jackson & Shandera, 1995).
6. The germ is the first fraction to be removed.[4] Pressurized hydrocyclones remove the lighter germ and drop the heavier starch and protein in the underflow[5] (Eckhoff & Watson, 2009).
7. Wet mills often send the underflow through a finer grind to recover the higher value germ not separated in the first grind (Rausch et al., 2019).
8. The fiber is separated next (Rausch et al., 2019).

After the fiber is separated, the process leaves a slurry that consists of a mixture of a) free starch from the floury endosperm, and b) the horny endosperm consisting of starch bound to protein known as corn gluten (Eckhoff & Watson, 2009). [6, 7] The defibered starch slurry is a mix of that still has 3-5% protein with a protein content can be as high as 8% in some cases (Eckhoff & Watson, 2009; D. S. Jackson & Shandera, 1995; Rausch et al., 2019). The desired concentration for food-grade starch is less than 0.3% total protein and 0.01% soluble protein to increase the efficiency of downstream production processes (Rausch et al., 2019). Free starch is much easier to separate and purify than the protein/starch fraction, and recovery from corn gluten can be expensive (Eckhoff & Watson, 2009).

9. Hydrated corn gluten particles have a lower density (1.1 g/cm^3) than starch particles (1.5 g/cm^3) (Eckhoff & Watson, 2009). Starch from floury endosperm can be separated from starch in the horny endosperm based on these differences in their respective densities (Rausch et al., 2019). Further washing, hydrocloning, and centrifuging are needed to reach the target protein levels (Eckhoff & Watson, 2009; Rausch et al., 2019). Grinding corn to a finer grit and then centrifuging can further remove protein from the free starch (Rausch et al., 2019). Further starch-gluten separation can be expensive (Eckhoff & Watson, 2009).
10. The resulting starch fraction is sold as native starch, converted to fermentable sugars for alcohol production (N. B. Smith et al., 1966), or further processed into chemically modified starches. The protein fraction is sold as corn gluten meal (D. S. Jackson & Shandera, 1995; Rausch et al., 2019).

Typical industry yields from the corn wet milling process are 67.5% starch, 11.5% fiber, 7.6% steepwater solubles (dry weight), 7.5% gluten, and 5.0% germ (Rausch et al., 2019).

[4] Corn starch is not treated with hexane. Manufacturers of corn oil use hexane or another synthetic solvent to extract the oil from the germ after it has been separated from the starch-containing fractions (Rausch et al., 2019).
[5] In a flowing stream with two immiscible liquids, the lighter or less dense stream is called the overflow and the heavier or denser stream is called the underflow (Earle & Earle, 2003)..
[6] "Gluten" is a misnomer because corn gluten does not contain gluten (Eckhoff & Watson, 2009).
[7] The slurry mixture of free starch and corn gluten is also called "prime mill starch" (Eckhoff & Watson, 2009).

Enzyme wet milling (E-milling)
Enzymes may also be used to remove protein from the corn gluten/starch fraction, a process known as E-milling (Eckhoff & Watson, 2009). For example, researchers compared the effectiveness of the protease enzyme bromelain with SO_2 and lactic acid (Johnston & Singh, 2004). The enzymatic treatment included using acetic acid, hydrochloric acid, or sodium hydroxide to adjust the pH (Johnston & Singh, 2004). Under laboratory conditions, the researchers were able to get cornstarch yields that were equivalent to the conventional control with 1 g enzyme/kg corn after soaking in steepwater at a pH of 5.0 at 48°C (118°F) for four hours (Johnston & Singh, 2004). E-milling has the potential to reduce or even replace the use of SO_2 (Rausch et al., 2019). An economic analysis showed that E-milling could be cost-competitive when corn feedstock costs are relatively high and enzyme costs are relatively low (Ramírez et al., 2009). As of 2019, E-milling was reportedly still in the pilot stage according to one source (Rausch et al., 2019). We were unable to confirm if this process has been piloted or scaled up to actual production.

Westfalia process
A process patented by GEA Westfalia Separators separates cornstarch from other fractions of corn using high pressure and a high-shear homogenizer (Huster et al., 1983). The system is more commonly used to prepare wheat starch (Bergthaller, 2004). The process to make cornstarch is like the conventional wet milling process described, with the following exceptions reported under experimental conditions:

1) The corn can be steeped with or without added SO_2 and lactic acid under 1×10^5 Pa for 48 hours (with SO_2) and 15×10^5 Pa for 3 hours (without SO_2) (Meuser et al., 1989).
2) The steeped grits, in a 10% aqueous suspension were disintegrated in a high-pressure homogenizer under 500×10^5 Pa at 20°C (68°F), with a second pass made for the horny endosperm remaining after the first pass (Meuser et al., 1989).

The subsequent separation and screening steps were the same for the two processes (Meuser et al., 1989). Starch yields for the floury endosperm by the Westfalia process were comparable to the conventional wet milling process, but starch yields from the horny endosperm were significantly lower under laboratory conditions and posed a refining problem (Meuser et al., 1989). One source reported that the process was practiced at one European mill, but was no longer used (Rausch et al., 2019). We were unable to find the name of the mill or determine if the process is currently used to make organic cornstarch.

Modified cornstarch
Cornstarch is often further chemically modified after it is isolated from the corn kernel through the wet milling process (J. BeMiller & Huber, 2011). Such modified starches are presumably synthetic and are not included on the National List at 7 CFR 205.605(b), so they are outside the scope of this technical report.

Evaluation Question #1(C) Discuss whether the petitioned substance is agricultural or non-agricultural. If the substance is non-agricultural, is it synthetic or non-synthetic? [7 U.S.C. 6502(21); NOP 5032-1; NOP 5033-2].

Agricultural or nonagricultural classification
Evaluation of cornstarch against Guidance NOP 5033-2 *Decision Tree for Classification of Agricultural and Nonagricultural Materials for Organic Livestock Production or Handling* (NOP, 2016) is discussed below.

1. *Is the substance a mineral or bacterial culture as included in the definition of nonagricultural substance at section 205.2 of the USDA organic regulations?*

No. Corn is a plant that is grown as an agricultural commodity.

2. *Is the substance a microorganism (e.g., yeast, bacteria, fungi) or enzyme?*

No. The substance is derived from corn, which is a higher plant that is an agricultural commodity.

3. *Is the substance a crop or livestock product or derived from crops or livestock?**

Yes. The substance is derived from corn, an agricultural commodity.

4. *Has the substance been processed to the extent that its chemical structure has been changed?*

No. Native (unmodified) cornstarch is a naturally occurring polymer that is extracted from the endosperm of corn kernels. While the wet milling process used to extract it includes the use of synthetic chemicals, they do not alter the chemical structure of cornstarch. Therefore, the substance is classified as an agricultural substance. Modified cornstarch products are outside the scope of this report.

In NOP 5034-1, *Guidance, Materials for Organic Crop Production,* the USDA classifies a related product, corn gluten meal [see step 10 in *Evaluation Question #1(B)* above], also as agricultural and nonsynthetic.

Evaluation Question #1(D) Does the substance in its raw or formulated forms contain nanoparticles?

Native cornstarch

No. While starch nanoparticles do exist, these would not be considered native cornstarch. Most engineered starch nanoparticles are chemically modified and combined with substances that are not permitted for use in food labeled as organic.

Native starch granules (all types, not just corn) range in size from 1 to 100 µm (Torres & De-la-Torre, 2022). Cornstarch granules range between 5 and 30 µm (Thomas & Atwell, 1999). Most granules fall in the range of 10-25 µm (Galliard, 1987). These are all above the 100 nm (0.1 µm) threshold established in NOP Policy Memo 15-2 (NOP, 2015).

However, native starch granules can undergo nanoengineering. In order to do this, the starch granules need to be further processed to disrupt micron-sized particles and prepare them into starch nanoparticles (Sun & Qin, 2024). Starch nanoparticles can be separated and concentrated physically using ultrasound, without the use of additional chemical treatment (Minakawa et al., 2019). Based on a guidance document from the FDA, it is not clear to us whether starch nanoparticles prepared from native cornstarch using only physical means could still be identified as “native” (US FDA, 2014).

Modified cornstarch and other starches

Nanoparticles can be made either by taking a bulk material that is larger than nanoscale and transforming it to particle sizes below nanoscale (“Top-down approach”) or by taking synthesizing nanoparticles at the atomic or molecular level (“Bottom-up approach”) (Abid et al., 2022). Most techniques to prepare starch nanoparticles would chemically modify the starch and use various manufacturing processes to reduce the particle size (Palanisamy et al., 2020; Sun & Qin, 2024; Torres & De-la-Torre, 2022). Researchers have used methods to fabricate (synthesize) starch by a “bottom-up” process on an experimental basis (Sun & Qin, 2024).

Researchers have studied the blending of starch nanoparticles derived from corn and other starches in both food and non-food applications (Le Corre et al., 2010; Le Corre & Angellier-Coussy, 2014; Ogunsona et al., 2018; Palanisamy et al., 2020; Torres & De-la-Torre, 2022). Food applications include nanoencapsulation and emulsion stabilization (Zhou et al., 2023). These blended starch nanoparticles can also be used in the manufacture of biodegradable food-grade packaging (Palanisamy et al., 2020).

Researchers have also studied the use of enzymatic hydrolysis to form starch nanocrystals in laboratory conditions (Le Corre et al., 2010; Le Corre & Angellier-Coussy, 2014). However, we did not find commercial food-use applications of the technology.

Evaluation Question #1(E) Does the substance in its raw or formulated forms contain ancillary substances?

Raw, native cornstarch contains no ancillary substances declared in technical specification and safety data sheets (Ingredion, 2020, 2022; Scholar Chemistry, 2009). Furthermore, labels for native cornstarch products often note that they are 100% pure cornstarch. Some modified starches may be blended with hydrocolloids—such as gum arabic or xanthan gum—but these are not native cornstarch (Mahmood et al., 2017).

Cornstarch itself is likely to be an ancillary substance in ingredients. At least one certifying agent contacted for this report identified non-organic cornstarch as an ancillary ingredient that was combined with other non-organic ingredients on the National List (Anonymous, personal communication, August 2024). Such ingredients could include flavors (Burdock, 2016), baking powder (Neeharika et al., 2020), vitamins (Lay Ma et al., 2011), and minerals (Deladino et al., 2016).

Evaluation Question #1(F) Is the substance created using Excluded Methods?

In most cases, probably yes. However, cornstarch made using excluded methods is prohibited for use in organic food (7 CFR 205.105(e)). Cornstarch can be produced from either commodity corn or contracted specific varieties, usually waxy varieties (P. J. White, 2001). Cornstarch can be produced from genetically modified corn (US FDA, 2024a). Genetically modified corn was commercially released in 1996, with the introduction of insect resistant and herbicide tolerant varieties to the U.S. market (Cabrera-Ponce et al., 2019). Other commercially released traits from genetic modification include (Cabrera-Ponce et al., 2019):

- male sterility
- drought stress tolerance
- increased lysine content
- improved ethanol production

Corn has also been genetically modified to change the form and functionality of the starch (J. N. BeMiller, 2019; Cabrera-Ponce et al., 2019; CRA, 2006). One genetically modified variety has expedited starch liquefaction (Cabrera-Ponce et al., 2019). Genetic modification to produce novel, higher yielding waxy corn varieties has also been developed (Gao et al., 2020). The corn refining industry is investing in research to develop genetically engineered varieties that produce cornstarch with the functionality of chemically modified starches, and some are reported to be commercially available (CRA, 2006).

