Corn Steep Liquor

Crop Production

Identification of Petitioned Substance

Chemical Name:
Corn Steep Liquor

Other Names:
(Corn steepwater, light steepwater, heavy steepwater, condensed fermented corn extractives

Trade Names:

CAS Number:
66071-94-1

Other Codes:
European Inventory of Existing Commercial Chemical Substances (EINECS) No. 266-113-4

Characterization of Petitioned Substance

Composition of the Substance:

Steeping is a procedure used during wet corn milling. The major objectives for corn steeping are to induce chemical and physical changes in the kernel by leaching the soluble components from the corn. Cleaned shelled corn is soaked for 30-48 hours at 120 - 130° F in a dilute sulfur dioxide solution. The steeped liquid is then separated from the non-soluble corn solids, which are further separated into germ, bran, starch, and gluten protein. The steeped liquor is concentrated by evaporation into Condensed Corn Fermented Extractives or Corn Steep Liquor (CSL). Corn steep liquor is a mixture of soluble protein, amino acids, carbohydrates, organic acids (e.g., lactic acid), vitamins, and minerals.

Wet corn milling is used to produce numerous corn based products that are subsequently used as biofuel, ingredients in food, and for livestock feed. These products include starch, high fructose corn syrup, oil, ethanol, bran, gluten feed, and meal. Corn steep liquor is one of the byproducts of corn wet milling directed to the production of animal feed. It is also used as a nutrient for microorganisms in the production of enzymes, antibiotics, and other fermentation products.

Properties of the Substance:

Product Chemistry

Physical State	Liquid
Melting Point	Not applicable, corn steep liquor is a liquid
Boiling Point	100 – 104 degrees Centigrade
Density	1.2 to 1.4 g/cm^3
Vapor Pressure	17.5 mm, 20 degrees Centigrade
Flammability/Flame Extension	not flammable
Explodability	not explosive
Solubility	Soluble in water

Oxidizer	not an oxidizer

Specific Uses of the Substance:

CSL is a mixture of soluble proteins, amino acids, carbohydrates, organic acids (e.g., lactic acid), vitamins, and minerals. It is used as a nutrient for microorganisms in the production of enzymes, antibiotics, and other fermentation products. It is sometimes combined with other ingredients in corn gluten feed and widely used in complete feeds for dairy and beef cattle, poultry, swine, and pet foods. It may also be sold separately as a liquid protein source for beef or dairy rations.

Approved Legal Uses of the Substance:

The Association of American Feed Control Officials, Inc. (AAFCO) has listed corn step liquor as a livestock feed ingredient.

The following is quoted directly from the AAFCO homepage.

"The purpose of the corporation shall be to establish and maintain an Association through which officials of any state, dominion, federal or other governmental agency and employees thereof charged with a responsibility in enforcing the laws regulating the production, labeling, distribution, or sale of animal feeds or livestock remedies may unite to explore the problems encountered in administering such laws, to develop just and equitable standards, definitions and policies to be followed in enforcing such laws, to promote uniformity in such laws, regulations and enforcement policies, and to cooperate with members of the industry producing such products in order to promote the effectiveness and usefulness of such products."

Action of the Substance:

Corn steep liquor is a byproduct of wet corn milling. Its components are soluble proteins, amino acids, carbohydrates, organic acids (e.g., lactic acid), vitamins, and minerals. It is sometimes combined with other ingredients in corn gluten feed and widely used in complete feeds for dairy and beef cattle, poultry, swine, and pet foods. Some corn steep liquor is used in the production of acetic acid, food acids, and fermentation processes. Some corn steep liquor is used in the pharmaceutical industry in the production of intravenous solutions and drugs, most notably antibiotics (penicillin).

Status

U.S. Environmental Protection Agency

Corn steep liquor is one of 2800 High Production Volume (HPV) chemicals identified on the US Environmental Protection Agency's (USEPA) 1990 Toxic Substances Control Act (TSCA) Inventory Update Rule (IUR). HPV chemicals are those that are manufactured or imported in quantities greater than 1 million pounds per year.

