Final Summary Report

External Peer Review of FDA's

Draft Qualitative Assessment of Risk to Public Health from On-Farm Contamination of Produce

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I. INTRODUCTION

The FDA Center for Food Safety and Applied Nutrition (CFSAN) conducted a qualitative assessment of risk (QAR) to public health related to the growing, harvesting, and postharvest activities performed during the production of fresh produce commodities. The purpose of the assessment is to provide support for risk management decisions that are responsive to Section 419 of the FD&C Act, which directs FDA to establish science-based minimum standards for the safe production and harvesting of those types of fruit and vegetable raw agricultural commodities for which FDA has determined that such standards minimize the risk of serious adverse health consequences or death. These standards are to include procedures, processes, and practices that FDA determines to be reasonably necessary to prevent the introduction of known or reasonably foreseeable biological, chemical, and physical hazards into fruit and vegetable raw agricultural commodities and to provide reasonable assurances that produce will not be adulterated.

This QAR is limited in scope to biological hazards and focuses on (but is not limited to) those biological hazards that present a risk of serious adverse health consequences or death to the consumer. For this peer review, five experts were selected to evaluate and provide written comments on CFSAN's report entitled "Draft Qualitative Assessment of Risk to Public Health from On-Farm Contamination of Produce."

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II. CHARGE TO REVIEWERS

This document is a draft qualitative assessment of risk (QAR) conducted by FDA to provide support for risk management decisions that are responsive to Section 419 of the FD&C Act, which directs FDA to establish science-based minimum standards for the safe production and harvesting of those types of fruit and vegetable raw agricultural commodities (RACs) for which we determine that such standards minimize the risk of serious adverse health consequences or death (section 419(a)(1)(A) of the FD&C Act). The QAR follows a structured approach, based on a risk assessment, including sections on Hazard Identification, Hazard Characterization; Exposure Assessment; and Risk Characterization.

Charge Questions:

1. Are the risk analysis framework and the risk management approach appropriate for the intended purpose of the QAR?

2. Are the scope and purpose of the QAR clearly identified? If not, what additional information should be provided?

3. Are the questions to be addressed in the QAR appropriate, given the scope and purpose of the QAR? If not, what changes would you suggest?

4. Does the QAR adequately cover the routes of contamination found on farms during the growing, harvesting, handling, packing and storing of produce? If not, what other routes or considerations should be addressed?

5. Does the selection of commodities in the QAR appear to adequately represent those commodities expected to fall within the scope of this document?

6. Considering the scope and purpose of the QAR, are the approaches to hazard identification, characterization, exposure assessment, and risk characterization appropriate?

7. Is the approach for determining the qualitative risk of each route/produce item combination in the draft QAR reasonable, given the purpose of the QAR? If not, how might this be revised?

8. Do the conclusions drawn seem appropriate given the information presented during the identification, characterizations, and assessments within this document?

9. Is the report written in a transparent and clear manner? If not, how might the report be revised?

10. Does the report adequately address the questions and stated objectives?

11. Are there further data gaps or research needs that are necessary to address in order to further refine this assessment?

12. Do you have any additional comments that might improve the document?

III. SUMMARY OF PEER REVIEW COMMENTS

GENERAL IMPRESSIONS

As a general response to the QAR, the reviewers were positive in their overall impressions. Several of the reviewers commended FDA/CFSAN on providing a risk analysis foundation and the first steps for understanding the biological hazards, likely routes of contamination, and the health risks to the public from consuming contaminated produce. Utilizing a risk analysis framework and risk management approach presents a linear and logical presentation of the scientific data on biological hazards. Reviewers also noted that the document was well written, reasonable, transparent, clear, and presented in a way that makes it accessible to a wide audience (technical and nontechnical). With minor revisions, the document will meet its stated goal and will be useful in guiding the development of risk mitigation and management strategies. However, shortcomings of the QAR were noted by all of the reviewers, as well as suggestions for improvement.

Several reviewers commented on the routes of contamination presented in the QAR. While one reviewer noted that the strength of the assessment is in its identification of the on-farm routes of contamination from the literature and reports from produce-associated outbreaks, several reviewers identified areas for improvement. One reviewer commented that while seed contamination is mentioned in the QAR as a verified route of contamination, it should be elevated to a route of contamination equivalent to water, soil amendments, animals, etc. Another reviewer suggested adding a discussion on the potential for bioaerosols to be a route of contamination.

Reviewers noted some limitations of the exposure assessment. A reviewer found it misleading to use produce consumption rates in calculating the likelihood of exposure. The calculation as presented may reflect the risk to the general consumer, but may actually underestimate the risk to a consumer from a specific commodity such as sprouts. Another reviewer expressed concerns that increasing the score of suspected sources that were found in epidemiological investigations is inherently biased. This bias could affect the relative risk of commodities that are in between a very high risk and a very low risk.

Regarding data gaps and research needs, a number of comments and suggestions were made. One reviewer pointed out that the data gaps affect our understanding of the process of microbial contamination of produce and therefore requires some degree of scientific inference in conducting qualitative risk rankings. Another reviewer highlighted the need for information on how plant diseases contribute to contamination of produce with human pathogens. This same reviewer also expressed a need to include the expansion of MDP, which currently includes a limited number of commodities. Another reviewer felt it was important to point out the limitations of the scoring system currently used in the QAR and to note that future scoring iterations may involve a different scale that is reflective of new information collected to fill data gaps.

Reviewers also commented on the conclusions presented in the QAR. One reviewer took issue with the conclusion that the likelihood of contamination is due in a larger part to agricultural practices than to characteristics of the commodity. While stating that the overall conclusions are generally appropriate, one reviewer noted that the current assessment does not adequately address the changes in pathogen levels that may occur during subsequent processing, shipping, and storage.

Several of the reviewers recommended changes in the presentation of data in the report. One reviewer commented that the tables and bulleted lists are generally effective in illustrating the approach and documenting evidence and decisions. However, this reviewer would have preferred that the tables with supporting information be placed before the summary tables to help in understanding the process. The same reviewer also noted errors in the references that need to be addressed (e.g., incorrect numbering, insufficient information, incorrect references).

RESPONSE TO CHARGE QUESTIONS

1. Are the risk analysis framework and the risk management approach appropriate for the intended purpose of the QAR?

Overall, the reviewers were in agreement that the risk analysis framework and the risk management approach were appropriate for the QAR. One reviewer stated that the framework and approach was the "most logical avenue for utilizing scientific and epidemiological data to identify the risks where contamination of produce on the farm occurs and which risks could be minimized through the application of regulatory standards." Another reviewer found the risk analysis approach to be "ideal for evaluating the risk of developing infectious disease associated with the consumption of contaminated produce." In terms of the risk management approach, a reviewer commented that is was reasonable to base the risk management on a qualitative assessment because the lack of data and extensive uncertainty and variability prohibited a quantitative risk assessment. This reviewer also noted that little actual risk management was documented in the report. However, the reviewer found that the separation of risk management from risk assessment did not detract from the merits of the report.

2. Are the scope and purpose of the QAR clearly identified? If not, what additional information should be provided?

When asked if the scope and purpose of the QAR are clearly identified, the majority of the reviewers found this to be the case. One reviewer commented that the QAR is a risk assessment and not a complete risk analysis since it does not address risk management or risk communication. This reviewer also noted that including the word "potential" in the framework makes it too broad and less appropriate and what the document actually presents is a risk assessment of the likelihood of becoming ill after consuming produce. In addition, the reviewer found that the document does not sufficiently emphasize the uncertainty and variability due to the lack of data.

3. ***Are the questions to be addressed in the QAR appropriate, given the scope and purpose of the QAR? If not, what changes would you suggest?***

While the majority of reviewers agreed that the questions to be addressed in the QAR were appropriate, three of the reviewers had comments and suggestions on the answers to these questions. Referring to Q1, one reviewer suggested including additional databases, both within and outside the U.S., to identify hazards of concern. The data limitations should also be expanded to include the implications of relying only on outbreak data and the fact that many foodborne disease outbreaks do not have a known pathogen etiology. This same reviewer recommended that the QAR indicate that the routes of contamination referred to in Q2 may not be exhaustive and other routes of contamination may be identified. Furthermore, the reviewer commented that it is not possible to answer Q3 in regards to variability of contamination among produce types with the information provided. In reference to the four questions, the reviewer noted that it is important that the QAR prioritize where interventions could be focused to reduce the greatest number of illnesses. It was also not clear to the reviewer how the proposed model was superior to other models and methods.