Since 2005, the majority of corn grown in the U.S. has been genetically modified using several excluded method techniques (USDA Economic Research Service, 2023). As of July 2024, the USDA reported that 94% of the corn planted in the U.S. in 2024 was from genetically engineered varieties (USDA Economic Research Service, 2024). Herbicide tolerance (90% of U.S. corn in 2024) and insect resistance (83% of U.S. corn in 2024) remain the most commercially important traits (USDA Economic Research Service, 2024).

Herbicide tolerance in corn through transgenic engineering

Monsanto patented a process for plants to express the genetic trait of tolerance to the herbicide glyphosate (Roundup®) in 1990 (Shah et al., 1990). Transgenic corn with glufosinate (Liberty®) tolerance was developed around the same time (Owen, 2000). Herbicide-tolerant corn was commercially released in 1996 and rapidly adopted by farmers (USDA Economic Research Service, 2024). The large scale planting of Roundup-Ready® (RR) crops has selected for glyphosate resistant weeds (Heap & Duke, 2018; Peterson et al., 2018). The industry response was to genetically engineer crops that are resistant to additional herbicides into glyphosate- and glufosinate- tolerant varieties (Duke, 2011). Other herbicide-tolerant corn varieties released include those resistant to dicamba (Cao et al., 2011) and 2,4-D (Peterson et al., 2016).

Insect resistance in corn through transgenic engineering

The other prevalent trait in genetically engineered corn is resistance to insects by the expression of the toxins produced by the soil microorganism *Bacillus thuringiensis* (Bt) (Cabrera-Ponce et al., 2019; USDA Economic Research Service, 2023). Corn expressing the Bt δ-endotoxin Cry1Ab, which confers resistance to the European corn borer (*Ostrinia nubilalis*), was considered unregulated by USDA APHIS in 1995 (60 FR 32299, June 21, 1995) and was commercially planted by U.S. farmers in 1996 (Gould, 1998). Transgenic corn resistant to the European corn borer was also partially effective against other pests in the same insect family, but additional Bt toxins needed to be introduced to the varieties for the plants to be toxic to pests such as corn earworm (*Helicoverpa zea*) (Dively et al., 2016). These additional toxins were not able to stop the selection of Bt resistant corn earworm populations (Dively et al., 2016). In 2001, corn expressing the Cry3B δ-endotoxin conferring resistance to the Coleopteran insect pest the corn rootworm (*Diabrotica vergifera vergifera*) was released in the U.S. (Moellenbeck et al., 2001).

Stacked varieties
A crop variety that is genetically engineered with both herbicide-tolerant and insect resistant traits is called "stacked" (USDA Economic Research Service, 2016). Stacked varieties can now have multiple Bt toxins effective against various pests and tolerance to several herbicides (Cabrera-Ponce et al., 2019).

Amylopectin production improvement in corn through CRISPR/Cas9 genetic engineering
Corteva has developed a variety of waxy corn using clustered regularly interspaced short palindromic repeats, more commonly known as "CRISPR" (Corteva Agriscience, 2024).[8] The CRISPR lines have 97% amylopectin starch compared with 75% for most varieties (Grobler et al., 2021). A CRISPR variety also demonstrated superior yields to the hybrids in field trials (Gao et al., 2020).

A USDA APHIS official issued a letter to Corteva indicating that corn only edited with CRISPR-Cas9 is not subject to its regulations regarding genetically engineered plant pests at 7 CFR 340 or noxious weeds under 7 CFR 360 (Firko, 2018).[9] Corteva has used this letter to claim that the waxy corn is not subject to other genetic engineering regulations, including labeling the product as genetically modified (Corteva Agriscience, 2024; Gao et al., 2020). However, we were unable to confirm whether the variety, known as "Next Gen Waxy Corn," has been commercially released in the U.S. as of the 2024 growing season.

GMO contamination
Identity preserved (IP) and organic corn can have unintended presence of genetically engineered material (USDA AC21, 2012, 2016).[10] In 2014, 1% of all U.S. certified organic farmers in 20 states reported that they experienced economic losses amounting to $6.1 million, excluded expenses for preventative measures and testing due to genetic engineered (GE) commingling during 2011-2014 (Greene et al., 2016). GE contamination in Illinois, Nebraska, and Oklahoma were above the national average (Greene et al., 2016).

GMO contamination of organic and non-GMO corn can occur at several places in the production and supply chain (Scott et al., 2019). Using computer simulations of non-GMO corn, researchers found that there is a low probability that producers and handlers can prevent contamination of the supply chain with genetically modified corn. They predicted that most non-GM corn would contain 2.5% to 6.25% genetically modified material (Gupta et al., 2022). We were unable to validate the simulation with available data.

We are also unable to verify how non-organic cornstarch used by organic processors is verified to be non-GMO. False non-GMO claims have been a concern from the first commercialization of genetically modified corn, where demand for such non-GMO product exceeds supply at premiums that are not sufficient to support the added costs of preserving identity (Saak, 2003). Corn fraudulently mislabeled as "organic" has also been a major concern of the USDA, leading to a major revision of the NOP through the Strengthening Organic Enforcement program [88 FR 3548, January 19, 2023]. The organic and non-GMO cornstarch market niches make up a small percentage of the total supply of corn and cornstarch.

Avoiding GMO contamination of corn has long been a challenge, even for certified organic producers and handlers (Martens, 2001; Scott et al., 2019). Potential sources of contamination include the seed supply, pollen drift, equipment, and agricultural products (Martens, 2001; Scott et al., 2019; USDA AC21, 2016). Producing organic hybrid corn seed is particularly difficult because parental inbreds can become contaminated with genetic impurities (Scott et al., 2019).

Identifying contamination can be difficult as well. Testing for contamination is the responsibility of the private sector, and is done mostly by handlers with some farmers also conducting tests (Greene et al., 2016; USDA AC21, 2016). Not all GE traits can be detected with laboratory methods (Greene et al., 2016). Detection also depends on the DNA, which is found in protein (Holden et al., 2003). Because the protein content of cornstarch is less than 1% and may be as low as 0.1%, the presence of the Cry9C protein

[8] CRISPR is used in a gene editing technique that involves 1) a guide RNA to match a desired target gene and 2) an endonuclease (e.g. Cas9) that causes a double-stranded DNA break that allows modifications to the genome.
[9] Cas9 is an enzyme often used in CRISPR technology, which cuts DNA. However, it is not the only enzyme used.
[10] An "identity preserved" (IP) crop is a crop of assured quality in which the identity of the material is maintained from the germplasm or breeding stock to the processed product on the retail shelf (USDA AC21, 2012).

associated with the StarLink trait could not be detected using analytical methods (US EPA, 2001). Samples of cornstarch made from GE corn tested negative for the trait (Holden et al., 2003).

Organic and identity preserved corn

Some crop producers grow organic and IP corn to serve a growing demand for non-GMO corn products, with varieties grown specifically for starch attributes. Producers and handlers of corn grown for specific starch traits are follow IP protocols (Elbehri, 2007). Most waxy corn grown for cornstarch are produced under contract by starch manufacturers (Fergason, 2000). The seed producers of waxy corn varieties have rigorous testing and purity requirements that go beyond the requirements for most hybrid corn varieties (Fergason, 2000).

We were unable to verify through publicly available sources whether organic and identity preserved non-GMO forms of cornstarch are commercially available in the appropriate form, quality, or quantity to fulfill the specific functions where non-organic cornstarch is currently being used as an ingredient in organic processed products. According to comments provided by the Organic Trade Association in 2015 and 2020 to the NOSB, processors believed that the supply of organic cornstarch was unstable, and that the available forms were did not meet the specifications needed in some instances (Organic Trade Association, 2015, 2020). Various organic agricultural alternatives—including organic cornstarch—are discussed further in *Evaluation Question #11* below.

Evaluation Question #2: 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.

Yes. Cornstarch, high amylose cornstarch, and waxy maize are recognized by FDA as common food ingredients that are exempt from premarket review, rather than as additives that require FDA notification (LSRO, 1979).

The FDA has issued a Compliance Policy Guide that states that "[i]n the absence of a standard of identity, starch meeting the specifications of the United States Pharmacopeia is acceptable for food use" (US FDA, 1980). The Select Committee on GRAS Substances concluded that "[t]here is no evidence in the available information on unmodified or pregelatinized corn, high amylose corn, [or] waxy maize . . . that demonstrates or suggests reasonable grounds to suspect a hazard to the public when they are used at levels that are now current or that might reasonably be expected in the future" (SCOGS, 2015). The full report upon which the conclusion was based evaluated other starches considered GRAS in addition to cornstarch (LSRO, 1979).

Cornstarch appears on the FDA GRAS List as a substance migrating from cotton and cotton fabrics used in dry food processing (21 CFR 182.70). It is also GRAS as a substance migrating to food from paper and paperboard products (21 CFR 182.90).

See *Approved Legal Uses of the Substance* above for more details.

Purpose and necessity of the substance:

Evaluation Question #3: Describe whether the primary technical function or purpose of the petitioned substance is a preservative [7 CFR 205.600(b)(4)].

Cornstarch does not fall within the FDA definition of being a chemical preservative [21 CFR 101.22(a)(5)]:

> The term *chemical preservative* means any chemical that, when added to food, tends to prevent or retard deterioration thereof, but does not include common salt, sugars, vinegars, spices, or oils extracted from spices, substances added to food by direct exposure thereof to wood smoke, or chemicals applied for their insecticidal or herbicidal properties.

However, starches—including cornstarch—can be used to preserve, stabilize, and extend the shelf life of various foods (Luciano et al., 2022). Bread glazed with cornstarch had a 66.7% decrease in acrylamide in the outer crust and a decrease of 77.1% in acrylamide in the inner crust, which was indicative of inhibited degradation (Liu et al., 2018). While this is not the primary function of cornstarch, it is a feature that makes it a desirable ingredient for certain applications.

Most of these preservative applications are composites with other ingredients (Luciano et al., 2022). Cornstarch combined with gum Arabic, lemongrass oil, and glycerol, applied postharvest as a fruit coating on pomegranates (var. "Wonderful"), reduced weight loss and increased total soluble solids, titratable acidity, and antioxidant capacity when compared with an untreated control (Kawhena et al., 2021). Grapes (var. "Red Crimson") treated with edible films composed of various combinations of both native, waxy, and modified cornstarch, gelatin, glycerol, and sorbitol reduced weight loss, extended refrigerated storage life, and maintained fruit quality over a 21-day period without adverse effects on consumer acceptance (Fakhouri et al., 2015). Cucumbers coated with a film of cornstarch that was chemically modified using citric acid and mixed with gelatin and sorbitol had lower weight loss, better texture and color, and enhanced shelf life for a period of 16 days (Kumar et al., 2021).