The following information is quoted directly from the USEPA homepage for New Chemicals.

"Under the Toxic Substances Control Act, section 8(b) provides EPA authority to "compile, keep current, and publish a list of each chemical substance that is manufactured or processed in the United States." TSCA section 3(2)(A) states that "the term 'chemical substance' means any organic or inorganic substance of a

particular molecular identity, including - (i) any combination of such substances occurring in whole or in part as a result of a chemical reaction or occurring in nature, and (ii) any element or uncombined radical." TSCA does not include chemical substances subject to other US statutes such as foods and food additives, pesticides, drugs, cosmetics, tobacco, nuclear material, or munitions."

U.S. Food and Drug Administration

Corn steep liquor is not listed as Generally Recognized as Safe by the FDA (FDA, 2004), but is listed as a component of a color additive allowed in chicken feed.

The following is directly quoted from 21 CFR Sec. 73.275.

"§ 73.275 Dried algae meal.
(a) *Identity.* The color additive dried algae meal is a dried mixture of algae cells (genus *Spongiococcum,* separated from its culture broth), molasses, cornsteep liquor, and a maximum of 0.3 percent ethoxyquin. The algae cells are produced by suitable fermentation, under controlled conditions, from a pure culture of the genus *Spongiococcum.*
(b) *Uses and restrictions.* The color additive dried algae meal may be safely used in chicken feed in accordance with the following prescribed conditions: (1) The color additive is used to enhance the yellow color of chicken skin and eggs. (2) The quantity of the color additive incorporated in the feed is such that the finished feed: (i) Is supplemented sufficiently with xanthophyll and associated carotenoids so as to accomplish the intended effect described in paragraph (b)(1) of this section; and (ii) Meets the tolerance limitation for ethoxyquin in animal feed prescribed in § 573.380 of this chapter."

Association of American Feed Control Officials, Inc.

The Association of American Feed Control Officials, Inc has listed corn steep liquor as a livestock feed ingredient.

International:

The European Union permits the use of stillage and stillage extracts as fertilizers and soil conditioners in organic crop production, however, corn steep liquor is not mentioned specifically (European Union, 2008). Stillage is defined as the mash from the fermentation of grains after the removal of alcohol by distillation (Association of American Feed Control Officials, 2005). Maize bran and gluten from wet corn milling are permitted as feed materials used in livestock production (European Union, 2008). European manufacturers refer to corn wet milling as maize processing. The processes are the same, which includes the use of sulfur dioxide.

The Codex Alimentarius permits the use of stillage and stillage extracts as fertilizers and soil conditioners in organic crop production, however, corn steep liquor is not mentioned specifically (Codex Alimentarius, 2008).

Corn steep liquor is included on the chemical inventory of the Domestic Substances List by the Canadian government.

Evaluation Questions for Substances to be used in Organic Crop or Livestock Production

Evaluation Question #1: Is the petitioned substance formulated or manufactured by a chemical process? (From 7 U.S.C. § 6502 (21).)

Corn steep liquor is produced by steeping corn grain in water for up to 48 hours. The soluble components in the corn are removed because a natural lactic fermentation is taking place during steeping. Sulfur dioxide is added at rates of 0.1 to 0.2 percent and is used to cleave disulfide linkages, resulting in the degradation of the corn protein that encapsulates the starch granules. The starch is then released from the encapsulating material. The steep water containing the corn solubles are concentrated with evaporators to

form corn steep liquor. Corn steep liquor is a mixture of soluble protein, amino acids, carbohydrates, organic acids (e.g., lactic acid), vitamins, and minerals. The nitrogen fraction is high in free amino acids and small peptides. In four samples of corn steep water, Hull et al., (1996) found a number of small poly-peptides present. Concentrations of poly-peptides generally increased during steeping. In the same study, Hull et al., (1996) found the amino acids glutamine, leucine, proline, and asparagine at the highest concentrations. Lower concentrations of lysine, cysteine, and methionine were reported. Concentrations of amino acids generally increased during steeping. The composition of amino acids in the four corn steep liquor samples compared characteristically similar to corn albumin, globulin, glutelin, and zein proteins (Wilson, 1987). Hull et al., (1996) found various non-protein nitrogenous compounds in corn steep water. Enzymatic activities provided no evidence for proteases during steeping, however, the length of steeping time (up to 30 hours), coupled with the higher temperature (50 to 55 degrees Centigrade) and the presence of micro-organisms could contribute to the enhancement of proteolytic activity during steeping (Hull et al., 1996). Corn steep liquor is very high in phosphorus, potassium, and sulfur (Kalscheur, et al., 2008).