Another reviewer, while agreeing that the questions are appropriate, noted that the answer to Q1 (identification of hazards of concern) is not sufficiently justified within the context of the assessment. The justification of the selected reference pathogens is inadequate and more thorough discussion on their selection is needed in the report because the technical merit of the report depends on the selection of these reference pathogens. A third reviewer also found the questions appropriate given the focus of the risk assessment. However, this reviewer felt that, in the broader sense, risk to consumers cannot be fully addressed without also considering the impact of post-harvest off-farm processing on contamination levels and the time/temperature histories that products encounter during transport and storage.

4. Does the QAR adequately cover the routes of contamination found on farms during the growing, harvesting, handling, packing and storing of produce? If not, what other routes or considerations should be addressed?

Most of the reviewers generally found that the routes of contamination on farms were adequately covered in the QAR. Additional routes of contamination were suggested by the reviewers including: (1) seeds (importance of this confirmed route of contamination is diminished in the QAR); (2) bioaerosols (produce fields down-wind from cattle or manure composting operations); (3) leakage from septic tanks; (4) insect infestations; (5) tote and conveyor belting materials; and (6) biofilms on equipment because of improper cleaning and maintenance. One reviewer emphasized that the report should include a sufficient description of the data limitation and uncertainty, as well as a statement that for most outbreaks and contaminated products, the source of the contamination is never identified.

5. Does the selection of commodities in the QAR appear to adequately represent those commodities expected to fall within the scope of this document?

In response to this charge question, all of the reviewers agreed that the commodities selected for consideration in the QAR represent the majority of commodities that are consumed and produced in the U.S., and fall within the scope of the document.

6. Considering the scope and purpose of the QAR, are the approaches to hazard identification, characterization, exposure assessment, and risk characterization appropriate?

Overall, the reviewers found that the approaches used for hazard identification, characterization, exposure assessment, and risk characterization were appropriate. However, all of the reviewers took issue with various aspects of the approaches, particularly with regard to the exposure assessment. One reviewer commented on the rate of consumption that is included in the exposure assessment. Consequently, a crop less likely to be eaten has a lower likelihood of exposure. However, the likelihood of exposure to a consumer is for every crop consumed, not just those commonly consumed by the public. Another reviewer took issue with the QAR assigning a level of contamination based on outbreak frequency and using those data to predict risk of illness (outbreak frequency). This reviewer noted that the predicted level of contamination does not always coincide with available data from the MDP database. The methodology used in the exposure assessment and the implications on the overall findings, in regards to the sensitivity on the assumptions employed, was questioned by one reviewer. Additional comments were received on the risk characterization approach. For example, a reviewer noted that the risk model is seriously limited by the lack of dose

response and the assumption that the likelihood of disease is directly proportional to the exposure assessment. Another reviewer suggested removing Table 13 (Assessment of Risk of Illness) from the document. The reviewer felt that the table was not needed as no change in the relative rankings of the commodities occurred and in every case the likelihood of exposure equaled the risk of illness. Table 13 could also lead some readers to question why a high severity of hazard and a medium likelihood of exposure would lead to only a medium risk of illness. The reviewer further recommended revising Table 11 (Assessment of Likelihood of Exposure) to include a column labeled "Likelihood of Exposure or Risk of Illness."

7. Is the approach for determining the qualitative risk of each route/produce item combination in the draft QAR reasonable, given the purpose of the QAR? If not, how might this be revised?

Nearly all of the reviewers suggested revisions to the approach for determining the qualitative risk of each route/produce item combination. One reviewer found the supporting information provided in Table 10 for commodity/practice ranking pair decisions practical but in need of a slight addition to the Soil Amendments and Tree Crops categories. The reviewer suggested adding the acknowledgement that indirect contamination to tree fruit by climbing animals and birds would increase if the contaminated soil amendment were placed on top of the soil beneath the trees. This same reviewer also noted several limitations in the scoring system. For example, applying a higher score for all routes identified as deficient during an outbreak investigation may result in a higher total score for that commodity than for a commodity identified with fewer potential routes. Another limitation of the scoring system is only considering epidemiological investigations associated with outbreaks in the U.S. Because of the disparity in epidemiological investigations and the associated bias they introduce into the scoring system, the reviewer suggested that the scoring system for higher risk commodities be based on the total number of outbreaks associated with that product. Another reviewer noted that grouping all pathogens together for each commodity may introduce some biases and suggested accounting for the virulence differences among pathogens by placing more weight on the pathogen likely to cause a disease. As previously noted, a reviewer questioned how sensitive the overall results are to the assumptions used in the assessment. A discussion on this point or a sensitivity analysis was recommended.

8. Do the conclusions drawn seem appropriate given the information presented during the identification, characterizations, and assessments within this document?

When asked to comment on the appropriateness of the conclusions, nearly all of the reviewers found the conclusions to be appropriate and supported by the analysis of the data presented in the QAR. However, one reviewer took issue with the final key conclusion regarding postharvest practices (page 64) that states, "Postharvest practices such as cooking (and, possibly certain peeling practices) before consumption may have an impact on the likelihood of contamination of the edible portion and the likelihood of illness." While the conclusion is true, the reviewer noted that washing will also decrease the likelihood of foodborne illness and should be considered. Otherwise, the common consumer practice of washing could potentially decrease for certain types of produce.

9. Is the report written in a transparent and clear manner? If not, how might the report be revised?

In response to the question regarding whether the report had been written in a clear and transparent manner, all of the reviewers found the report to be clearly written and transparent (noted by one reviewer as one of its strengths), with one exception. One reviewer expressed concern with the reference section of the report. Specifically noted were missing article titles (e.g., references 31, 38 and 184) and cited references that did not match the subject matter being discussed (e.g., an article on thermal resistance of *E. coli* in apple juice was referenced for domestic and wild animals as being carriers of human pathogens). As a result, this reviewer could not verify that the proper references were being provided.

10. Does the report adequately address the questions and stated objectives?

Overall, the reviewers found that the report generally addressed the questions and stated objectives of the QAR except as previously noted (see response summaries above and specific reviewer comments).

11. Are there further data gaps or research needs that are necessary to address in order to further refine this assessment?

All but one of the reviewers provided suggestions for refinements to identified data gaps or pointed out additional data gaps that should be addressed in the assessment. Data gaps/refinements include: (1) the role of plant disease as a multiplier of human pathogens; (2) more specificity and prioritization of the presented data gaps to ensure scarce resources will be applied to areas with the greatest impact on reducing foodborne illness associated with produce; (3) the attributable fraction of contamination that occurs and persists from pre-harvest stages of production; (4) the origin, incidence and levels of pathogens in field-grown produce; (5) the distance between produce fields and livestock operations needed to minimize contamination; (6) on-farm routes for pathogen transfer (e.g., from soil to tractors / harvesters to produce to conveyors to bins); (7) post-processing routes for transfer (conveying, flume washing, shredding, slicing, dicing, drying); (8) sanitizer use and efficacy during flume washing; (9) extent to which contaminated products mix with uncontaminated products during commercial processing; (10) pathogen growth in/on produce during transport and retail storage/display; (11) consumer storage practices for fresh produce; and (12) consumer preparation practices (e.g., washing practices, slicing, dicing, cutting board).

12. Do you have any additional comments that might improve the document?

All of the reviewers provided specific comments (some extensive) on report language, terminology, and presentation in the Specific Observations Sections and Attachment A of this report.