Evaluation Question #4: 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). If so, how? [7 CFR 205.600(b)(4)].

A major use of cornstarch is as a thickener, which changes the texture of food. Starch imparts a thick-bodied consistency, largely through cross-linking with other ingredients (Pomeranz, 1991). However, native starches generally produce undesirable textures when compared with chemically modified starches (J. BeMiller & Huber, 2011).

Cornstarch has a bland taste that does not mask flavors or aromas (Ingredion, 2023). However, researchers have found that starch pastes increase flavor perception (Ferry et al., 2006). The effect is believed to be the way starch increases the viscosity of the food matrix, influencing mouth feel (Ferry et al., 2006). Starches—including cornstarch—are often used as a vehicle for other ingredients used to enhance flavors, including natural flavors (Burdock, 2016; FEMA, 2011).

Cornstarch is color-neutral (Ingredion, 2023), and it is not used to improve nutritive values lost in processing.

Evaluation Question #5: 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)].

Native cornstarch is an oligosaccharide carbohydrate (BeMiller, 2004; Stephen & Phillips, 2006).[11] As such, adding cornstarch will increase the carbohydrate content and dilute the protein, fat, vitamin, and nutrient mineral content of the foods to which it is added.

Evaluation Question #6: 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)].

The FDA establishes "action levels" for poisonous or deleterious substances that are unavoidable in human food and animal feed (U.S. FDA, 2000). These include aflatoxin, cadmium, lead, polychlorinated biphenyls (PCBs), and many other substances. The FDA uses different action level tolerances for these substances, depending on the commodity. Commodities are largely food items; however, the FDA also includes tolerances for ceramic and metal items, such as eating vessels and utensils.

While cornstarch is not included on the list of commodities with action levels, corn has action levels of 0.1 ppm for chlordane and 0.1 ppm for lindane (CPG 575.100).[12] Milled grains—including corn products—have an action level of 150 ppb for ethylene dibromide (EDB) (CPG 575.100).

The Food Chemicals Codex specifies limits on impurities in unmodified cornstarch of not more than 1 mg/kg (1 ppm) for lead (U.S. Pharmacopeia, 2023). The Food Chemicals Codex does not provide specific

[11] An oligosaccharide is a carbohydrate that is made up of between two and ten simple sugars or monosaccharides linked by covalent bonds known as glycosidic bonds.
[12] Compliance Policy Guides (CPGs) are intended to advise FDA staff as to the Agency's strategy when assessing and enforcing compliance.

limit values for arsenic or other heavy metals in cornstarch. Industry limits heavy metals in unmodified food starch as Pb at 0.002% (20 ppm) (CRA, 2000). The tolerance for arsenic in modified food starch has a limit of <3 mg/kg (<3 ppm). The Food Chemicals Codex established a limit of not more than 0.005% (50 ppm) of sulfur dioxide (U.S. Pharmacopeia, 2023). Industry limits protein content of unmodified starch to <0.5% (500 ppm) (CRA, 2000).

Evaluation Question #7*: 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 production of cornstarch has impacts on the environment both directly and indirectly. Direct impacts include pollution of air and water by the operation of corn wet mills. Indirectly, cornstarch production impacts are the results of energy use and the electric power plants that emit greenhouse gases. The ecological impacts of conventional corn production—including biodiversity loss, declining soil health, and non-point pollution from the runoff and leaching of fertilizers and pesticides—are another indirect consequence of non-organic cornstarch production.

Corn Wet Milling Environmental Impacts

Corn wet mills have many places where air pollutants can be discharged into the environment. A typical facility will have over 100 emission points (Midwest Research Institute, 1994). Corn wet mills emit air pollutants:

- The main pollutant of concern is particulate matter (Midwest Research Institute, 1994).
- Sulfur dioxide emissions are another significant air pollutant (IDNR, 2010; Midwest Research Institute, 1994).
- Volatile organic compounds (such as hexane) used to extract oils are also emitted by corn wet mills.

The harmful effects of particulate matter include (US EPA, 2024a):

- premature death in people with heart or lung disease
- nonfatal heart attacks
- irregular heartbeat
- aggravated asthma
- decreased lung function
- increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing

In 2023, Ingredion agreed to an $8 million settlement with the U.S. Federal government and the state of Indiana for corn wet mill in Indianapolis for Clean Air Act violations involving emissions of particulate matter (US DoJ, 2023). The location identified in the consent decree as where the violations occurred is certified as organic under the USDA National Organic Program (NOP, 2024a).

Sulfur dioxide is harmful to both human health and the environment (US EPA, 2024b):

- Short-term exposure to SO_2 can harm the human respiratory system and make breathing difficult.
- People with asthma—especially children—are sensitive to SO_2.
- Sulfur dioxide can interact with particulate matter contributing to greater penetration in the lungs.
- Gaseous SO_2 can harm plants by damaging foliage and decreasing growth.
- Sulfur dioxide contributes to acid rain that can harm sensitive ecosystems.

Enzymatic processes (E-milling) have the potential to reduce—but thus far, not eliminate—sulfur dioxide use and emissions (Johnston & Singh, 2004; Ramírez et al., 2009). E-milling also has the potential to increase starch yield (Ozturk et al., 2021). Novozyme markets a commercial enzyme that claims to increase starch yield and reduce carbon dioxide emissions (Novozymes, 2024). It is unclear to us whether E-milling is currently used by any commercial industrial scale processor.

According to Rausch et al. (2019), large-scale corn wet mills can generate as much effluent as a medium to large city. For example, the National Pollutant Discharge Elimination System Permit for the Ingredion

Argo wet mill in Bedford Park, IL lists the average daily discharge as 48.0 million gallons per day into the Chicago Sanitary and Ship Canal and nearby wetlands (IEPA, 2013). National When manufacturers release effluent into waterways, it can cause increased biological oxygen demand (D. R. Brown & Van Meer, 1978; Övez et al., 2001; Rausch et al., 2019).[13] Based on information from an older source, pretreatment with microorganisms can improve the quality of the effluent, but it remains a point source pollutant (D. R. Brown & Van Meer, 1978).

Corn wet milling is the most energy intensive type of operation in the food industry, accounting for 15% of all energy use in that sector (Galitsky et al., 2003). Wet mills are heavy consumers of electricity, and the indirect carbon footprint of wet-milling depends on how the electricity is generated (Flannery & Mares, 2022; Rosenfeld et al., 2018; C. Taylor et al., 2023). Most corn wet-milling in the U.S. is done in the Midwestern region, where coal still makes up a large share of electricity generating capacity (C. Taylor et al., 2023). Transitioning to natural gas and increasing investment in energy efficiency would lead to lower net emissions in the wet milling process (Rosenfeld et al., 2018).

Nonorganic Corn Production Environmental Impacts

Comparisons between the ecological and economic impacts of organic and conventional farming have a long history (Oelhaf, 1978; Stanhill, 1990). Multiple articles on the subject have been published since 1980, when the USDA issued its first Report and Recommendation on Organic Farming (USDA Study Team on Organic Farming, 1980). The first comparative field trials of organic and conventional farming systems that include corn began in 1981 at the Rodale Research Center in Kutztown, PA (Hanson et al., 1997; Moyer, 2021). Other long-term farming system trials comparing organic and conventional production with corn in rotation have been established across the U.S. (Cavigelli et al., 2009, 2013; Clark et al., 1999; Delate et al., 2017; Porter et al., 2003; Posner et al., 1995; K. E. White et al., 2019). A meta-analysis of these trials shows that organic systems with longer and more diverse rotations enhance soil organic carbon and nitrogen storage when compared to corn monocultures or corn-soybean short rotations (Delate et al., 2017).

Corn is the most widely produced grain in the U.S. and is second only to wheat globally (Johnson, 2000). Most conventional corn in the U.S. is produced as either a continuous monoculture or in a short rotation with soybeans (Daberkow et al., 2008; Gentry et al., 2013; Plourde et al., 2013; Porter et al., 2003). Corn is grown as a monoculture with large applications of synthetic fertilizers and herbicides (Sandhu et al., 2020). Some scholars regard the loss of biodiversity in the Midwestern U.S. due to large plantings of corn monoculture crops to be an extreme example (Altieri et al., 2017; Greco, 2012). Corn farming replaced a diverse grassland ecosystem with a simpler system that has significantly less biodiversity (Gliessman & Francis, 2024; Tilman, 1999).

In the United states, corn monocultures further increased with the commercialization of genetically engineered herbicide-tolerant and insect-resistant corn varieties (Daberkow et al., 2008). Within ten years of the release of these varieties, 16% of the U.S. acreage planted in corn was done so as a monoculture, year after year (Daberkow et al., 2008). Farmers also planted corn as a monoculture due to an increased demand for ethanol fuel (Daberkow et al., 2008). Continuous corn systems and corn-soybean short rotations dominate large parts of the Midwestern U.S. In Illinois, continuous corn production made up about 20% of the corn acreage in the mid-2010s (Vogel et al., 2015). According to a University of Illinois extension agent, over 60% of Illinois is a monoculture of either corn, soybeans, or wheat (Hansen, 2024). A study of corn acreage frequency in the Midwestern U.S. showed that some locations had planted corn for as many as 11 consecutive years between the 2008 and 2018 crop seasons (Ahlersmeyer, 2023).

Crop diversity in farming systems provides many benefits for insect pest management (Pimentel, 1961). Agronomists and agroecologists have long understood the adverse, agroecological impacts of continuous conventional monoculture corn production, and the environmental benefits of rotation, diversification, and organic production are also well documented (Bullock, 1992; R. G. Smith et al., 2008). Without synthetic fertilizers and pesticides, continuous monocultures would not be possible to sustain (Bullock,

[13] Biological oxygen demand (BOD) is a way to measure the amount of organic (carbon-containing) matter present in water. A higher BOD indicates that more dissolved oxygen is needed to break down organic matter. High BOD is an indicator of poor water quality.

1992; Mortensen & Smith, 2020). Continuous corn production can lead to diminished yields when stressors such as weather, corn residue accumulation, and low nitrogen availability impact the system (Gentry et al., 2013). It also diminishes biodiversity and soil carbon, especially compared to organic corn production, as described in *Evaluation Question #11* below.

The continuous planting of monocultures of herbicide-tolerant crops has changed weed biodiversity by selecting for those weeds that are resistant to the herbicides applied, mainly glyphosate (Roundup®) (Schütte et al., 2017). The emergence of glyphosate-resistant weeds in corn crops has resulted in the genetic modification of corn to be tolerant of other herbicides, such as 2,4-D and dicamba (Green, 2014). Dicamba-tolerant corn and soybeans have reinforced the trend towards farming simplification and consequent loss of biodiversity (Mortensen & Smith, 2020). Weeds are a part of biodiversity, and many non-crop species have a beneficial agroecological role (Altieri, 1999; MacLaren et al., 2020). One relevant example is that the use of herbicide-tolerant crops is linked to the loss of milkweed (*Asclepias* spp.) in the Midwest has been linked to a decline in migratory monarch butterfly (*Danaus plexippus*) populations that rely on milkweed as a food in their larval stage (Pleasants & Oberhauser, 2013). A meta-analysis showed that, on average, crop rotation with diverse species reduces weed density (Weisberger et al., 2019).

