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National Organic Standards Board
USDA-AMS-NOP
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Docket ID # AMS-NOP-21-0038

Re. CS: Chitosan petition

These comments to the National Organic Standards Board (NOSB) on its Fall 2021 agenda are submitted on behalf of Beyond Pesticides. Founded in 1981 as a national, grassroots, membership organization that represents community-based organizations and a range of people seeking to bridge the interests of consumers, farmers and farmworkers, Beyond Pesticides advances improved protections from pesticides and alternative pest management strategies that reduce or eliminate a reliance on pesticides. Our membership and network span the 50 states and the world.

This petition is for plant disease control. Chitosan is also used as an "inert"—a "sticker" for pesticides.

Chitosan as an "inert" is not approved for food use.

Although not directly relevant to this petition, it is worthwhile mentioning that chitosan is not approved as an "inert" for use in food-use pesticides. In 2004, the NOSB received a petition to allow chitosan as an adhesive ("sticker") in fungicides used in organic production. The NOSB approved the petition, but NOP did not add it separately to the National List because the use was considered an "inert," and chitosan was listed on EPA's List 4B. EPA no longer maintains its "inerts" lists, however, and has reassessed "inerts." The purposes for which they are allowed, as well as references to tolerances or exemptions from tolerance (if any), can be found in EPA's InertFinder database. Chitosan is listed in the database as allowed for non-food use only.[1,2] In view of this fact, we are concerned about the TR's statement, "At this time, it is

[1] https://iaspub.epa.gov/apex/pesticides/f?p=INERTFINDER:2::::::
[2] See also TR, lines 307-310.

used as an inert ingredient within at least 13 OMRI-Listed crop products and one livestock product."[3] In other words, EPA has listed chitosan with a restriction (annotation) that must carry-over to its use in organic production and processing. Outside of this restriction, any food use would be in violation of existing allowances.

Chitosan does not meet OFPA criteria for the National List.

Chitosan is not in any of the categories of OFPA §6517(c)(1)(B)(i).

The 2020 petition and the Technical Review (TR)[4] state that chitosan is petitioned as a production aid. OFPA §6517(c)(1)(B)(i) allows a substance to be added to the National List if it "is used in production and contains an active synthetic ingredient in the following categories: copper and sulfur compounds; toxins derived from bacteria; pheromones, soaps, horticultural oils, fish emulsions, treated seed, vitamins and minerals; livestock parasiticides and medicines and production aids including netting, tree wraps and seals, insect traps, sticky barriers, row covers, and equipment cleansers." The term "production aids" is not defined, but is explained by example. A fungicide/nematicide is not a production aid. It is a pesticide. If all pesticides were to be allowed, then this subsection of OFPA would be unnecessary. The term "production aids" should **not** be used to allow any substance that does not fit into other categories. Therefore, chitosan is not eligible for inclusion on the National List for the petitioned uses.

The CS review responds to this question with, "The petitioner is requesting that chitosan be added to 7 CFR 205.601(j)(4) as a synthetic substance allowed for use in organic crop production as a plant disease control." Please note that "plant disease control" is not a category under OFPA §6517(c)(1)(B)(i), and only plant disease controls that are in one of the OFPA §6517(c)(1)(B)(i) categories are eligible to be on the National List.

Chitosan and its environmental effects are not well characterized.

The TR repeatedly makes the point that because "chitosan" is a polymer of undefined size, it may have different and opposite effects depending on polymer size, crop, and pest (internal citations removed):

- "Chitosan is a polymer, which means that it can exist in a range of molecular sizes (usually measured by weight). The molecular weight of a chitosan sample can affect its properties. For example, low-molecular-weight chitosan is more effective as a plant growth stimulator than high-molecular-weight chitosan polymers. Not only does the molecular weight of chitosan affect its properties, but so too does the degree (and distribution) of deacetylation. For example, as the degree of acetylation increases, chitosan becomes more amorphous (less crystalline) and better able to chelate metal ions."[5]
- "There is no degree of deacetylation that officially defines when chitin becomes chitosan, but the lower limit described in literature is 40–60 percent."[6]

[3] TR, lines 454-455.
[4] Nexight Group, 2020. Technical Evaluation Report for Chitosan. Line 571.
[5] TR, lines 93-99.
[6] TR, lines 75-76.