IV. INDIVIDUAL REVIEWER COMMENTS

REVIEWER #1

Peer Review Comments on FDA's Draft Qualitative Assessment of Risk (QAR)

Reviewer #1

I. GENERAL IMPRESSIONS

The QAR provides a foundation for understanding the potential hazards and likely routes of contamination for produce that may be eaten raw and an assessment the risk of illness from consuming a specific commodity. The QAR concludes that the likelihood of a commodities contamination is due to agricultural practices more than characteristics of the commodity. Sprouts may be an exception to this as the commodity may not be separated from the agricultural practice due to the possibility of seed contamination and their production. Seeds as a verified route of contamination are noted in the QAR, but they should be elevated to a route of contamination equivalent to water, soil, etc. The QAR calculates the likelihood of exposure using produce consumption rates which might be misleading. The QAR calculation as calculated may reflect the risk of the general consumer, but may under estimate the risk of the consumer of a specific commodity. For example, Table 11 has a medium rate of consumption for sprouts, but its likelihood of contamination is higher. Thus, the calculated likelihood of exposure is medium, when in truth for a consumer of sprouts, their exposure is higher. It is noteworthy that results from the MDP were critical to determine the likelihood of exposure and the subsequent assessment of the risk of illness. Since the MDP includes a limited number of commodities, a continuation of the MDP or expansion should be included in the data gaps. Finally, the QAR lists survival and growth of pathogens on produce under data gaps and research needs, but makes no mention of plant pathogens, recognized biological multipliers of human pathogens on plants. How plant disease contributes to contamination of produce with human pathogens is unknown, yet important due to their role in pathogen growth and survival.

II. RESPONSE TO CHARGE QUESTIONS

1. ***1. Are the risk analysis framework and the risk management approach appropriate for the intended purpose of the QAR?***

   Yes.

2. ***Are the scope and purpose of the QAR clearly identified? If not, what additional information should be provided?***

   Yes.

3. ***Are the questions to be addressed in the QAR appropriate, given the scope and purpose of the QAR? If not, what changes would you suggest?***

   Yes.

4. ***Does the QAR adequately cover the routes of contamination found on farms during the growing, harvesting, handling, packing and storing of produce? If not, what other routes or considerations should be addressed?***

By not including seeds in Section IV. Exposure Assessment, B. Routes of Contamination, the importance of this confirmed route of contamination is diminished. The page 41 discussion of seeds states "…has not been demonstrated to be relevant..." Perhaps the question should be: Have seeds been considered a route of contamination for crops other than sprouts?

5. Does the selection of commodities in the QAR appear to adequately represent those commodities expected to fall within the scope of this document?

Yes.

6. Considering the scope and purpose of the QAR, are the approaches to hazard identification, characterization, exposure assessment, and risk characterization appropriate?

The exposure assessment includes rate of consumption. Thus, if a crop is less likely to be eaten, then the likelihood of exposure was calculated as lower. However, the likelihood of exposure to a consumer is for every crop consumed, not just those commonly eaten by the entire populace.

7. Is the approach for determining the qualitative risk of each route/produce item combination in the draft QAR reasonable, given the purpose of the QAR? If not, how might this be revised?

Yes.

8. Do the conclusions drawn seem appropriate given the information presented during the identification, characterizations, and assessments within this document?

Yes.

9. Is the report written in a transparent and clear manner? If not, how might the report be revised?

Yes.

10. Does the report adequately address the questions and stated objectives?

Yes.

11. Are there further data gaps or research needs that are necessary to address in order to further refine this assessment?

The document does not take into account the role of plant disease as a multiplier of human pathogens. Whereas human pathogens grow poorly in the phyllosphere, since they cannot penetrate healthy plant tissue, plant pathogens can liberate nutrients from plants, thus, providing a nutrient source for human pathogens that can lead to subsequent increase in the human pathogen population.

12. Do you have any additional comments that might improve the document?

The document does not mention that infectivity of the biological hazards have not been assessed from contaminated plants, most relevant for bacteria.

III. SPECIFIC OBSERVATIONS

Page	Paragraph or Line #	Comment or Question
5	175	Why other than sprouts? If they are left out, the reason should be explained.
11	393	…such as "sprouts," tomatoes, and leafy greens.
14	408	Sprout outbreak, 2006-*S. Braenderup,* bean sprouts
16	441	Why is wildlife and livestock feces "nonpoint source?" Wouldn't a flood event be nonpoint source? Point source and nonpoint source should be defined.
16	445-449	I'm not sure the most recent literature actually supports this statement. Both *Salmonella* and *E. coli* have been shown to survive "under a wide range of natural conditions." Winefied and Groisman, 2003. AEM.
17	465	What about contaminated irrigation water as a "direct" route?
24	728	Isn't it well accepted in 2013 that the so-called "indicator" organisms are in fact poorly or **not** correlated with actual pathogens?
26	813	Typo? Shouldn't it read "…2 log decrease…" not increase?
26	826 and 836	This sentence suggests that sprout irrigation water is important factor in sprout contamination…without references. Doesn't the data support the fact that contaminated seed, not contaminated irrigation water is the greatest (only) risk factor for contaminated sprouted seeds?
30	971-975	This may be a "chicken or egg" argument. It is true that enteric pathogens replicate faster and to higher populations within animals; however, it seems naïve to state that they "…are not generally considered to be environmental…" Recent data supports the theory that the part of an enteric's life cycle outside an animal host could be equally important.
41	1363-1385	Since seeds are a known route of contamination, this section should be included in Section IV. Exposure Assessment, B. Routes of Contamination.

REVIEWER #2

Peer Review Comments on FDA's Draft Qualitative Assessment of Risk (QAR)

Reviewer #2

I. GENERAL IMPRESSIONS

In Section 419 of the FD&C Act, FDA was tasked with providing minimum standards for the safe production and harvesting of fruit and vegetable raw agricultural commodities. To provide transparency to this task as to how these standards were derived, the FDA drafted this document, "Qualitative Assessment of Risk to Public Health from On-Farm Contamination of Produce," summarizing the currently available scientific data on routes of on-farm contamination and potential interventions that could affect the risk of raw agricultural commodities. In addition, they attempted to categorize the different raw agricultural commodities as to their relative risk of contamination so that the severity of applied standards would be in proportion to that level of risk.

Although the FD&C Act stipulates that biological, chemical and physical hazards be addressed in their setting of standards, they have rightfully focused on biological hazards that present the greatest risk to public health. Utilization of a risk analysis framework and risk management approach is moreover the best structured means by which presentation of the scientific data on biological hazards proceeds in a linear and logical fashion. Tables and bulleted lists are, for the most part, used effectively to illustrate the approach and document evidence and decisions. In my opinion, where the document fell a little short in this area is the decision to place summary tables before tables that explained how that table was derived (see Specific Comments section for affected tables). My preference would be the opposite as I need to understand the process before I see the outcome.

Overall, the presentation of information is clear; however, referencing in the document could be improved. Specifically, there was a large section that was incorrectly numbered, several references had insufficient information to allow the reviewer to access that publication, and there were several other instances, as noted in the Specific Comments section, where references were incorrect or another reference would be more appropriate.

The bulleted conclusions made for each of the five identified sources of contamination were reasonable given the current body of knowledge regarding on-farm contamination of raw agricultural commodities. As noted in charge question #4, it would be prudent to also discuss the potential for bioaerosols to be a contributing source of contamination. Definitely, there is less conclusive proof that bioaerosols serve as a route of contamination but if more definitive proof were to come to light in the future, its inclusion in this document would provide a clearer path toward implementing standards to minimize that potential route.

To account for the large disparity in commodity types and production practices, risk assessments were conducted on 46 different commodities that primarily took into account the likelihood of contamination on the farm and their rate of consumption for each commodity. As noted in charge question #7, I'm concerned that increasing the score of suspected sources that were found in epidemiological investigations of outbreaks, to be inherently biased. This bias is not so evident in commodities that one would expect to be at very high risk (i.e., leafy greens, tomatoes) or very low risk (i.e. citrus fruits), but could affect the relative risk of commodities in

between these two extremes. I suspect that many different scoring systems were considered in this task and the scoring system used for the QAR was considered the best for the datasets currently available. It would be prudent, however, to point out the limitations in their scoring system and make note that future scoring iterations may involve a different scale that is reflective of new information collected to fill the data gaps.

II. RESPONSE TO CHARGE QUESTIONS

1. ***1. Are the risk analysis framework and the risk management approach appropriate for the intended purpose of the QAR?***

   Yes, a risk analysis framework and risk management approach were the most logical avenue for utilizing scientific and epidemiological data to identify the risks where contamination of produce on the farm occurs and which risks could be minimized through the application of regulatory standards.

2. ***Are the scope and purpose of the QAR clearly identified? If not, what additional information should be provided?***

   In the first page of the document, the scope and purpose of the QAR are clearly delineated.