Individual field trials and experiments comparing organic and conventional farming systems need to be placed in the context of climates, soils, neighboring land uses, selected practices, and methodological factors that may create biases (Chaplin-Kramer et al., 2011; Delate et al., 2017; Seufert & Ramankutty, 2017). A meta-analysis of the data from 27 studies of corn production systems with legume cover crops around the world showed a corn yields increased by between 11.6% and 63.3% compared with controlled experiments without legume cover crops for a pooled average of an increase of 34.9% (Joshi et al., 2023). The authors of the meta-analysis cautioned about the interpretation of the information based on the small sample size and high variability. Soil organic carbon data provided clearer and more consistent results, with the experiments showing a range of 4.9% to 9.6% increased soil organic carbon when cover crops are included in a corn production system, as opposed to when they are not, with a pooled average of 7.3% for all experiments meta-analyzed (Joshi et al., 2023). The authors of the meta-analysis did not perform separate meta-analyses for organic and conventional systems.

Some researchers make the case that because organic yields are frequently lower than conventional yields, the relative impact on the environment should be adjusted by yield rather than area in production (De Ponti et al., 2012; Seufert et al., 2012; Seufert & Ramankutty, 2017; Stanhill, 1990). Others say that the yield gap is overestimated and that the ecological benefits and long-run productivity of organic farming systems outweigh any immediate challenges caused by lower yields of specific commodity crops (Ponisio et al., 2015; Reganold & Wachter, 2016; Wilbois & Schmidt, 2019).

The correlation between vegetational diversity and animal diversity has been studied by ecologists for nearly 100 years (Elton, 1927). Diverse agroecosystems have, on average, greater populations of beneficial organisms and are more resilient against invasive pests and diseases than continuous monocultures (Andow, 1991, 2023; Chaplin-Kramer et al., 2011; Sánchez et al., 2022). There are many studies that specifically compare the biodiversity of organic and conventional farming systems, and these have been summarized in several key meta-analyses, including studies that compare organic and non-organic corn production (Bengtsson et al., 2005; Hole et al., 2005; Tuck et al., 2013).

A study performed a cross-sectional analysis comparing 60 pairs of organic and non-organic farms paired by proximity, crop type, and cropping season in the same season between 2000 and 2003 (Feber et al., 2015). The data from the study supported the hypothesis that the greater cropping and habitat diversity of organic farms generally increases overall biodiversity. Organic farms had greater populations of natural enemies of pests when compared to nearby conventional farms with similar crops and planting dates. The population differences were species-specific and depended on the dispersal patterns of the beneficial organisms in question (Feber et al., 2015).

The development and release of corn varieties that express the *Bacillus thuringiensis* (Bt) endotoxin has been correlated with a decrease in the foliar application of insecticides in the carbamate and neo-nicotinoid families (Perry & Moschini, 2020). However, conventional producers still apply these pesticides for pests that are not controlled by Bt, particularly neonicotinoids used as corn seed treatments (Perry & Moschini, 2020). Chronic exposure to neonicotinoids reduces honey bee health in populations near corn crops (Tsvetkov et al., 2017).

Biodiversity loss from continuous corn production is also linked to the emergence of plant pathogens. Plant pathologists observed the re-emergence of Goss's wilt and blight (*Clavibacter michiganensis* subsp. *nebraskensis*) in the mid-2000s which was correlated with an increase in continuous corn production (T. A. Jackson et al., 2007). Corn anthracnose (*Colletotrichum graminicola*) is 91% higher in continuous corn production than in soybean-corn rotations, with 24 to 78% higher severity (Jirak-Peterson & Esker, 2011). Genetic uniformity of corn varieties makes southern corn leaf blight (*Bipolar maydis*) an ongoing concern (Bruns, 2017).

Evaluation Question #8: 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)].

Starch is a carbohydrate, and as such it is a part of a balanced and healthy diet along with proteins, fats, fiber, vitamins, minerals, and other carbohydrates (Otten et al., 2006). The link between carbohydrate consumption in general and starch consumption in particular and obesity in humans is less clear, somewhat controversial, and the subject of ongoing research (Hite et al., 2011; Ludwig et al., 2018; Speakman & Hall, 2021). Obesity results in unfavorable human health outcomes such as diabetes, strokes, and cardiovascular problems (Mozaffarian, 2016).

The scientific literature does not always isolate cornstarch from other sources of starch. A meta-analysis of low carbohydrate diets found that they, more often than not, caused weight loss in the short term, but the long-term weight loss and cardiovascular risk outcome results were not as clear (Santos et al., 2012).

Diets high in simple carbohydrates like sugar and starch have been linked to greater long-term weight gain when compared to diets with foods with more complex carbohydrates and higher fiber content (Wan et al., 2023). A large, long-term cohort study of 136,432 men and women conducted over a 24-28 year time period showed that sugar and starches from refined grains were associated with a 1.5 kg (3.3 lbs.) weight gain in men and 0.9 kg (2.0 lbs.) weight gain in women, on average every four years, compared with subjects on diets composed of whole grains, fruit, and non-starchy vegetables (Wan et al., 2023). The authors concluded that starch from refined grains, along with sugars and starchy vegetables, contribute to excessive body weight (Wan et al., 2023).

Animal subjects that are fed standard diets offer more controlled results than human epidemiology studies. Carbohydrate consumption has long been linked to overeating and obesity in laboratory rats (Sclafani, 1987). Chemically modified cornstarch caused more overeating and a greater incidence of obesity in rats than amylopectin from waxy corn (such as is found in native cornstarch), with both causing significantly more overeating and obesity in the rats than the control diet without added starch (Sclafani et al., 1988).

Native cornstarch is not considered a wholly resistant starch. However, it is one of the most studied sources of starch used to determine whether starch, in general, is beneficial, detrimental, or has no effect on human health. Reviewers of the literature on the link between starches, sugars, and obesity found that the form of the starch and the link between starch and sugar consumption (Aller et al., 2011). Carbohydrates from whole grains, legumes, and vegetables contained carbohydrates less linked to obesity and related health problems than foods rich in sugars (Aller et al., 2011). Higher intake of slowly digestible and resistant starches are more likely to be associated with reduced body weight compared with rapidly digestible starch (Aller et al., 2011). Native cornstarch, prepared in a way that is slowly hydrolyzed, lowered glucose and insulin levels in type-2 diabetic patients to levels comparable to healthy patients, while native cornstarch, prepared in a way that was rapidly hydrolyzed, resulted in significantly higher blood glucose and insulin levels in the diabetic patients (Seal et al., 2003).

A low-starch diet has been used to treat the chronic autoimmune disease ankylosing spondylitis, and to Crohn's disease in genetically susceptible individuals exposed to the enteropathic organism, *Klebsiella pneumoniae* (Rashid et al., 2013).

Elimination or reduction of starch, sugars, and other fermentable oligo-, di- and monosaccharides and polyols (FODMAPs) are known to reduce irritable bowel syndrome and other bowel disorders in part of the population, but researchers are uncertain as to the cause (El-Salhy et al., 2014; El-Salhy & Gundersen, 2015; Lacy et al., 2016; Mitchell et al., 2019; Ohlsson, 2021).

Alternatives:

Evaluation Question #9: Are there alternative natural (nonsynthetic) source(s) of the substance? [7 CFR 205.600(b)(1)].
Native cornstarch is a naturally occurring substance.

Organic cornstarch was claimed by a petitioner to be commercially available prior to the implementation of the NOP rule (NOSB, 2004a). However, we were unable to find the petition, any evidence that the petition was reviewed, or verify that the claim was valid.

Sources of organic cornstarch are discussed further under *Evaluation Question 11* below, as are sources of other organic starches. Starch is present in all plants, and any edible plant is a potential natural source of starch (Zobel & Phillips, 2006).

Evaluation Question #10: Describe all nonagricultural non-synthetic substances or products which may be used in place of the petitioned substance [7 U.S.C. 6517(c)(1)(A)(ii)]. Additionally, identify which of those are currently allowed under the NOP regulations.
Other nonagricultural nonsynthetic thickeners on the National List at 7 CFR 205.605(a) include:

- agar-agar
- calcium sulfate
- carrageenan
- gellan gum (high-acyl form only)
- potassium chloride

Nonsynthetic anti-caking agents—such as calcium sulfate, carrageenan, and gelatin—already appear on the National List at 7 CFR 205.605. Cellulose and xanthan gum are also on the National List at 7 CFR 205.605(b) and available for organic processors to use as alternatives to non-organic cornstarch as anti-caking agents.

In addition to the nonagricultural alternatives, several alternative agricultural thickeners appear on § 205.606, including:

- gelatin
- gum Arabic
- locust bean gum
- carob bean gum
- pectin (non-amidated forms only)
- tamarind seed gum
- tragacanth gum

We searched the FDA's database of Substances Added To Food for each non-organic substance allowed for use in organic food on the National List (7 CFR 205.605 and 606) using the following keywords: anticaking agent, free-flow agent, drying agent, flavoring agent, adjuvant, formulation aid, humectant, non-nutritive sweetener, nutritive sweetener, vehicle, stabilizer, thickener, texturizer (see *Table 3*). The FDA groups solvents and vehicles together, but cornstarch has no solvent properties (US FDA, 2024b).

Table 3: Cornstarch alternatives on the National List of nonorganic ingredients

Ingredient	Technical effects in common with cornstarch	NOP citation	FDA GRAS citations
Agar agar	Stabilizer or thickener, texturizer	605(a)(2)	184.1115
Calcium sulfate— mined	Anticaking agent, free-flow agent, drying agent, formulation aid, stabilizer, thickener	605(a)(8)	175.300, 176.170, 178.3297, 1841.1230
Carrageenan	Anticaking agent or free flow agent, drying agent, flavoring agent or adjuvant, humectant, nonnutritive sweetener, nutritive sweetener, solvent or vehicle, texturizer	605(a)(9)	172.620, 172.625, 182.7255
Cellulose	Anticaking agent	605(b)(11)	Not explicitly listed as GRAS
Gelatin	Anticaking agent, free-flow agent, drying agent, flavoring agent, adjuvant, formulation aid, humectant, vehicle, stabilizer, thickener, texturizer	606(h)	172.230, 172.255, 172.280, 182.70
Gellan gum	Stabilizer or thickener	605(a)(13) (high acyl only); 605(b)(18) (low acyl)	172.665
Gum Arabic	Formulation aid, vehicle, stabilizer, thickener, texturizer	606(j)	172.780, 184.1330
Carob and locust bean gum	Flavoring agent, adjuvant, vehicle, stabilizer, thickener, texturizer	606(j)	182.20, 184.1343, 186.1343, 240.1051
Pectin	Flavoring agent, adjuvant, vehicle, stabilizer, thickener, texturizer	606(o) (non-amidated forms only)	173.385, 184.1588
Tamarind gum	Flavoring agent, adjuvant	606(r)	182.20
Tragacanth gum	Flavoring agent, adjuvant, vehicle, stabilizer, thickener	606(s)	184.1351
Xanthan gum	Anticaking agent, drying agent, formulation aid, vehicle, stabilizer, thickener, texturizer	605(b)(37)	172.695, 176.170, 177.1350

These substances all appear on the Substances Added to Food list and are affirmed GRAS by the FDA, with the exception of cellulose (US FDA, 2024b). The NOSB considered environmental impacts in their review for each substance. The NOSB recommended that carrageenan be removed from the National List in November 2016 (NOSB, 2016a), preferring cellulose as an anti-caking agent even though it is synthetic. The recommendation was not accepted by the USDA, and both carrageenan and cellulose were relisted in 2018 (83 FR 14347, April 4, 2018). The technical review for carrageenan provided extensive information on the reported human health effects of the additive (NOSB, 2016b).