Therefore, the chemical composition of corn steep liquor will probably vary and is reflective of the processing strategy used by a particular manufacturer, depending on which corn component they are interested in isolating. Factors affecting the composition of CSL are corn hybrid, steeping time, temperature, and the presence of micro-organisms.

Evaluation Question #2: Is the petitioned substance formulated or manufactured by a process that chemically changes the substance extracted from naturally occurring plant, animal, or mineral sources? (From 7 U.S.C. § 6502 (21).)

Corn steep liquor is derived from corn which is a naturally occurring plant. Clean corn is steeped in warm water containing small amounts of sulfur dioxide. Soaking softens the kernels and the dilute sulfurous acid formed when the sulfur dioxide reacts with water prevents excessive bacterial growth and loosens the gluten bonds within the corn and releases the starch. The steep water absorbs the soluble components and is later evaporated and concentrated to a solid content of about 50%. As mentioned in the response to Question 1, the chemical composition of corn steep liquor will probably vary and is reflective of the processing strategy used by a particular manufacturer, depending on which corn component they are interested in isolating. This is affected by steeping time, temperature reached during the lactic acid fermentation, and the microbial environment of the fermentation (Hull et al., 1996). These factors will also likely affect the quality of the fermentation end-products.

Evaluation Question #3: Is the petitioned substance created by naturally occurring biological processes? (From 7 U.S.C. § 6502 (21).)

Corn steep liquor is not created by a naturally occurring biological process. It is created as a result of a process designed to separate corn into its four basic components, starch, germ, fiber, and protein in an aqueous medium. It is a complicated process of chemical and biochemical reactions that, despite the long history of the wet-milling industry, are still not fully understood. A summary of the process is provided in evaluation question #1.

Evaluation Question #4: Is there environmental contamination during the petitioned substance's manufacture, use, misuse, or disposal? (From 7 U.S.C. § 6518 (m) (3).)

Manufacture

Corn steep liquor, itself, should not cause any environmental contamination, because the material is approximately 50% water and the soluble proteins, amino acids, carbohydrates, organic acids (e.g., lactic acid), vitamins, and minerals would be readily metabolized and utilized by micro-organisms. The sulfur dioxide added to the fermented material to cleave the disulfide linkages may need to be vented to the atmosphere. However, the wet corn milling process that generates corn steep liquor may have some issues

of concern related to environmental contamination. The wet milling process is designed to separate the corn into its components, starch, germ, protein (gluten) and fiber and convert them into higher value products such as starch, high fructose corn syrup, corn oil, ethanol, bran, gluten feed, and meal. It is the making of the high value products that result in the generation of millions of pounds of waste at wet corn milling plants annually. If the waste is not managed properly it will stress the environment. The USEPA has funded a pilot project to assist small and medium-size manufacturers who want to minimize their generation of waste but who lack the expertise to do so. For more information see: http://www.p2pays.org/ref/02/01481.pdf.

Corn dust produced during the handling and cleaning processes could be a safety hazard, due to the fact that the corn dust is explosive. The organic materials used to extract the corn oil from the germ may be a concern, due to accidental spills and the release of volatile organic compounds. There are no reported incidences on environmental contamination due to the production of corn steep liquor.

Evaluation Question #5: Is the petitioned substance harmful to the environment? (From 7 U.S.C. § 6517 (c) (1) (A) (i) and 7 U.S.C. § 6517 (c) (2) (A) (i).)