3. ***Are the questions to be addressed in the QAR appropriate, given the scope and purpose of the QAR? If not, what changes would you suggest?***

   The four questions encompass the major issues that serve to define the level of risk associated with different raw agricultural produce commodities and the on-farm activities that would impact risk.

4. ***Does the QAR adequately cover the routes of contamination found on farms during the growing, harvesting, handling, packing and storing of produce? If not, what other routes or considerations should be addressed?***

   The routes of contamination that are discussed in this document would be the ones that are likely to be the most prevalent as well as the ones where some degree of control may be asserted to minimize the contamination. The only other route of contamination that could be addressed is bioaerosols which I would rank as the 6^{th} most probable route of contamination. There are limited studies addressing this route and of those that have been conducted, the scientific data appears conflicting as to whether they would contribute significantly to contamination of produce fields. Despite this inconclusive data, it seems plausible that produce on a farm could be contaminated on a regular basis if there are wind patterns that consistently blow across a heavily populated cattle operation or manure composting operation immediately before it reaches the produce farm.

5. ***Does the selection of commodities in the QAR appear to adequately represent those commodities expected to fall within the scope of this document?***

To the best of my knowledge, the commodities selected for consideration in this QAR appear to address the major ones consumed and produced in the U.S. and that would fall within the scope of this document.

6. Considering the scope and purpose of the QAR, are the approaches to hazard identification, characterization, exposure assessment, and risk characterization appropriate?

The approaches used for hazard identification, characterization, exposure assessment and risk characterization were fundamentally sound and appropriate. The inclusion of Table 13, however, was not needed as no change in the relative rankings of the commodities occurred and in every case, the likelihood of exposure equaled the risk of illness. Therefore, the right-most column in Table 11 could easily have been labeled "Likelihood of Exposure or Risk of Illness." Moreover, including Table 13 could lead some readers to question why a high severity of hazard and a medium likelihood of exposure would lead to only a medium risk of illness and not a high risk of illness as would be taken if a worst case scenario approach were being used.

7. Is the approach for determining the qualitative risk of each route/produce item combination in the draft QAR reasonable, given the purpose of the QAR? If not, how might this be revised?

At first glance, I found the approach used to classify the qualitative risk associated with each route/produce item to be reasonable. In particular, I agree that the supporting information found in Table 10 for commodity/practice ranking pair decisions in Table 9 is practical; however, I would suggest that under the category Soil Amendments and Tree Crops that an acknowledgment be made that indirect contamination to tree fruit by climbing animals (i.e. squirrels) and birds would increase if a contaminated soil amendment were to be placed on top of the soil beneath the trees. Such an acknowledgment would not change the relative ranking of that practice. There would still be greater risk for soil amendments being applied to soil where contact with the crop could occur and a lower risk for pasteurized soil amendments being used for the cultivation of mushrooms.

On further examination of the other portion of the scoring scheme (differentiating between relatively higher and medium rankings), I did find some limitations. More specifically, by applying a higher score for all the routes identified as deficient when an outbreak investigation was conducted, a higher total score may occur for that commodity than for a commodity which may have identified fewer potential routes. For example, according to reference "ix", municipal water that supplied the packing shed of parsley was unchlorinated and workers had limited sanitary facilities available on the farm at the time of the outbreak. Since workers at Farm A were involved in both harvest and postharvest activities, the total score for parsley increased by 6 instead of just by 3 and led to it being placed in the category of higher relative likelihood of contamination on-farm. In contrast, grapes for which one outbreak had been recorded in 2001, was placed in a lower relative likelihood of contamination on-farm because the epidemiology investigation failed to identify the farm and potential sources of contamination. Therefore, the scoring system appears to be dependent more on the relative success or strength of the epidemiological investigation rather than on

the routes that actually contributed to the contamination in an outbreak. In essence, finding more deficiencies at a farm, even though only one deficiency may have been the culprit, increases the route score risk of that commodity. Another limitation in using their scoring system is that it appeared that they only considered epidemiological investigations associated with outbreaks that occurred in the U.S. One epidemiological investigation that explored an outbreak of *Salmonella* in contaminated papaya in Australia found that untreated river water was used for washing papaya and therefore it was considered as a suspected vehicle. If this study had been included in this rating exercise, papaya would have received a total route score placing it in the category of having a medium relative likelihood of contamination on-farm rather than the lower relative likelihood of contamination on-farm. Given the disparity in epidemiological investigations and the associated bias they introduce to this scoring system, I would suggest that the scoring system used for medium, relatively lower, and not applicable continue, but that higher risk commodities perhaps be based on the number of outbreaks that has occurred with that product.

8. Do the conclusions drawn seem appropriate given the information presented during the identification, characterizations, and assessments within this document?

Given the state of our knowledge on the subject area and the discussion provided in this document on identification, characterization and assessment of risks associated with raw agricultural commodities, the conclusions drawn are fundamentally sound and reasonable.

9. Is the report written in a transparent and clear manner? If not, how might the report be revised?

The discussion within the report was written in a clear manner and it followed a logical progression toward understanding the various components that would affect the risk of a raw agricultural produce commodity. The one component to this report that I felt weakened the report in terms of its transparency was the reference section. As noted under specific observations, there were several citations that I could not find (to confirm the accuracy of the information presented) because the article title was not given (#31 and #38). One of the references that was noted to have additional details on sampling activities within it was also inaccessible (#184). In addition, there was a huge section of the document where most of the references cited did not match the subject matter being discussed. As an example, an article on thermal resistance of *E. coli* in apple juice was referenced for domestic and wild animals as being carriers of human pathogens. While these errors may be easily corrected in the revised draft, for my review, I was unable to verify that the proper references were being provided for the information they presented.

10. Does the report adequately address the questions and stated objectives?

Overall, the report adequately addresses the four questions made at the beginning of the document and laid the foundation for generating practices and standards that would reduce the risk associated with the production and harvesting of raw agricultural produce commodities.

11. Are there further data gaps or research needs that are necessary to address in order to further refine this assessment?

The areas listed are very broad and if they were to be read by themselves, it would give the impression that we are completely void of any knowledge of food safety risks that are associated with raw agricultural fruits and vegetables. More specificity and prioritization of those data gaps would ensure that scarce resources will be applied to areas that will have the greatest impact on reducing foodborne illness association with produce.

12. Do you have any additional comments that might improve the document?

Numerous comments are provided in Section III below.

III. SPECIFIC OBSERVATIONS

Page	Paragraph or Line #	Comment or Question
3	124-126	The sentence mentions an order of prevalence, but Table 1 only lists them. Should also refer to Table 2 here as that table prioritizes the pathogen agents by the number of outbreaks and illnesses.
3	135-139	Replace "In many cases" with "In several cases" as only two outbreaks and two reference citations are used and several would be a more appropriate description.
3	142-144	A reference citation for this potential mode of contamination should be given. The following reference could be used: Buchholz, A.L., G.R. Davidson, B.P. Marks, E.C.D. Todd, and E.T. Ryser. 2012. Transfer of *Escherichia coli* O157:H7 from equipment surfaces to fresh-cut leafy greens during processing in a model pilot-plant production line with sanitizer-free water. J. Food Prot. 75:1920-1929.
5	198	*Listeria* needs to be italicized.
Biological Hazards Section		Bacterial and viral agents were discussed individually in alphabetical order and then the three parasitic agents were included in their own section at the end. If the section on the parasitic agents was labeled "5. Parasitic agents: *Cryptosporidium parvum, Cyclospora cayetanensis, Giardia lamblia*", then it could be placed after the "4. Norovirus" section and before the "6. *Salmonella*" section.
Biological Hazards Section		Some of the material presented for the different agents was inconsistent. As an example, the infective dose was listed for *E. coli* O157:H7 but not for *Shigella*.
6	221-222	To be consistent on the information presented in the section on Biological Hazards, the reference citation for the infectious dose should be #79 instead of a book chapter.
7	227	According to Table 3, the case fatality rate is 0.5% so either it could be specified as such, instead of using "approximately 1%" or for consistency, it should be presented as "less than 1%" as was stated for *Salmonella* which has the same case fatality rate of 0.5%.