Evaluation Question #11: Provide a list of organic agricultural products that could be alternatives for the petitioned substance [7 CFR 205.600(b)(1)].
The clear organic agricultural product alternative to non-organic cornstarch is organic cornstarch. The viability of organic cornstarch as an alternative to the non-organic form mainly depends on whether it is now commercially available in sufficient quality and quantity to meet the demand for organic processed products where it is used as an ingredient.

According to written comments made by the Organic Trade Association, producers feel that organic alternatives are not sufficient for the following reasons (Organic Trade Association, 2015, 2020):

- While organic forms are available, the supply is not consistent. Two shortages had occurred within the decade.
- The available organic cornstarch does not meet the specifications that some manufacturers require.
- Other types of organic starches (beyond cornstarch) are not functional equivalents, and therefore not real alternatives.
- Organic molding starch (used for making gummy candies) is not available.

We found that at the time of this report, the Organic Integrity Database includes (NOP, 2024a):

- 358 operations that are certified for agriculturally derived starches.
- 123 operations that were certified specifically for cornstarch on (see the *Appendix* below).

We reached out to certifiers of organic cornstarch (Anonymous, personal communication, August 2024). From this communication, we learned that the supply chains for cornstarch are complex. Most of the certifiers that we talked to certify distributors that repackage organic cornstarch. Through these conversations (and by surveying publicly available information), we were unable to develop a clear understanding for how organic producers overcome technological barriers related to steeping.

Other organic starches

During our review, we did not find obvious organic alternatives for nonorganic cornstarch beyond organic cornstarch. The information below should not be taken to indicate that these are viable alternatives for the uses that organic processors need – especially for those processors who need cornstarch with very specific characteristics. Rather, these are alternative starches that may or may not hold potential in *some* applications.

Agricultural sources of starch in both traditional and industrial food systems include (Zobel & Phillips, 2006):

- potatoes (*Solanum tuberosum*)
- wheat (*Triticum vulgare*)
- rice (*Oryzae sativa*)
- sorghum (*Sorghum bicolor*)
- barley (*Hordeum vulgare*)
- oats (*Avena sativa*)
- arrowroot (*Maranta arundinicea*)
- cassava or tapioca (*Manihot esculenta*)
- yams (*Dioscorea* spp.)
- plantain (*Plantago* spp.)
- palm trees (*Metroxylon sagu* and *Arenga pinnuta*)
- buckwheat (*Fagopyrum esculentum*).

Table 4: Cornstarch alternatives from organic agricultural sources

Source Ingredient	Technical effects in common with cornstarch	FDA GRAS / SCOGS citations
Arrowroot	Stabilizer or thickener	SCOGS #115
Barley		Not found
Buckwheat		Not found
Cassava (Tapioca)	Stabilizer or thickener	SCOGS #115
Oat		Not found
Palm		Not found
Plantain		Not found
Potato	Flavoring agent or adjuvant, flavoring aid, formulation aid, stabilizer or thickener, texturizer.	182.70
Rice	Stabilizer or thickener	SCOGS #115
Sorghum (milo)		SCOGS #115
Wheat	Flavor enhancer; flavoring agent or adjuvant, formulation aid, solvent or vehicle stabilizer or thickener, texturizer.	182.70 and SCOGS #115
Yam		Not found

In addition to sources of organic cornstarch, the Organic Integrity Database has certified organic (NOP, 2024a):

- potato starch (82 handlers)
- wheat starch (53 handlers)
- cassava starch/tapioca starch (144 handlers)
- rice starch (38 handlers)
- buckwheat starch (4 handlers)
- oat starch (3 handlers)
- and arrowroot starch (3 handlers)

Pea starch contains as much amylose as cornstarch and more than rice or wheat starch (DeMan et al., 2018). The Organic Integrity Database also includes operations certified to handle various starches derived from the processing of legumes, such as:

- pea (*Pisum sativum*) starch (83 handlers),
- fava bean (*Vicia faba*) starch (16 handlers),
- mung bean (*Vigna radiata*) starch (37 handlers),
- soybean (*Glycine max*) starch (3 handlers),
- and adzuki bean (*Vigna angularis*) starch (1 handler).

There are many published sources of the specific technical and functional effects, performance, and test data of various starches, and it would be difficult to provide a simple summary of all of them (BeMiller & Huber, 2011; Mason, 2009; Thomas & Atwell, 1999; Zobel & Phillips, 2006). The following illustrate a few alternatives and their suitability for use in specific processed food products.

- Non-cereal starches, such as potato and tapioca, have lower lipid content (J. BeMiller & Huber, 2011).
- Potato starch is more commonly used in Europe (J. BeMiller & Huber, 2011; Mason, 2009), and is the preferred starch for many food applications because of its clarity, adhesive properties, and moisture retention (Grommers & van der Krogt, 2009).
- Gluten-free rice bread containing potato starch had a higher sensory score than bread made with cornstarch (Kim et al., 2015).
- When used as edible films, rice, potato, and tapioca starch all outperformed cornstarch in strength and clarity tests (Brain Wilfer et al., 2021).

Tapioca/cassava/manioc starch is produced in the tropics and is more commonly used in Asia, Latin America, and Africa (J. BeMiller & Huber, 2011). Tapioca starch is less likely to cause food allergies than cornstarch (Breuninger et al., 2009), and is preferred for thickening puddings and baby food (Mason, 2009). A naturally occurring mutant of amylose-free cassava has been discovered (Ceballos et al., 2007). The unimproved mutant strain produced starch that was not sufficiently soluble, so efforts were made to select varieties that had low amylose and more desirable traits through both classical breeding and induced mutation using gamma-irradiation (Ceballos et al., 2008). These varieties show promise in producing starch that is comparable to or even superior to starch from waxy corn for certain applications, such as frozen foods (Sanchez et al., 2010).

Various low-carbohydrate diets offer substitutes for cornstarch and other starches. The Atkins diet proposes the use of guar and carob gums as agriculturally derived substitutes for cornstarch (Atkins, 2014). Ketogenic diet recipes use glucomannan powder from the konjac plant, almond flour, chia seeds, flaxseeds, cauliflower, gelatin, and guar gum as agricultural substitutes for cornstarch (Lodge, 2022; Sullivan, 2024). A paleolithic diet website recommends avoiding baking powder with corn or other grains, and offers arrowroot flour, coconut flour, and almond flour as substitutes for grain flour (Jay, 2024). These are not peer-reviewed sources. The scientific literature has little information on the functionality of these cornstarch substitutes.

Evaluation Question #12: Describe if there are any alternative practices that would make the use of the petitioned substance unnecessary [7 U.S.C. 6518(m)(6)].

We found little information in the scientific literature regarding alternative practices to modify food textures, stability, caking, and other food properties in the manner that cornstarch does.

Some foods can be thickened or have their texture altered by physical means. Reducing the liquid by boiling off excess water is one way to thicken sauces and soups without adding any starches or other ingredients (Culinary Institute of America, 2011; Dinner Tonight, 2018). Straining out the liquid is another means to thicken a sauce or other food matrix without additional cooking or ingredients (Culinary Institute of America, 2011).

Dehydration techniques can also be used instead of adding cornstarch as a drying agent. Methods of dehydration include air convection drying, drum or roller drying, and vacuum drying (Potter &

Hotchkiss, 1998). Heat transfer by convection and removal of condensed moisture can be also used to dry certain foods (Toledo, 1999).

Report Authorship

The following individuals were involved in research, data collection, writing, editing, and/or final approval of this report:

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Appendix

Table 5 contains a list of USDA NOP Certified Organic starch handlers downloaded from the USDA Organic Integrity Database on July 31, 2024. The database is a union of the search for "Cornstarch" and "Starch" certified as organic under the handler scope. The results for "Corn Starch" are reported as two words and include those operations that are certified for "Maize Starch." Operations that are certified for cornstarch are identified in **bold.** Based on information received from certifying agents, most of the operations listed below are distributors and not primary producers. Parent companies and subsidiaries were included in the table, but duplicate records were removed. Some operations are certified by more than one agent, with certification agents certifying different starches handled by the same handler.

Table 5: USDA certified organic starch handlers

Operation name [a]	Certified starch products	Certifier [b]	Country [c]
4care Co.,Ltd.	Tapioca starch	BAC	Thailand
4care Inno Co.,Ltd.	Tapioca starch	BAC	Thailand
Abbott Blackstone Company Inc.	Pea starch, potato starch, tapioca starch	NFC	USA
Advanced Marketing Group	Tapioca starch	OTCO	USA
Agridient, Inc	Potato starch, tapioca starch	QAI	USA
Agroder Hububat Bakliyat Gida San. İç Ve Diş Tic. Ltd. Şti.	Starch (all kinds) [unspecified]	MAYA	Turkey
Agroindustrias Jas E.I.R.L.	Ginger starch	CAAE	Peru
All Ingredients Plus, Inc.	Corn starch, wheat starch	CCOF	USA
Aloja-Starkelsen Sia	Potato starch	BCS	Latvia
American International Foods Inc	Tapioca starch	OTCO	USA
American Key Food Products	Tapioca starch	CCOF	USA
American River Ag, Inc.	Tapioca starch	CCOF	USA
Amerikoa Ingredients	Tapioca starch	CCOF	USA
Anchor Ingredients Co., Llc	Pea starch	QAI	USA
Aps Phoenix Llc	Tapioca starch	AI	USA
Arasa Gida Perakende Yatirim Ve Isletme San. TIC. A.S	Wheat protein starch	OIA	Turkey
Arbor Organic Technologies, LLC	Tapioca starch	WFCFO	USA
Ardent Mills, LLC	Potato starch, tapioca starch	WFCFO	USA
Ark Logistics	Pea starch	QAI	USA
Arkherb Organics Nutrition Inc	Corn starch, mung bean starch, pea starch, potato starch	BCS	China
Aryan Food Ingredients Ltd	Corn starch, potato starch, wheat starch	MAYA	India
Aryan International Fzc	Wheat starch	BIOI	UAE
Asia Hoa Son Corporation	Tapioca starch	CUC	Viet Nam
ASR Naturals Llc	Tapioca starch	OTCO	USA
Austrade, Inc.	Starches [unspecified]	AI	USA
Azure Farm, Inc.	Corn starch, potato starch, tapioca starch, wheat starch	OTCO	USA
Baolingbao Biology Co., Ltd.	Corn starch	ECO	China
Barentz North America Llc	Potato starch, rice starch, tapioca starch	OTCO	
Bayco, Inc.	Tapioca starch	QAI	USA
Bedemco, Inc	Corn starch, tapioca starch	OEFFA	USA
Beijing Dairy International Trade Co., Ltd	Tapioca starch	CERES	China
BENEO Inc.	Rice starch	OTCO	USA
Biocosechas De México S.A. De C.V.	Potato starch, starch [unspecified]	BCS	Mexico
Bioneutra Dahui (Thailand) Co.,Ltd.	Tapioca starch	ECO	Thailand
Biorgânica Produtos Orgânicos Ltda.	Tapioca starch	IBD	Brazil
Bluearth Naturals Inc.	Pea starch	CCOF	USA
Bokor Rice Products Co., Ltd.	Rice starch	BCS	Cambodia
Botanical Cube Inc.	Potato starch, starch [unspecified]	BCS	China
Bridgewell Agribusiness LLC	Corn starch, potato starch, tapioca starch	QAI	USA
Bright People Foods, Inc	Corn starch, potato starch	QAI	USA
Burapa Prosper Co. Ltd.	Tapioca starch	BCS	Thailand
Butter Buds Inc.	Rice starch	OTCO	
Capitol Distribution Company LLC	Corn starch, potato starch, tapioca starch	QAI	USA
Cas Organics, LLC	Rice starch, tapioca starch	QCS	USA
Cascade Fruit Marketing Dba Foodguys, Inc.	Corn starch, tapioca starch	OTCO	
Central Milling/Keith Giusto Bakery Supply	Corn starch	CCOF	USA
Cereal Byproducts Company	Pea starch, tapioca starch	OTCO	