- "Commercial chitosan usually contains at least 65 percent glucosamine and less than 35 percent N-acetylglucosamine. The degree of deacetylation can vary, and so any given quantity of chitin or chitosan will typically contain both types of monomers."[7]
- "Chitosan has multiple modes of action. When used as a pesticide, it acts directly on target pathogens with toxic as well as growth inhibitory effects. It also has effects on plants themselves, stimulating plant immunity. Chitosan's effect on both plants and pathogens is not universal."[8]
- "Low-molecular-weight chitosan can permeate cell membranes while high-molecular-weight chitosan cannot. It appears that molecular weight plays a role in chitosan's different modes of actions – in some cases acting as a growth inhibitor for bacteria, while in other cases having the opposite effect and acting as a bacterial growth promoter."[9]
- "Chitosan is known to act as a plant growth promoter."[10] "Chitosan's effects as a plant growth promoter are variable, however, and depend on chitosan's chemical characteristics and the plant species involved. Khan, Prithiviraj, and Smith found small chitosan oligomers caused an 8–10 percent increase in maize photosynthesis but had little to no effect on soybean. On the other hand, larger chitosan molecules caused a decrease in photosynthesis for both maize and soybean. Despite these changes in photosynthesis, no differences in plant growth or development were observed after 10 days in comparison with control plants."[11]
- "Researchers do not fully understand how chitosan inhibits bacterial growth, and Gram-negative and Gram-positive bacteria do not appear to respond the same way. Additionally confounding matters, chitosan can also have the opposite effect—it can cause accelerated growth in the same bacteria, depending on the molecular weight, and possibly the dosage, of the chitosan used. Generally, chitosan's antibacterial effects are weaker than its antifungal effects."[12]
- "Due to the variety of results found from different studies, it is likely that chitosan has multiple antibacterial modes of action. The most relevant mode of action depends on factors such as the type of bacteria involved and the properties of the chitosan used."[13]
- "As with its antimicrobial effect, the mode of action of chitosan on fungi and oomycetes is not fully understood. Researchers hypothesize that chitosan functions in two ways; chitosan can initiate systemic resistance in plants and may act directly between host and pathogen to block the growth of the pathogen itself."[14]

[7] TR, lines 78-82.
[8] TR, lines 334-336.
[9] TR, lines 177-180.
[10] TR, line 241.
[11] TR, lines 247-252.
[12] TR, lines 340-343.
[13] TR, lines 346-348.
[14] TR, lines 365-368.

- "It is worth noting that despite chitosan's classification as such a material [biochemical pesticide with non-toxic mode of action], it also has toxic modes of action to the target pest as described above."[15]
- "Under laboratory conditions, chitosan increases sporulation and the mycelial growth of beneficial *P. chlamydosporia* and causes an increase in the production of a protease used by the fungus to parasitize plant-damaging root-knot nematodes. However, these effects are not observed in agricultural soils. Instead, chitosan appears to promote the colonization of *P. chlamydosporia* in plant roots, which in turn makes the fungus a more effective biocontrol."[16]

Chitosan use in agriculture may contribute to antimicrobial resistance.

Although EPA believes evidence points to low direct toxicity,[17] it has not received GRAS status from FDA.[18] And, while we do not believe that a GRAS ranking substitutes for NOSB review for listing or allowance, it is an indicator here of a potential hazard concern.

More importantly, chitosan is antimicrobial.[19] According to the TR, "The petitioner bases the request on chitosan's antimicrobial properties as well as its role in plant defense signaling pathways."[20] Various antimicrobial uses of chitosan in human medicine have been explored.[21] Since any use of an antimicrobial substance contributes to the development of resistance to all microbial diseases,[22] the use such an antimicrobial substance in organic production is hazardous to humans.

The need for chitosan has not been established.

The TR states, "The petition did not clearly indicate a specific use for which chitosan is essential for organic production. Instead, it suggested that chitosan is an alternative to currently available materials and organic management practices, offering benefits related to toxicity and environmental safety."[23] As indicated by the CS, there are over 200 nonsynthetic materials listed by OMRI for the same use.[24]

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[15] TR, lines 376-377.
[16] TR, lines 419-423.
[17] TR, lines 299, 303-305.
[18] TR, lines 319-323.
[19] TR, lines 261-262.
[20] TR, lines 207-208.
[21] Bellich, B., D'Agostino, I., Semeraro, S., Gamini, A. and Cesàro, A., 2016. "The good, the bad and the ugly" of chitosans. *Marine drugs*, *14*(5), p.99.
[22] Thomas F. O'Brien, 2002. Emergence, Spread, and Environmental Effect of Antimicrobial Resistance: How Use of an Antimicrobial Anywhere Can Increase Resistance to Any Antimicrobial Anywhere Else, Clinical Infectious Diseases 34(Suppl 3):S78–84.
[23] TR, lines 49-52.
[24] CS notes, 6/1/2021.

Conclusion

In conclusion, chitosan should not be added to the National List because it is not necessary, is not consistent with organic practices, can contribute to microbial resistance in human pathogens, and its environmental impacts are not well characterized.

Thank you for your consideration of these comments.

Sincerely,

Terry Shistar, Ph.D.
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