Page	Paragraph or Line #	Comment or Question
7	232-234	Reference #187 covers the outbreak with green onions only. References for outbreaks associated with frozen strawberries and frozen raspberries should also be given otherwise the reference number should follow immediately after listing green onions.
7	249	Checked Reference #41 but did not find an article with that volume and page number and discussing the potential transfer of viruses through water or handling.
8	267	The abbreviations Lm and RA had not been defined previously in the document so should be spelled out.
8	297	"usually higher" is vague and should be more specific.
9	315	The references cited only refer to *Cyclospora* (#40) and *Giardia* (#74). Instead of having a separate reference for *Giardia* from the Bad Bug Book, the document should refer to reference #79 that would include both *Giardia* and *Cryptosporidium*.
11		Greater emphasis to several statements and phrases made on this page should be made by bolding them: all of lines 378-379, "alone" on line 386, and "greater or lesser" on line 386.
Table 5		This table is actually a compilation of bar graphs. Presentation of the data in tabular form would facilitate greater comparison among the commodities as well as be more space efficient.
12	398-399	Since the point was made that outbreaks had been associated with both honeydew melon (smooth rind) and cantaloupe (netted rind), it would be advantageous to present the outbreak data for these two commodities separately.
16	456-463	To emphasize the point that prediction of pathogen survival rates is difficult, a specific example, along with a reference where the pathogen did not survive for extended periods of time, should also be given.
16	462	The original references for this data should be given instead of the citations listed. They are: • Islam, M., J. Morgan, M.P. Doyle, S.C. Phatak, P. Millner, and X. Jiang. 2004. Persistence of *Salmonella enterica* serovar Typhimurium on lettuce and parsley and in soils on which they were grown in fields treated with contaminated manure composts or irrigation water. Foodborne Path. Dis. 1:27-35. • Islam, M., M.P. Doyle, S.C. Phatak, P. Millner, and X. Jiang. 2004. Persistence of enterohemorrhagic *Escherichia coli* O157:H7 in soil and on leaf lettuce and parsley grown in fields treated with contaminated manure composts or irrigation water. J. Food Prot. 67:1365-1370.
17	469	Reference #92 does not appear to be a correct citation for the statement as it deals with *Salmonella* contamination in surface waters.

Page	Paragraph or Line #	Comment or Question
17	477-486	Given that the majority of the outbreaks where workers have been implicated as a source of contamination have been in the retail setting, it may be advantageous to clarify that human transfer of pathogens in that setting would be just as likely as human transfer during harvesting.
18	503	Instead of reference #158 being cited, reference #159 would be more appropriate.
18	507-508	Only one study was cited (#99), whereas the sentence stated that "studies had demonstrated."
18	526-527	Studies are described as "recent" but reference #130 was published in 2000 and the other citation (reference #147), while published in 2008, was compiling data from outbreaks occurring from 1991-2002. In the absence of truly more "recent" data, I would remove the word.
19	552	Reference 10 is an incorrect citation for this statement as the paper is discussing variations in survival with plant cultivars not pathogen cultivars.
19	555-557	This statement, regarding the lack of recovery from bell pepper when irrigated by subsurface drip or furrow irrigation, does not belong in this section as it relates to contamination of the crop, not survival or persistence in the crop.
19	560	A more appropriate term to describe the surface characteristics of the commodity would be surface roughness, not surface texture.
20	581-585	Previous discussion of attachment was dealing with cultivated plants whereas the observations of growth reported in this paragraph were conducted under postharvest conditions when the tissue has been severed from its source. It should be clarified that "postharvest plant colonization can occur at rapid rates."
21	618	Given that more detail on how the inspections, investigations and surveillance sampling activities are to be found in the references cited, reference #184 has very little details to enable one to access that information.
21	Table 6	Reference #50 should be listed at the end of the title.
21-22	639-648	This paragraph listing limitations is almost word for word a repeat of what was stated in the last half of the previous paragraph. Rephrase if the point is to emphasize these limitations.
23	708-709 and 712-714	The two sentences found within these lines are repetitive.
24	730	The years in which the data were collected should be specified rather than just stating "during the last two reporting periods."
26	809	For increased clarity of the experimental conditions, insert "unsanitized" before "water."

Page	Paragraph or Line #	Comment or Question
26	812-824	To provide a more logical presentation of the information that would be based on the order in which activities are experienced, move the last two sentences of this paragraph (dealing with contamination) to follow the first sentence. Activities that affect reduction of contaminated product would then follow.
29	917	Instead of starting the sentence with "And" start with "In addition,"
29	925	Italicize "*L. monocytogenes*."
30	955	Reference #104 did not address asymptomatic shedders and should therefore be deleted.
31	979	Since the maximum populations of *Salmonella* and *E. coli* O157:H7 in animal feces was later specified, it would also be valuable to specify here the value associated with "very large populations" of human pathogens in human waste.
31-35	995-1128	More than half of the reference citations appeared to be incorrect (articles addressed a subject matter different from what was being discussed). With so many being wrong, I can only assume that reference numbers within the text were not changed when deletions or additions to the reference list were made.
35	1156	For clarification, insert the word "Human" before workers and visitors.
38	1236	A more appropriate reference for the information presented in this sentence would be the following: Zhou, B., Y.G. Lu, P. Millner, and H. Feng. 2012. Sanitation and design of lettuce coring knives for minimizing *Escherichia coli* O157:H7 contamination. J. Food Prot. 75:563-566.
39	1308-1309	The mass unit that the pathogen populations encompass should be specified. I'm assuming it is per gram, but is that per gram wet weight or per gram dry weight?
39	1309	Levels of *E. coli* O157:H7 in fresh cattle manures averaged 6 log/g wet weight in the following study and was as high as 8 log cfu/g wet weight: Hutchison, M.L., L.D. Walters, S.M. Avery, B.A. Synge, and A. Moore. 2004. Levels of zoonotic agents in British livestock manures. Lett. Appl. Microbiol. 39:207-214.
Tables 9 and 10		Since Table 10 offers explanations on how Table's 9 categories of ranking were derived, it would be more logical to present Table 10 before presenting Table 9 as the reader of this document would then be capable of understanding the assigned scores.
Tables 9 and 10		Since these tables span multiple pages, it would be advantageous for the headers to be included on each page.

Page	Paragraph or Line #	Comment or Question
Table 9		The column widths for the different sources of contamination varied and, therefore, it was difficult to match the source with their score on pages where the header was not included. Given that the routes of contamination were considered equivalent as factors contributing to the likelihood of contamination on-farm, the columns should have similar widths to reflect this assignment. Otherwise if the table is viewed alone, one could mistakenly assume that sources with wider columns, such as animals, present a greater risk than narrower columns, such as equipment.
55-56		Although it is explicitly stated that the results of the analysis are presented first in Table 11 and is followed by the discussion of how those results were derived, my preference would be to present the discussion first before presenting the table. It was impossible for me to understand the table without going through the discussion first.
57	1570-1571	An article just published in the January issue of Journal of Food Protection addresses the removal of viruses from contaminated produce by peeling and could be advantageous to include as a reference in this section. The article is: Wang, Q., M.C. Erickson, Y. Ortega, and J.L. Cannon. 2013. Physical removal and transfer of murine norovirus and hepatitis A virus from contaminated produce by scrubbing and peeling. J. Food Prot. 76:85-92.
58	1599-1600	No reference was given for this data.
68-83	References	Formatting of references was inconsistent. For example: • With article titles, in some cases the first letter of each major word was capitalized whereas in other cases, only the first word of the title was capitalized. • Pathogen names were not italicized. • In some cases, only the year was included whereas in other cases, the month, day, and year for the citation date was included. • MMWR was abbreviated whereas all other journal titles were spelled out. • A couple of the references that were found in Morbidity and Mortality Weekly Report did not list the article title (#31, #38) or page numbers (#31) and thus made it difficult to find the information that was cited.
72	1959	Missing page numbers.
73	2017	C in *coli* should not be capitalized.
74	2020-2021	Should probably reference second edition that is now online.
74	2045	Missing volume and page numbers.
75	2080	C in *coli* should not be capitalized.
77	Ref #124 and #125	Listed page numbers in #124 but did not in #125.
77	2152	Missing co-authors.
78	2168	Missing page numbers.
78	2179	C in *coli* should not be capitalized.