Operation name [a]	Certified starch products	Certifier [b]	Country [c]
Chaiyaphum Plant Products Co, Ltd.	Tapioca starch	BAC	Thailand
Changsha Comext Biotech Co.,Ltd	Corn starch	ECO	China
Charasmatic Trading & Consulting	Tapioca starch	OTCO	
Chen-Chee Grains And Consumable Oils Co.,Ltd	Corn starch, mung bean starch, pea starch	IBD	China
Chen-Chee Grains And Consumable Oils Co.,Ltd (Harbin Hada Starch)	Mung bean starch, fava bean starch, chickpea starch	IBD	China
Chen-Chee Grains And Consumable Oils Co.,Ltd (Heilongjiang Longfeng Corn Development)	Corn starch	IBD	China
ChienHo Feed Co.,Ltd.	Corn starch, mung bean starch, pea starch, potato starch, rice starch, wheat starch	IBD	China
Ciranda, Inc.	Potato starch, tapioca starch	QAI	USA
Comercio Alternativo De Productos No Tradicionales Y Desarrollo En Latinoamerica Y Perú - Candela Perú	Potato starch	IMOC	Peru
Compound Solutions, Inc.	Potato starch	QAI	USA
Crownrise Pharmaceutical Llc.	Potato starch	CERES	China
Crux Ingredients Llc	Tapioca starch	CCOF	USA
Czarnikow Group Limited	Tapioca starch	BAC	UK
Dahui (Cambodia) Starch Co., Ltd.	Tapioca starch	ECO	Cambodia
Dairiconcepts L.P - Bruce	Starch [unspecified blends]	BAC	USA
Dairy Farmers Of America, Inc. - Bruce	Starch [unspecified blends]	BAC	USA
Dalian Bio Grains International Trading Company Ltd.	Corn starch, pea starch, potato starch, rice starch	IBD	China
Dalian Chunlin Biotech Co.,Ltd	Corn starch, potato starch	LETIS	China
Dalian Dongenhui Agriculture Development Co., Ltd	Pea starch, rice starch, wheat starch	IBD	China
Dalian Doudou Agricultural Development Co.,Ltd	Corn starch, pea starch, potato starch, rice starch, wheat starch	IBD	China
Dalian Gindy Oil & Foodstuff Co., Ltd.	Corn starch, wheat starch	IBD	China
Dalian Guanghe Agricultural Products Co., Ltd	Pea starch, potato starch, wheat starch	IBD	China
Dalian Guanghe Agricultural Products Co., Ltd.	Wheat starch	BCS	China
Dalian Guanghe Agricultural Products Co., Ltd. (Warehouse)	Pea starch, potato starch, wheat starch	IBD	China
Dalian Guangyu Cereals Processing Co., Ltd.	Pea starch, potato starch, wheat starch	IBD	China
Dalian Huaen Co. Ltd / Dalian Rihua Organic Food Clean Co. Ltd.	Corn starch, pea starch, rice starch, wheat starch	IBD	China
Dalian Huaen Co., Ltd - (Guanxian Xinrui Industrial)	Corn Starch, Mung bean starch, Pea starch, Wheat Starch	IBD	China
Dalian Huaen Co., Ltd. (Inner Mongolia Yuwang Biological Technology)	Corn starch, Potato starch	IBD	China
Dalian Jade Agriculture Development Ltd. - Dalian Changxing Island Port	Corn starch	IBD	China
Dalian Jm Eternal International Co.,Ltd	Mung bean starch, pea starch	CUC	China
Dalian Mujing Agriculture Development Co., Ltd	Rice starch, wheat starch	IBD	China
Dalian Shengfang Organic Food Co., Ltd.	Corn starch, potato starch, wheat starch	BCS	China
Dalian Shengfang Organic Food Co.,Ltd.	Corn starch, mung bean starch, pea starch, potato starch, rice starch, wheat starch	IBD	China
Dalian U-Ka Organics Co., Ltd.	Mung bean starch, pea starch, starch [unspecified]	BCS	China
Dalian Weifeng International Trade Co.,Ltd.	Pea starch, potato starch, wheat starch	IBD	China
Dalian Yuhang International Trade Co.,Ltd.	Corn starch, broad [Fava?] bean starch, mung bean starch, pea starch, potato starch, rice starch, tapioca starch, wheat starch	ECO	China
Dalian Zhengye Trading Co., Ltd.	Pea starch	BCS	China
Davidsun Naturals Pte Ltd	Tapioca starch	CUC	Singapore
Delícia Potiguar Fécula E Derivados De Mandioca Ltda.	Tapioca starch	IBD	Brazil
Dervişoğlu Bakliyat A.Ş.	Corn starch, starch (all kinds), rice starch, wheat starch	MAYA	Turkey
Development On Agriculture And Consultation Of Environment Company Limited (DACE CO.,LTD)	Turmeric starch	CUC	Viet Nam
Do-It Food Ingredients Bv	Tapioca starch	CUC	Netherlands

Operation name [a]	Certified starch products	Certifier [b]	Country [c]
Dostavka Morem Agro Llc	Wheat protein starch	LETIS	Russia
Draco Natural Products, Inc.	Corn starch	OTCO	USA
Dupuy Storage & Forwarding Llc	Tapioca starch	OTCO	USA
Dutch Organic International Trade Bv (Do-It)	Tapioca starch	CUC	Netherlands
Earth Supplied Products, LLC	Arrowroot starch, corn starch, potato starch, rice starch, tapioca starch	QCS	USA
Edward & Sons Trading Co.	Corn starch, tapioca starch	QAI	USA
Essex Food Ingredients	Corn starch, tapioca starch	CCOF	USA
Excalibur Seasoning Co. Ltd	Corn starch	MOSA	USA
Farbest Tallman Foods Corp	Pea starch	CCOF	USA
Fenghui (Tianjin) Agricultural Technology Co., Ltd	Pea starch, potato starch, tapioca starch, wheat starch	IBD	China
Fg Products Company Limited	Tapioca starch	ONI	Viet Nam
Florida Crystals Food Corp.	Corn starch	QAI	USA
Flyloong Biotechnology (Qingdao) Co., Ltd.	Buckwheat starch, fava bean starch, mung bean starch, pea starch	CERES	China
Food Ingredients Inc.	Corn starch, potato starch	OTCO	USA
Formulator Sample Shop, Llc	Tapioca starch	WFCFO	USA
Frontier Co-Op	Corn starch, potato starch	QAI	USA
Funtrition LLC	Vegetable starches	AI	USA
Futaste Pharmaceutical Co., Ltd.	Corn starch	CERES	China
Fying Inc.	Pea starch	NFC	
Gansu Bochang Health Technology Co., Ltd	Pea starch, potato starch	SRS	China
Gansu Zhongshida International Trade Co.,Ltd.	Pea starch	IBD	China
Gansu Zhongshida International Trader Co. Ltda (The Tianjin Jinyue Agricultural Products Co.,Ltd.)	Pea starch	IBD	China
Garden Spot Foods LLC	Corn starch, potato starch	PCO	USA
General Food Products Co.,Ltd.	Rice starch, tapioca starch	CERES	Thailand
General Mills Inc.	Corn starch, wheat starch	OTCO	
Giusto's Specialty Foods, Llc	Arrowroot starch, tapioca starch	QAI	USA
GK Foods, Inc.	Corn starch, tapioca starch	OC	USA
Glant Hope Co., Limited	Wheat starch	IBD	China
Glenn, LLC	Corn starch, tapioca starch, wheat starch	OTCO	USA
Global Resources Direct Llc	Pea starch	NFC	USA
Glorybee Natural Sweeteners Inc.	Corn starch	QAI	USA
Glucorp (Pvt) Ltd	Rice Starch, Tapioca starch	CUC	Pakistan
Gluten Free Alimentos Ltda	Rice starch	IBD	Brazil
Golden Organics Inc.	Tapioca starch	CDA	USA
Gonçalves E Tortola S.A	Pregelatinized starch [Unspecified], Tapioca starch	IBD	Brazil
Grace Bio Co. Ltd.	Tapioca starch	ECO	Thailand
Grain Millers, Inc.	Tapioca starch	OTCO	
Green Boy Group	Corn starch, potato starch, tapioca starch, wheat starch	ECO	USA
Green Roots LLC	Corn starch, arrowroot starch, tapioca starch	CCOF	USA
Gulshan Polyols Limited	Corn starch	ONI	India
H&M Usa Inc.	Fava bean starch, mung bean starch	CCOF	USA
Hangzhou Natur Foods Co., Ltd.	Corn starch, mung bean starch, potato starch, rice starch, soybean starch,	IBD	China
Hangzhou Pekhill Foods Co., Ltd.	Corn starch, potato starch, tapioca starch	CERES	China
Harbin Hengling Trading Co., Ltd	Corn starch, potato starch, wheat starch	CUC	China
Harbin Junshuo Agricultural Technology Co., Ltd.	Tapioca starch	IBD	China
Harbin Zhenneng Import & Export Trading Co., Ltd.	Corn starch, potato starch, wheat starch	IBD	China
Harvest Commodities Marketing Dba Harvest Commodities Organic	Corn starch	MOSA	USA
HB Specialty Foods - Nampa	Corn starch, potato starch, tapioca starch	SCS	USA
Hddes Extracts (Pvt) Ltd	Chickpea starch, fava bean starch, mung bean starch, pea starch	CUC	Sri Lanka
Hebei Abiding Co.,Ltd	Corn starch, soybean starch	ECO	China
Hebei Happy Family Foods Co., Ltd	Starch [unspecified]	SRS	China
Hebei Jinfeng Starch Sugar Alcohol Co., Ltd.	Corn starch, potato starch, tapioca starch	CERES	China
Hebei Yongju Biotechnology Co., Ltd.	Mung bean starch, rice starch	ECO	China
Hebes Company Limited	Tapioca starch	ONI	Viet Nam