Corn steep liquor, itself, should not cause any environmental contamination, because the material is approximately 50% water and the soluble proteins, amino acids, carbohydrates, organic acids (e.g., lactic acid), vitamins, and minerals would be readily metabolized and utilized by micro-organisms. Corn steep liquor could be used in crop production to add organic matter and other nutrients to the soil, however, there are probably other materials (animal manures) that are more cost effective. Corn steep liquor is used in the diets of ruminants (Kalscheur et al., 2008).

Evaluation Question #6: Is there potential for the petitioned substance to cause chemical interaction with other substances used in organic crop or livestock production? (From 7 U.S.C. § 6518 (m) (1).)

The water, soluble proteins, amino acids, carbohydrates, organic acids (e.g., lactic acid), vitamins, and minerals in corn steep liquor would be readily metabolized and utilized by microorganisms. Corn steep liquor should not interact chemically with other substances used in organic crop or livestock production.

Evaluation Question #7: Are there adverse biological or chemical interactions in the agro-ecosystem by using the petitioned substance? (From 7 U.S.C. § 6518 (m) (5).)

Corn steep liquor should not cause any adverse biological or chemical interactions in the agro-ecosystem. The release of lactic acid, which comprises 10 to 25% of corn steep liquor, to the environment, may be an issue, if large quantities were released to the environment. However, this would not be expected since the production of corn steep liquor is performed by a controlled process. Any lactic acid released to the environment would be readily metabolized and utilized as an energy source by micro-organisms, therefore, it should have little to no long-term impact on the agro-ecosystem.

Evaluation Question #8: Are there detrimental physiological effects on soil, organisms, crops, or livestock by using the petitioned substance? (From 7 U.S.C. § 6518 (m) (5).)

There is no information available to indicate that using corn steep liquor has detrimental physiological effects on soil, organisms, crops, or livestock. Because it is rich in nutrients, it can be applied to soils as a fertilizer or soil conditioner and it has been successfully fed to livestock for many years (Kalscheur et al., 2008).

Evaluation Question #9: Is there a toxic or other adverse action of the petitioned substance or its breakdown products? (From 7 U.S.C. § 6518 (m) (2).)

Corn steep liquor should not have any toxic or other adverse actions. The components of corn steep liquor are readily metabolized and utilized by micro-organisms as an energy source. Because corn steep liquor is a nutrient source, algal growth is possible, if corn steep liquor reaches bodies of water in concentrated

form. However, the manufacturing of corn steep liquor is a controlled process and given the current uses of corn steep liquor, one would not expect large quantities of corn steep liquor being released to bodies of water.

Hull et al., (1996) analyzed four different corn steep waters for chemical composition. When analyzed for heavy metals, iron was the most prevalent heavy metal present in corn steep water. Chromium and cadmium were not detected in the four samples. Copper and nickel were detected at levels approximately 5 to 10% of that of iron (1.6 mg/L or less). Lead was detected in one sample (36 ug/L).

Evaluation Question #10: Is there undesirable persistence or concentration of the petitioned substance or its breakdown products in the environment? (From 7 U.S.C. § 6518 (m) (2).)

The components of corn steep liquor are readily metabolized and utilized by micro-organisms as energy sources, therefore, corn steep liquor would not persist and concentrate in the natural environment.

Evaluation Question #11: Is there any harmful effect on human health by using the petitioned substance? (From 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).)

Corn steep liquor has no harmful effects on human health. The components of corn steep liquor are used as ingredients in foods for human consumption (proteins, amino acids, carbohydrates, vitamins, and minerals). Corn steep liquor has been successfully fed to livestock for many years (Kalscheur et al., 2008) without any adverse effects on human health.

Individuals who handle corn steep liquor should wear gloves, protective clothing, and protective eyeware.

Evaluation Question #12: Is there a wholly natural product that could be substituted for the petitioned substance? (From 7 U.S.C. § 6517 (c) (1) (A) (ii).)

In the case of adding organic matter to soils for crop production, composted and raw manures could be used depending on the crop being grown, time of harvest, and whether the crop will be used for human consumption (Organic Materials Review Institute, 2007). For adding inorganic nutrients to soils, unprocessed mined materials could be used (Organic Materials Review Institute, 2007).