Page	Paragraph or Line #	Comment or Question
78	Ref #138	The title was incomplete and the page numbers were incorrect. The title is: "… produce: A review." Page numbers should be 75-141.
80	2234-2239	Reference #159 and Reference #160 are the same reference.
82	2300	No title of publication given which could facilitate finding the information contained within it. Is this publication accessible on the internet? Indicated that additional details on sampling activities found within it.
82	2311	Misspelled word.
86	Table summarizing MPD data 2002 - 2009	Is it possible to separate the data collected for tomatoes and cantaloupes into those that were field packed and those that were shed packed? This division would be useful since the risk assessment in this document considered field packed and shed packed commodities as separate entities.
92	2441	Based on table comparing the assessments of the two rankings, there were 11/27 that were scored similarly for a 41%.
92	2443	"… two commodities received a higher score …" not "… one commodity..."

REVIEWER #3

Peer Review Comments on FDA's Draft Qualitative Assessment of Risk (QAR)

Reviewer #3

I. GENERAL IMPRESSIONS

The described scope of the document is to provide a qualitative risk assessment (eg., ranking the probability as low, medium, or high) of the potential for adverse human health consequences related to the consumption of a variety fresh fruits and vegetables contaminated prior to harvest (on the farm) with microbial pathogens (bacteria, viruses, and parasites). Biological hazards of concern are listed, current knowledge of how fruits and vegetables become contaminated during the pre-harvest stages of production are outlined, and the likelihood of contamination of specific produce items, and subsequent illness attributed to specific produce commodities, are reviewed and ranked.

This task, although clearly defined, is enormous and daunting. The lack of supporting data in many of the areas of investigations leave numerous gaps in our understanding of the process of microbial contamination of produce and therefore requires some degree of scientific inference to be applied to achieve qualitative risk rankings. Notwithstanding these inherent limitations of the available scientific literature, the document provided is comprehensive, clearly written with logical flow and is based on the science that is available. It is a valuable summary document that may be useful in guiding the development of risk mitigation and management strategies surrounding known issues pertaining to vegetable production.

II. RESPONSE TO CHARGE QUESTIONS

1. ***1. Are the risk analysis framework and the risk management approach appropriate for the intended purpose of the QAR?***

   A risk analysis approach is ideal for evaluating the risk of developing infectious disease associated with the consumption of contaminated produce. Some of the hallmarks of this method are that they are: 1) data supported, 2) transparent, 3) systematic, 4) documented, and 5) reproducible. It is recognized that this is an iterative process and as new information becomes available it will be necessary to update and re-evaluate the document. Other skilled individuals with access to the same data should be able to develop a risk model, and hopefully achieve comparable results.

2. ***Are the scope and purpose of the QAR clearly identified? If not, what additional information should be provided?***

   The stated goal of the QAR is to "provide a scientific evaluation of potential adverse health effects resulting from human exposure to hazards in produce, with a focus on public health risk associated with on-farm microbial contamination."

   What is provided is a Risk Assessment. It is not a complete risk analysis in the classical sense, as it does NOT address risk management nor risk communication. It is indeed a good start on the risk assessment. In general, including the word "potential" in the framework makes this work too broad, less appropriate, and it is not fulfilled by the narrative that

follows. First, there are many "potential" microbes that could contaminate produce and make them deleterious to health. What is provided is a risk assessment of the likelihood of becoming ill following the consumption of produce. The document does not sufficiently emphasize the level of uncertainty and variability inherent in the model due to the absences of data in some aspects.

3. Are the questions to be addressed in the QAR appropriate, given the scope and purpose of the QAR? If not, what changes would you suggest?

There were four questions posed:
1. What are the hazards?
2. How does produce become contaminated (on the farm)?
3. Is the likelihood of contamination different among different commodities?
4. Does the likelihood of illness depend upon type of produce consumed?

Hazards identification is performed by listing foodborne disease outbreaks associated with produce and fruits. Two databases were used for the hazard identifications: a CDC and an FDA database. Although it is presumed that this QAR is tailored for the USA, it might be beneficial to look at other databases describing sources of disease, both within and outside the US, to attempt to make it as comprehensive as possible.

The section on data limitations II, A, 3 is good, However, in addition, the section on data limitations could be expanded to include the implications of relying only on outbreak data and the fact that many foodborne disease outbreaks do not have a known pathogen etiology.

The primary pitfall of this approach is that the attributable fraction of produce contamination that pre-harvest and post harvest is not precisely known. Although extensive investments are being made to better understand (and subsequently intervene) during the pre-harvest stages of production, if pre-harvest contamination accounts for only 10% of the contamination events, then, even with 100% elimination of these routes of contamination, 90% of the contamination will still remain within the system. Thus, it is important that a holistic approach be used to assess contamination and illness at all stages of production, storage and preparation so resources and intervention strategies can be directed at the stages of within the food chain that would receive the greatest magnitude of enhancement.

Question 2: The routes of contamination are outlined to the extent that available knowledge is available. It would be valuable to indicate that this list may not be exhaustive and other routes of contamination may be identified. Like, it is important to indicate the gaps in knowledge in respect to the lack of data regarding which of these routes contribute the most to vegetable contamination. For example, irrigation water may occasionally be contaminated with pathogens, but if they do not reach the edible portions of the produce and do not survive, then extensive mitigation strategies to completely eliminate them from irrigation sources may have negligible impacts on contamination rates and subsequent illnesses.

It is not possible to answer question 3 (variability of contamination among produce types) with the information provided. The method used to prioritize/rank likelihood of contamination is flawed; it was based on the commodities that had been linked to outbreaks. The incidence of outbreaks associated with a particular commodity is not necessarily directly

proportional to the frequency and magnitude of contamination. In fact, it is likely there is much more contamination that occurs on the farm that never results in disease outbreaks because of a number of other factors (which are described elsewhere in the document, such as die-off). Other factors, such as lower pathogenicity of certain strains, magnitude of contamination and host immunity, also likely play important roles in governing whether an outbreak will occur, such as the frequency of consumption and preferred method of preparation and storage. These factors are accounted for in the risk model and including the number of outbreaks as a surrogate measure of contamination is redundant. Information, at least on a limited number of produce commodities, is available in the USDA Microbiological Data Program, the MDP. However, even here it is limited, as MDP samples were collected at retail, and could be indicative of contamination at any point, including off-farm sources, prior to collection.

In reference to the fourth question, it is important to prioritize where the interventions could be focused to reduce the greatest number of illnesses. The produce most likely contaminated may not be the ones responsible for the largest number of illnesses because of the factors mentioned above, especially consumption rates. It is not clear how the proposed model for assigning risk is superior to the FDA-RTI 2011 risk ranking model (or any explanation of why there are differences) or how this method is better than simply determining the number of illnesses attributed to contaminated tomatoes (or whatever commodity) and dividing by the per/person estimate of tomato consumption.

4. ***Does the QAR adequately cover the routes of contamination found on farms during the growing, harvesting, handling, packing and storing of produce? If not, what other routes or considerations should be addressed?***

   Known routes of contamination are covered. Again, there should be sufficient description of the data gaps and uncertainty, including the statement that for most outbreaks and contaminated product, the source of the contamination is never identified.

5. ***Does the selection of commodities in the QAR appear to adequately represent those commodities expected to fall within the scope of this document?***

   Yes.

6. ***Considering the scope and purpose of the QAR, are the approaches to hazard identification, characterization, exposure assessment, and risk characterization appropriate?***

   ID - adequate.

   Exposure - see above. The inclusion of food commodity specific consumption rates is an excellent idea. However, this document assigns level of contamination of particular products based on outbreak frequency and then uses that data to predict risk of illness (outbreak frequency). This is a circular argument. Problematic is that the predicted level of contamination does not always coincide with available data from the MDP database.

Characterization - the lack of dose response and the assumption that the likelihood of disease is directly proportional to the exposure assessment is a serious limitation of the risk model.

7. Is the approach for determining the qualitative risk of each route/produce item combination in the draft QAR reasonable, given the purpose of the QAR? If not, how might this be revised?

Given that certain pathogen:commodity pairs are overrepresented as a cause of outbreaks, grouping all pathogens together for each commodity may introduce some biases. For example, the dose response to *E. coli* O157 is different than that of *Salmonella*. *Salmonella* has been reported as a cause of far more illnesses than *E. coli* in tomatoes. Virulence differences among pathogens associated with different commodities is not accounted for in the model. More weight should be placed on the more likely pathogen to cause a disease.