Operation name [a]	Certified starch products	Certifier [b]	Country [c]
Heilongjiang Longfeng Corn Development Co.,Ltd.	Corn starch	LETIS	China
Hengyuan Biotechnology Co., Ltd	Pea starch	ACO	China
High Quality Organics, Inc	Corn starch, potato starch, tapioca starch	QAI	USA
Honeyville Foods	Pea starch, rice starch	UDAF	USA
Honeyville Grain Inc	Pea starch	OC	
Hunan Delore Natural Products Co.,Ltd	Corn starch, pea starch	ECO	China
Hunan Er-Kang (Cambodia) Investment Co., Ltd.	Tapioca starch	CERES	Cambodia
Hunan Mt Health Inc	Buckwheat starch	ECO	China
Hylen Co.,Ltd.	Corn starch	CERES	China
ICI Foods	Corn starch, potato starch, tapioca starch	MOSA	USA
IFC Solutions Inc.	Rice starch, starch blend [unspecified]	OTCO	USA
I-Futurz (Dalian) Co., Ltd.	Chickpea starch, fava bean starch, mung bean starch, pea starch	ECO	China
Indus Cosmeceuticals Private Limited	Corn starch	ECO	India
Indústria Agro Comercial Cassava S/A	Tapioca starch	IBD	Brazil
Indústria Agro Comercial Cassava S/A	Tapioca starch	IBD	Brazil
Ingredientes Sin Gluten La Clementina	Corn starch, potato starch, tapioca starch	MAYA	Mexico
Ingredion (Thailand) Co., Ltd.	Rice starch, tapioca starch	CUC	Thailand
Ingredion Incorporated	Corn starch, rice starch, tapioca starch	QAI	USA
Inzee (Thailand) Co., Ltd.	Tapioca starch	CERES	Thailand
Ion Labs, Inc.	Potato starch	WFCFO	USA
Irca Group Usa Llc	Rice starch	QCS	USA
Jiangsu Grain Foods Co., Ltd.	Pea starch	ECO	China
Jiangsu Hejiu Import & Export Trade Co., Ltd.	Tapioca starch	CERES	China
Jiangsu Yuanjie Agricultural Development Co., Ltd.	Tapioca starch	CERES	China
Jianyuan International Co. Ltd.	Pea starch	ACO	China
Jilin Ecological Science & Technology Co.,Ltd.	Corn starch, wheat starch	IBD	China
Jiujiang Tiantai Food Co.,Ltd	Pea starch	IBD	China
Jonker & Schut Bv	Potato starch, Tapioca starch	CUC	Netherlands
Juicing Experts S.A.C.	Turmeric starch	ECO	Peru
Just About Foods S De R.L. De C.V.	Tapioca starch	CMEX	Mexico
Kate Farms, Inc.	Pea starch	QAI	USA
Koop Agro Gida Sanayi Dis Tic. Ltd. Sti.	Starch (all kinds) [unspecified]	SCS	Turkey
Lakeside Food Sales, Inc.	Tapioca starch	MOSA	USA
Lakeview Farms LLC Dba Fresh Cravings LLC	Corn starch	CCOF	USA
Lani Ingredients Inc	Tapioca starch	ONE	USA
Lani Ingredients Inc	Tapioca starch	ONE	USA
Lao Natur Development Sole Co., Ltd	Tapioca starch	CERES	Laos
Lao Proper Co., Ltd	Tapioca starch	CERES	Laos
Lexunder Inc. Dba Food To Live	Potato starch	CCOF	USA
Lincoln Transloads & Processing	Pea starch	MOSA	USA
Linkone Ingredient Solutions LLC	Starch [unspecified]	OC	USA
Linqing Deneng Golden Corn Biological Co., Ltd.	Corn starch	CERES	China
Linyi Yuwang Vegetable Protein Co., Ltd.	Pea starch	CERES	China
Lodaat LLC	Potato starch	CUC	USA
M/S Pratithi Organic Foods Private Limited	Corn starch	ONI	India
Mak Ingredients Llc	Potato starch	NFC	USA
Malk Organics, Llc	Tapioca starch	OTCO	USA
Mane, Inc.	Corn starch	OTCO	USA
Manildra Milling Corp.	Wheat starch	QAI	USA
Marroquin Organic International, Inc.	Corn starch, potato starch, wheat starch	OTCO	USA
Master Sweetener	Tapioca starch	CUC	Pakistan
Mclob America LLC	Starches [unspecified]	OC	USA
Meelunie America Inc.	Corn starch, potato starch, wheat starch	OTCO	USA
Millbio Singapore Pte Ltd	Tapioca starch, wheat starch	CUC	Singapore
Miranda LLC	Wheat starch	LETIS	Russia
Monroe Stutzman	Corn starch	OEFFA	USA
Mt Olive Company (HP)	Corn starch	OC	USA
Montana Premier Protein Inc	Lentil starch	MTDA	USA
Morii Foods, Inc.	Tapioca starch	SCS	USA

Operation name [a]	Certified starch products	Certifier [b]	Country [c]
Mountain Rose Herbs	Rice starch, tapioca starch	OTCO	USA
Nanjing Harvest Biot-Tech Co.,Ltd.	Corn starch	ECO	China
Nanjing Hosia Biot-Tech Co., Ltd	Corn starch	ECO	China
Natural Produce Of Peru E.I.R.L.	Ginger starch	CAAE	Peru
Nature's Ingredients Asia Co., Ltd	Tapioca starch	CUC	Thailand
Nature's Ingredients, Inc Dba Hill Pharma	Pea starch, rice starch	SCS	USA
Nature's Kingdom Usa Llc	Pea starch	OTCO	USA
Naturz Organics (Dalian) Co., Ltd. (includes Yantai, Heilongjiang, and USA subsidiaries)	Corn starch, fava bean starch, mung bean starch, pea starch, potato starch, rice starch, tapioca starch, wheat starch	IBD	China
Neff Co., Inc.	Tapioca starch	OTCO	USA
Newark Nut Company	Potato starch, tapioca starch	CCOF	USA
Nexxus Foods Corp	Pea starch	ECO	USA
Ningbo Excare Pharm Inc.	Fava bean starch, mung bean starch, pea starch, tapioca starch	ECO	China
Ningbo Herb Pharma Corp.	Pea starch	ECO	China
North Central Companies, Inc.	Corn starch, potato starch, tapioca starch, wheat starch	CCOF	USA
Nurture LLC Dba Happy Family Organics; Happy Family Brands	Tapioca starch	CCOF	USA
Nutra Food Ingredients Llc	Pea starch	SCS	USA
Nutra-Agri Ingredients Llc	Tapioca starch	OTCO	
Nutracean Co.,Ltd.	Fava bean starch, Mung bean starch, Pea Starch	ECO	China
Nutraonly(Xi'an) Organic Nutritions Inc.	Fava bean starch, mung bean starch, pea starch, potato starch, rice starch, tapioca starch	IBD	China
Nutripharma Ingredient Inc.	Pea starch	OC	USA
Onset Worldwide Lc	Tapioca starch	WFCFO	USA
Organic Creations	Corn starch	ODA	USA
Organic Partners International, LLC	Corn starch, potato starch, tapioca starch	QAI	USA
Organic Spices and Herbs India	Corn starch	CUC	India
Organicway (Xi'an) Food Ingredients Inc.	Corn starch	SRS	China
Organicway Food Industry Co., Ltd	Corn starch, potato starch	TNC	China
Pacific Choice Brands, LLC.	Corn starch	QAI	USA
Pacific Spice Company, Inc.	Corn starch	QAI	USA
PacMoore Process Technologies	Corn starch, pea starch	QAI	USA
Pallas Biotech Co.,Ltd	Wheat starch	ECO	China
Panhandle Milling, Llc	Tapioca starch	QAI	USA
Paradise Farm Organics, Inc.	Rice starch	IDA	USA
Parchem Trading Ltd	Corn starch, potato starch, tapioca starch	ONE	USA
Particle Control Inc.	Lentil starch, pea starch, tapioca starch	MOSA	USA
Phalada Agro Research Foundations Pvt. Ltd.	Corn starch, tapioca starch	CUC	India
Phoenix Agro Co.,Ltd.	Corn starch, potato starch, mung bean starch, pea starch, rice starch, wheat starch	IBD	China
Premium Food Group Inc.	Tapioca starch	NFC	USA
Processor's Choice, Inc.	Corn starch, rice starch, tapioca starch	CCOF	USA
Producers Meat and Provisions, Inc.	Corn starch	CCOF	USA
Productos Picantes De Baja California S.A De C.V.	Tapioca starch	OTCO	Mexico
Proseccosource DBA Anthony's Goods DBA Pennypacker	Corn starch, potato starch	CCOF	USA
Pure Life Organic Foods Limited	Tapioca starch	ONE	USA
Pure Organic Foods Dmcc	Tapioca starch	ONI	UAE
Pure Truherb Private Limited	Corn starch	ONI	India
Puris Proteins Llc Dba Puris	Starch [unspecified]	OCIA	USA
Qimei Industrial Group Co.,Ltd	Corn starch, adzuki bean starch, black bean starch, black rice starch, buckwheat starch, lentil starch, oat starch, pea starch, pinto bean starch, potato starch, red kidney bean starch, rice starch, soybean starch, sweet potato starch, wheat starch, white kidney bean starch	ECO	China
Qingdao Ahead Technology Co., Ltd.	Corn starch, mung bean starch, pea starch, tapioca starch	CERES	China
Qingdao Futaste Co., Ltd.	Corn starch	CERES	China
Qingdao Mapert Ingredients Co.,Ltd	Mung bean starch, pea starch	ECO	China