In the case of supplementing livestock feeds with vitamins and minerals, natural vitamin supplements and non-synthetic minerals, respectively, can be used (Organic Materials Review Institute, 2007).

Wet corn milling is defined as corn steeped in water with or without sulfur dioxide to soften the kernel in order to facilitate the separation of the various component parts (Association of American Feed Control Officials, 2005). Therefore, the wet corn milling could be conducted without sulfur dioxide, the lactic acid fermentation and the subsequent separation of the corn components (including natural drying to concentrate the soluble materials in the liquid portion) may be another method of processing the corn. This may be an alternative to adding sulfur dioxide after the lactic acid fermentation and the concentrating of the corn steep liquor with evaporators. However, the quantities and quality of the end-products may be different.

In the case of organic crop production, corn steep liquor would be used in very few, if any, products on the National List of Allowed and Prohibited Substances. As in (7 CFR 206.601), herbicides (soap-based) for use in farm stead maintenance and ornamental crops would be a mixture of either calcium or sodium fatty acids and corn steep liquor should not be used in their manufacture. However, in the case of organic livestock production, trace mineral and vitamin supplements are allowed for enrichment or fortification when FDA approved. If feed ingredient manufacturers use corn steep liquor to produce trace mineral and vitamin supplements, this would be a significant use of corn steep liquor in organic livestock production.

Evaluation Question #13: Are there other already allowed substances that could be substituted for the petitioned substance? (From 7 U.S.C. § 6517 (m) (6).)

As alternatives, organic crop producers could use synthetic substances that are already allowed in organic crop production to amend soils listed in 7 CFR 205.601. They include: 1) elemental sulfur; 2) magnesium sulfate; 3) soluble boron products; 4) sulfates, carbonates, oxides, or silicates of zinc, copper, iron, manganese, molybdenum, selenium, and cobalt; and 5) vitamins B_1, C, and E. Depending on the crop of interest and the micro-nutrient that is in deficiency, some decision would have to be made about which one would be the most appropriate to use.

As alternatives, organic livestock producers could use synthetic substances that are already allowed in organic livestock production to maintain productive and healthy animals listed in 7 CFR 205.603. They include the following feed additives: 1) magnesium sulfate; 2) trace minerals (used for enrichment or fortification when approved by the FDA); and 3) vitamins (used for enrichment or fortification when approved by the FDA). Depending on the livestock species and the micro-nutrient or vitamin that is in deficiency, some decision would have to be made about which one would be the most appropriate to use. In both cases (crop production and livestock production), the conditions for using materials on the National List of Synthetic Substances must be documented in the organic farming system plan.

Evaluation Question #14: Are there alternative practices that would make the use of the petitioned substance unnecessary? (From 7 U.S.C. § 6517 (m) (6).)

As found in 7 CFR 205.205, organic crop producers must implement a crop rotation including but not limited to sod, cover crops, green manure crops, and catch crops that provides for maintaining and improving soil organic matter content and managing deficient or excess plant nutrients. More specifically 7 CFR 205.203 states that organic crop producers: 1) must select and implement tillage and cultivation practices that maintain or improve the physical, chemical, and biological condition of soil and minimize erosion; 2) must manage crop nutrients and soil fertility through rotations, cover crops, and the application of plant and animal materials; and 3) must manage plant and animal materials to maintain or improve soil organic matter content in a manner that does not contribute to contamination of crops, soil, or water by plant nutrients, pathogenic organisms, heavy metals, or residues of prohibited substances. When these practices prove insufficient to prevent deficient or excess nutrients in soils or plants, a substance on the National List of Synthetic Substances allowed for use in organic crop production (7 CFR 205.601) may be applied to maintain adequate nutrients for plant productivity and health (see the information in response to Question13). .

As found in 7 CFR 205.237, organic livestock producers must provide livestock with a total feed ration composed of agricultural products, including pasture and forage, that are organically produced and if applicable, organically handled. Non-synthetic substances and synthetic substances allowed in 7 CFR 205.603 may be used as feed additives and supplements (see the information in response to Question 13).

References

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