8. Do the conclusions drawn seem appropriate given the information presented during the identification, characterizations, and assessments within this document?

Most of the conclusions reported are supported by the narrative and cited references.

9. Is the report written in a transparent and clear manner? If not, how might the report be revised?

Yes.

10. Does the report adequately address the questions and stated objectives?

See responses above.

11. Are there further data gaps or research needs that are necessary to address in order to further refine this assessment?

The attributable fraction of contamination that occurs (and persists) from pre-harvest stages of production is essential in order to estimate the impact of pre-harvest control of pathogens.

12. Do you have any additional comments that might improve the document?

Reference 52 is incomplete. Is it true the FDA surveillance had no reported outbreaks of disease associated with noroviruses between 1996-2010 (Table 2)?

References to websites should have url and access date.

III. SPECIFIC OBSERVATIONS

[This reviewer provided mark-ups with comments and specific suggestions for improvement on an electronic version of the document, which has been included as Attachment A of this report.]

REVIEWER #4

Peer Review Comments on FDA's Draft Qualitative Assessment of Risk (QAR)

Reviewer #4

I. GENERAL IMPRESSIONS

This document describes a qualitative risk assessment for on-farm contamination of fresh fruits and vegetables. A total of nine microbial pathogens have been targeted based on the top five pathogens found in produce (*Salmonella*, enterohemorrhagic *Escherichia coli, Shigella, Cyclospora cayetanesis*, *Hepatitis A)* or severity of illness (*Listeria monocytogenes*, *Norovirus, Cryptosporidium parvum*, and *Giardia lamblia*) as evidenced from other produce-associated outbreaks that have been documented in the literature. Hence, pathogens that have been chosen and characterized are appropriate given the overall intent. The strength of this risk assessment lies in the identification of the on-farm routes of contamination which have been categorized as water, soil amendments, animals, worker health and hygiene, and equipment and buildings, with these routes of contamination well-documented through both the scientific literature and investigative reports from various produce-associated outbreaks. The document includes an assessment of the likelihood of potential contamination from these on-farm routes for 43 different types of produce (Table 9 in the report) along with a likelihood of exposure assessment based on a national food consumption survey and finally a determination of the risk of illness from these same 43 types of produce. While the overall conclusions from this qualitative risk assessment are generally appropriate, the current report does not adequately address the changes in pathogen levels that may occur during subsequent processing (e.g., conveying, washing, peeling, slicing, dicing, drying), shipping, retail storage/display, and storage in the home by consumers. Nonetheless, this risk assessment represents an important first step in determining the relative risks associated with the vast majority of products that are most widely consumed by the public.

II. RESPONSE TO CHARGE QUESTIONS

1. ***1. Are the risk analysis framework and the risk management approach appropriate for the intended purpose of the QAR?***

   The risk analysis framework and approaches being proposed are generally appropriate given the overall intent.

2. ***Are the scope and purpose of the QAR clearly identified? If not, what additional information should be provided?***

   Both the scope and purpose of the QAR are clear.

3. ***Are the questions to be addressed in the QAR appropriate, given the scope and purpose of the QAR? If not, what changes would you suggest?***

   The four questions posed are appropriate given the focus of this risk assessment on on-farm contamination of produce. However, in the broader sense, risk to consumers cannot be fully addressed without also considering the impact of post-harvest off-farm processing (e.g., value-added products that are commercially washed, sliced/diced, and packaged) on

contamination levels, and the time/temperature histories that products encounter during transport, retail storage/display and consumer storage.

4. Does the QAR adequately cover the routes of contamination found on farms during the growing, harvesting, handling, packing and storing of produce? If not, what other routes or considerations should be addressed?

The primary routes for on-farm contamination of produce have been adequately covered with the information presented being well-supported from the scientific literature and various outbreak investigations. A few additional areas that could be considered would include dust and air-borne contaminants (e.g., produce fields down-wind from cattle feed lots), leakage from septic tanks, flies, insect infestations (related to climactic conditions and overall health of the crop), wooden vs. plastic totes, conveyor belting materials (continuous smooth vs. interlocking belts), and the impact of biofilms on equipment as related to improper cleaning, sanitizing and equipment maintenance.

5. Does the selection of commodities in the QAR appear to adequately represent those commodities expected to fall within the scope of this document?

The 43 commodities chosen comprise a highly diverse group of fruits and vegetables and represent the vast majority of such products that are regularly consumed by the public.

6. Considering the scope and purpose of the QAR, are the approaches to hazard identification, characterization, exposure assessment, and risk characterization appropriate?

The approaches to hazard identification, characterization, exposure assessment, and risk characterization are appropriate. However, as mentioned earlier, the weak links in this risk assessment include post-harvest processing (value-added fresh-cut produce), distribution, retail storage/display, and consumer storage practices prior to consumption, with this risk assessment assuming that any on-farm contamination will carry through to the point of consumption, and that the level of contamination neither increases nor decreases unless contamination is minimized through consumer (cooking or peeling – not washing) or retail handling practices.

7. Is the approach for determining the qualitative risk of each route/produce item combination in the draft QAR reasonable, given the purpose of the QAR? If not, how might this be revised?

Use of the ordinal scale to assign risk (Table 9) appears to be a reasonable approach with N/A = 0, Lower = 1, Medium = 3, and Higher = 6. Except for a few commodity/contamination routes as noted later, the assigned risks (lower, medium, higher) and the resulting scores also generally seem to be appropriate.

8. Do the conclusions drawn seem appropriate given the information presented during the identification, characterizations, and assessments within this document?

The first four conclusions on page 64 are appropriate based on analysis of the data presented. However, the last conclusion states that "Postharvest practices such as cooking (and, possibly certain peeling practices) before consumption may have an impact on the likelihood of contamination of the edible portion and the likelihood of illness." While this is true, washing, which typically removes 90 – 99% of the microbial contamination, will also decrease the likelihood of foodborne illness, particularly for those pathogens having a higher oral infectious dose. If this latter notion is not considered, the common consumer practice of washing could potentially decrease for certain types of produce.

9. Is the report written in a transparent and clear manner? If not, how might the report be revised?

The report has been well-prepared and appears to be free from any undue bias.

10. Does the report adequately address the questions and stated objectives?

The questions and stated objectives have generally been adequately addressed except as previously noted.

11. Are there further data gaps or research needs that are necessary to address in order to further refine this assessment?

Additional data gaps include: 1) the origin, incidence and *levels* of pathogens in field-grown produce, 2) the distance between produce fields and livestock operations needed to minimize contamination, 3) on-farm routes for pathogen transfer (e.g., from soil to tractors / harvesters to produce to conveyors to bins), 4) post-processing routes for transfer (conveying, flume washing, shredding, slicing, dicing, drying), 5) sanitizer use and efficacy during flume washing, 6) extent to which contaminated products mix with uncontaminated products during commercial processing, 7) pathogen growth in/on produce during transport and retail storage/display, 8) consumer storage practices for fresh produce, and 9) consumer preparation practices (e.g., washing practices, slicing, dicing, cutting board).

12. Do you have any additional comments that might improve the document?

See below.

III. SPECIFIC OBSERVATIONS

Page	Paragraph or Line #	Comment or Question
1	68-69	…into fruit and vegetable RACs and…
1	70	Section 402 or 419 of the FD&C Act?
1	76	Suggest "for" rather than "in" since most microbial contaminants are found on the surface of fresh produce as opposed to the interior.
2	87	…involved analyses for which…
2	89-90	…data from these analyses were used.