Operation name [a]	Certified starch products	Certifier [b]	Country [c]
Qingdao Nutralong Pharmachem Co., Ltd.	Pea starch	ACO	China
Qingdao Sunrise Biotechnology Co., Ltd	Corn Starch, mung bean starch, pea starch, potato starch	CERES	China
Qingdao Sunrise Health Co., Ltd.	Corn starch, mung bean starch, pea starch, potato starch	CERES	China
Qingdao Tanjia Trade Co., Ltd.	Corn starch, mung bean starch, potato starch, sweet potato starch	TNC	China
Rapid Organic Private Limited	Corn starch	ONI	India
Reliable Products Inc.	Potato starch	OTCO	USA
Rfi Llc	Starch complex	QAI	USA
Richtek Ltd	Fava bean starch, mung bean starch, pea starch	IBD	China
Riega Foods, LLC	Corn starch	QAI	USA
Rocky Mountain Spice Company	Potato starch	CDA	USA
Roquette America Inc.	Pea starch	QAI	USA
Rosun Natural Products Pte Ltd	Tapioca starch	CUC	Singapore
Royal Ingredients Group Usa, Inc.	Wheat starch	CUC	USA
Sam Nhut Company Limited (Sam Nhut Co., Ltd)	Tapioca starch	CUC	Viet Nam
Sanjeevani Organics Usa Division Llc	Tapioca starch	OTCO	USA
Sanmik Food (Pvt) Ltd	Tapioca starch	CUC	Sri Lanka
Sanmik Natural Food Pty Ltd	Tapioca starch	ACO	Australia
Seyrani Agro Gida Sanayi Dis Ticaret Limited Sirketi	Corn starch, rice starch, wheat starch, starch (all kinds) [unspecified]	LETIS	Turkey
Shaanxi Natural Healthcare Group Co.,Ltd	Buckwheat starch	ECO	China
Shaanxi Runke Plant Science & Technology Co., Ltd	Potato starch	CERES	China
Shaanxi Undersun Biomedtech Co., Ltd.	Pea starch	BCS	China
Shaanxi Yeehealth Biotech Co., Ltd	Starch [unspecified vegetables]	SRS	China
Shaanxi Yuherbbio-Engineering CO.LTD.	Corn starch, wheat starch	ECO	China
Shafi Gluco Chem Pvt. Ltd.	Rice starch, tapioca starch	CUC & ECO	Pakistan
Shanantina S.A.C.	Tapioca starch	CUC	Peru
Shandong Aromaholly Chemicals Co., Ltd	Corn starch	ECO	China
Shandong Fukuan Biological Engineering Co., Ltd	Corn starch	CERES	China
Shandong Hua-Thai Foodproducts Co., Ltd.	Pea starch	ECO	China
Shandong Jianyuan Bioengineering Co. Ltd.	Pea starch	ACO	China
Shandong Premium Select Foods Co., Ltd	Corn starch, rice starch	SRS	China
Shandong Saigao Group Corporation	Corn starch	CUC	China
Shandong Starlight So True Biological Technology Co., Ltd	Corn starch	SRS	China
Shanghai Elim Organic Food Co. Ltd.	Corn starch, potato starch, tapioca starch	ACO	China
Shanghai Fine Agriculture Technology Co. Ltd.	Corn starch, mung bean starch, potato starch, tapioca starch	ACO	China
Shanghai Sankeng Biological Co.,Ltd.	Pea starch	ECO	China
Shanghai Tianyuan Plant Product Co., Ltd.	Corn starch	ECO	China
Shimane Organic Farm Co., Ltd.	Tapioca starch	ECO	Japan
Skidmore Sales & Distributing	Corn starch, tapioca starch, wheat starch	CCOF	USA
Smirk's LTD.	Tapioca starch	OTCO	USA
Smith And Truslow	Potato starch	CDA	USA
Sole Ingredients	Corn starch	TDA	USA
Southeast Asia Organic Co.,Ltd	Tapioca starch	BAC	Thailand
Spiceworks, LLC	Tapioca starch	ODA	USA
St Charles Trading, Inc	Potato starch, tapioca starch	QAI	USA
Starhealth Anguo Herbs Processing Factory	Oat starch	CERES	China
Starhealth Botanical Technology Corporation	Oat starch	CERES	China
Startchy Inc.	Corn starch	OTCO	USA
Starwest Botanicals	Corn starch	QAI	USA
Sunatura Exports Private Limited	Corn starch, potato starch, wheat starch	CUC	India
Sunrise Foods International B.V.	Wheat starch	QCS	Turkey
Sunrise Foods International B.V. - Dia Corum	Wheat starch	QCS	Turkey
Sunsweet (Shandong) Biotech Co.,Ltd	Corn starch	ECO	China
Supply And Marketing Grain and Oil Harbin Co., Ltd	Corn starch	ECO	China
Suzanne's Specialties, Inc	Tapioca starch	ONE	USA
Sweet Life Services, Llc	Potato starch, tapioca starch	CCOF	USA
Tay Ninh Tapioca Joint Stock Company	Tapioca starch	CUC	Viet Nam

Operation name [a]	Certified starch products	Certifier [b]	Country [c]
T C Bauer Co dba eSutras Organics	Corn starch	MOSA	USA
Thai Wah Public Company Limited	Tapioca starch	CUC / ECO	Thailand
The Dojo, Llc	Potato starch, tapioca starch	CCOF	USA
The Green Labs, Llc	Starch [Unspecified, possibly Tapioca]	CCOF	USA
The Purple Mixer, Llc Dba Miss Jones Baking Co.	Tapioca starch	OTCO	USA
The Scoular Company	Pea starch	WFCFO	USA
The Sun Tree (Xiamen) Biological Engineering Co., Ltd	Corn starch, tapioca starch	ECO	China
Top Seedz LLC	Corn starch	NFC	USA
Tianjin Aso Organic Foods Co., Ltd.	Sweet potato starch	ECO	China
Tianjin Taizhen Import and Export Trade Co., Ltd	Pea starch, potato starch, wheat starch	IBD	China
Todd's BBI	Pea starch	IDALS	USA
Tongliao Shengda Bioengineering Co., Ltd.	Wheat starch (fermented)	ECO	China
Tootsi Impex Usa Inc	Potato starch	ECO	USA
Top Organic Products and Supplies Co., Ltd.	Tapioca starch	BAC	Thailand
Total Food Package	Tapioca starch	OTCO	USA
Tradin Organic Agriculture B.V.	Tapioca starch	CUC	Netherlands
Tradin Organic USA	Tapioca starch	OTCO	USA
Ubon Bio Agricultural Company Limited	Tapioca starch	CUC	Thailand
Ubon Sunflower Company Limited	Tapioca starch	CUC	Thailand
Ugreen Co., Ltd	Corn Starch, mung bean starch, potato starch	ECO	China
United International Llc.	Tapioca starch	ECO	USA
Universal Raw Ingredients Llc	Tapioca starch	NFC	USA
Urmatt Ltd.	Rice starch	ECO	Thailand
USA Container Co., Inc.	Corn starch	QAI	USA
Vallon Farm Direct Pvt. Ltd.	Corn starch	ONI	India
Vedan Vietnam Enterprise Corp., Ltd	Tapioca starch	CUC	Viet Nam
Viet Haus Company Limited	Tapioca starch	CUC	Viet Nam
Viet Nam Tapioca Co., Ltd	Tapioca starch	CUC	Viet Nam
Vifood Co.,	Tapioca starch	MAYA	Viet Nam
Virco International (Pvt) Limited	Tapioca starch	CUC	Sri Lanka
Vostok-Snab Llc	Tapioca starch, wheat starch	IBD	Russia
Wangkui Agri-Ecology Co., Ltd	Corn starch, mung bean starch, pea starch	CUC	China
Wellmore Holdings	Pea starch	CCOF	USA
Western Foods	Potato starch	CCOF	USA
Wuxi Accobio Biotech Inc.	Potato starch, starch [unspecified, possibly pea]	BCS	China
Wuxi Jinnong Biotechnology Co.Ltd. Shanggao Branch	Rice starch	ECO	China
Xi'an Finesoul Biotech Co., Ltd.	Pea starch	BCS	China
Xi'an Gawen Biotechnology Co., Ltd.	Mung bean starch, pea starch	BCS	China
Xi'an Aogu Biotech Co., Ltd.	Corn starch, mung bean starch, tapioca starch	ECO	China
Xi'an Faitury Bio-Tech Co.,Ltd	Sweet potato starch	ECO	China
Xinjiang Foisun Agriculture Development Co. Ltd.	Corn starch	ECO	China
Xuan Hong Import Export Processing Co., Ltd	Tapioca starch	ONI	Viet Nam
Yancheng Maichuang Vegetables Co., Ltd.	Corn starch	ECO	China
Yantai Oriental Protein Tech Co., Ltd.	Fava bean starch, mung bean starch, pea starch	CERES	China
Yantai Shuangta Food Co., Ltd	Pea starch	SRS	China
Yantai Shuangta Food Co.,Ltd	Fava bean starch, mung bean starch, pea starch	ECO	China
Yantai T.Full Biotech Co., Ltd.	Fava bean starch, mung bean starch, pea starch	ECO	China
Yantai Zhongzhen Trading Co., Ltd.	Fava bean starch, mung bean starch, pea starch	CERES	China
Yosin Biotechnology (Yantai) Co., Ltd.	Mung bean starch, pea starch	ECO	China
Zhaoyuan Junbang Trading Co., Ltd.	Fava bean starch, mung bean starch, pea starch	BCS	China

[a] Cornstarch Handlers certified under the USDA NOP are listed in **Bold**. Note that some of the product that is represented as certified organic under the USDA NOP standard may be produced by standards

other than the USDA NOP and recognized as equivalent under an international agreement before it is repackaged under the supervision of a USDA Accredited Certifying Agent.

[b] USDA Accredited Certifying Agents:

- [ACO] ACO Certification Ltd.
- [AI] Americert International
- [BAC] BioAgriCert
- [BCS] Kiwa BCS Öko-Garantie GmbH
- [BIOI] Bio.Inspecta
- [CAAE] Servicio de Certificación CAAE S.L.U.
- [CCOF] CCOF
- [CDA] Colorado Department of Agriculture
- [CERES] CERES
- [CMEX] Certificadora Mexicana de Productos y Procesos Ecologicos SC
- [CUC] Control Union Certifications
- [ECO] Ecocert SAS (formerly Ecocert SA)
- [IBD] IBD Certifications
- [IDA] Idaho Department of Agriculture
- [IDALS] Iowa Department of Agriculture and Land Stewardship
- [IMOC] IMOcert Latinoamerica LTDA
- [LETIS] LETIS S.A.
- [MAYA] Mayacert S.A.
- [MTDA] Montana Department of Agriculture
- [MOSA] Midwest Organic Services Association
- Inc.
- [NFC] Natural Food Certifiers
- [OEFFA] Ohio Ecological Food and Farm Association
- [OCI] OneCert, International Private Limited
- [ONE] OneCert, Inc.
- [ODA] Oregon Department of Agriculture
- [OTCO] Oregon Tilth Certified Organic
- [OC] Organic Certifiers, Inc.
- [OCIA] Organic Crop Improvement Association
- [OIA] Organización Internacional Agropecuaria
- [PCO] Pennsylvania Certified Organic
- [QAI] Quality Assurance International
- [QCS] Quality Certification Services
- [SCS] SCS Global Services, Inc.
- [SRS] SRS Certification GmbH
- [TDA] Texas Department of Agriculture
- [TNC] Transitioning to a New Certifier
- [UDAF] Utah Department of Agriculture and Food
- [WSDA] Washington State Department of Agriculture
- [WFCFO] Where Food Comes From Organic (formerly A Bee Organic).

[c] Physical location of the operation where given:

- [China] The People’s Republic of China
- [Laos] Lao People's Democratic Republic
- [Netherlands] The Netherlands
- [Russia] The Russian Federation
- [UAE] United Arab Emirates
- [UK] The United Kingdom of Great Britain and Northern Ireland
- [USA] The United States of America.

Source: (NOP, 2024a)