Page	Paragraph or Line #	Comment or Question
3	106	The article mentions *E. coli* serotypes O6:NM and O11:H43 but not O145, O111 and O104:H4, with produce-related outbreaks from these last three serotypes only having been documented during the last few years.
3	111	…chain from the farm to the point of…
3	138	…its RAC form…
4	Table 1	Reference 156 lists 5 outbreaks for *Campylobacter* which exceeds those from *L. monocytogenes*.
5	172	…on farms.
5	175	…fresh-cut…
5	178	…regulated RACs other…
5	183	…to be of continued concern…
5	185	This Hazard Characterization…
5	198	Italicize *Listeria.*
5	199	…document) with the others ranking among the top five causes of produce-associated outbreaks.
5	200	Several servings might also need to be consumed over time to ingest a sufficient number of organisms to cause illness (e.g., growth of *L. monocytogenes* in contaminated cantaloupe during refrigerated storage).
6	213	…and deaths…
6	217	for under-reporting and…
6	228	…*coli* - part of the group called STEC, such as O145 (*49*), and O104 (*64*), are increasingly…
7	232	…(*66*). Outbreaks of HAV have been linked…
7	254	…experience mild listerial…
7	261	…diarrhea (*69, 88*).
8	267	The FDA/FSIS *L. monocytogenes* risk assessment showed …
8	270	…food was that…
8	279	Norovirus causes an intestinal illness (*79*). Symptoms of infection usually…
8	286	*Salmonella enterica* - the bacterium…
8	300	…approximately 3.6 percent…
9	307	…raw fruits and…
9	308	…honeydew melon…
9	311	…ranges from 8 – 50…
9	320	…ranges from 1 – 2…
9	321	Cryptosporidiosis has an onset time of 7 to…
9	323	…individuals are at higher risk…
10	356	…has been obtained from the CFSAN…
10	361	…for the majority (77%) of all…produce-related…
11	370	Although the harvestable portion grows in the ground, the tops of green onions are also consumed (unlike potatoes).

Page	Paragraph or Line #	Comment or Question
11	382	While true for whole apples, numerous *E. coli* O157:H7 outbreaks have been traced to apple cider with the apples assumed to be the source of the pathogen (e.g., from deer droppings).
16	457	…thrive. Various sites in production areas may provide safe harborage for pathogens and act as reservoirs from which food contamination may occur. When manure composts contaminated with S*almonella* and *E. coli* O157:H7 were applied in fields, survival times…
16	465	Produce is subject to both direct (e.g., insanitary hand or equipment contact) and indirect (e.g., contaminated runoff) pathogen contamination.
16	478	…of contaminating food during handling (*20*).
17	488	…as a potential…
17	498	…outbreak of listeriosis linked…
19	570	…produce, pathogenic *E. coli* O157:H7 was…mechanisms exhibited poor attachment (*196*).
19	575	…showed significantly different degrees of serovar-cultivar colonization…suggesting different colonization…
20	581	…and is frequently…
20	591	…see the FAO/WHO meeting report on…
20	594	…and holding of produce on farms.
20	597	…(1) water, (2) soil amendments, (3) animals, (4) worker health and hygiene, and (5) equipment and buildings.
22	649	Delete this line
23	684	…coliform-positive…
23	707	…(*147*). In another…found that…
23	712	This sentence is a repeat of 708 – 710 and can be deleted.
23	714	This sentence is unclear. Were these pathogens detected in well or groundwater samples?
23	717	…*Campylobacter* contamination over… (Note: A well cannot be infected since the term infection relates to disease).
24	750	*E. coli* O145 in all probability originated on the farm as an isolated contamination event, but was likely spread to many bags of product during commercial processing. While decreased efficacy of the sanitizer in the presence of a high organic load may have been partly responsible, recovery of the pathogen from the processing environment would be unlikely days or weeks later.
24	755	…concentrated animal feeding operations;
25	761	…this canal section…
25	762	…was the most likely source of contamination.
25	796	…reported that…
26	805	… transportation, it is often disinfected to minimize contamination.
26	807	…cross-contamination during washing…after a 1 minute wash… [Note: The impact or organic load on decreased sanitizer efficacy (particularly for chlorine-based sanitizers) cannot be overlooked.]

Page	Paragraph or Line #	Comment or Question
26	817	CFU non-pathogenic *E. coli* per 100 ml (10,000 CFU non-pathogenic *E. coli*…
26	828	Define "treated agricultural tea."
27	866	…source for contamination…
27	869	…despite the regulation of many U.S. public wells under the Ground Water Regulation.
30	943	Agricultural teas that contain "amendments," such as molasses intended to enhance the growth of beneficial microorganisms, also reduce the expected die-off time of pathogens, and possibly…
30	960	…common in…common in…
30	968	A biological soil amendment of animal origin can spread pathogens to produce by either directly or indirectly contacting the food surface.
30	977	…can all potentially infect new human hosts (*181*).
31	980	40 CFR part 503 does not allow the use of human waste as a soil amendment.
31	995	Also, biological soil amendments of animal origin are expected to have a high content of available nutrients and minerals, including those expected to support rapid and prolific microbial growth, provided that sufficient moisture is available (*109*).
31	1000	…excreta (e.g., *Shigella* and HAV)…
31	1007	While not used as a soil amendment, calcium carbonate (used as a food ingredient) was recently recalled due to contamination with *Salmonella*. See http://ohsonline.com/articles/2012/11/09/salmonella-recall-hits-nesquik-powder.aspx
31	1011	…to the likelihood…
32	1037	…soil) (*100, 182*).
32	1047	…interval, coupled…
32	1050	… days, months, or years (*99, 103, 188, 196*). [Note: see also L1070.]
32	1054	… while the above ground harvestable portion…
33	1059	Soil amendments can be a source of produce contamination.
33	1073	L1073 is a repeat of 1064
33	1076	…above ground harvestable…
34	1091	Animal excreta are a well-established source of pathogens (48, 119, 123, 145, 195), often at very high populations (such as *Salmonella* spp. up to 7 log (10^7) (*141*) and *E. coli* O157:H7 up to 5 log (10^5) (*95*) that, when present on farms, can…
34	1102	Italicize (*37, 41, 82, 98-100, 150, 155*).
34	1111	Italicize (*48, 123, 195*).
34	1116	…and Dunn and colleagues reported that the prevalence of *E. coli* O157:H7 infection in white-tailed deer ranged from undetectable levels to 2.4 percent (*60*).
35	1156	…such as norovirus, hepatitis A virus…

Page	Paragraph or Line #	Comment or Question
36	1160	…lettuce, tomatoes, or…
36	1167	Wearing jewelry in the field (e.g., a wrist watch) as well as eating or use of tobacco products would appear to present a lower risk in produce fields as compared to a post-processing facility where such actions are always banned.
36	1184	Italicize（*4, 17, 38, 84, 125, 184*）.
37	1208	Italicize (*89*) and (*18*)
37	1214	…can contaminate produce or…
37	1228	…iceberg…in simulated field coring (*167*).
37	1230	…demonstrated to various extents…
38	1235	…sanitizing would…
38	1248	Buildings and equipment that are not easily accessible and cleanable are less likely to be properly maintained and may therefore become a source or route of contamination (*80*)…in buildings in which multiple activities are conducted (*96*)…
38	1253	Un-italicize "of"
38	1271	Un-italicize "for"
39	1305	…surfaces.
40	1324	Food contact surfaces and equipment that are…
40	1341	…Apples…Carrots…Green onions…Mushrooms…Onions…Peaches…Peppers, Tomatoes…Tomatoes… and Watermelon.
41	1348	Isn't squash also typically cooked before consumption?
41	1380	Operations that are…
42	1391	Also note that our…
42	1413	…growing habitat…
42	1415	…is generally less…
43	1424	delete
43	1425	In order for us to obtain a total…
45		Deer contact with apples has been strongly associated with outbreaks of *E. coli* O157:H7 from apple cider. Consider ranking as 6.
52		Comment for water (direct) general – fluming may also lead to pathogen internalization in some products if the product temperature exceeds the water temperature by more than 10ºC.
54	1502	…other routes of…
54	1510	…limitations. Further, although…

Page	Paragraph or Line #	Comment or Question
54	1513	Table 11: In addition to peeling and cooking, washing before consumption (typically reduces bacterial populations ~90%) is also standard practice for many of the products listed in Table 11. This risk assessment also fails to consider the routes and spread of contamination during production of value-added/fresh-cut produce which may be substantial for certain products that are commercially processed prior to reaching retail markets. Some examples would include fresh-cut leafy greens, apples, tomatoes, carrots and blueberries. Concerning consumption, other items typically peeled would include grapefruit, oranges, and onions. Pineapples and melons are always cut with any contamination of the edible portion coming from the outer rind during cutting or slicing.
54	1555	As the organic load increases in wash water during washing of produce, the efficacy of chlorine-based sanitizers decreases.
57	1573	…cutting and peeling provide…(21). One study…*Salmonella* Miami…
58	1592	Please clarify these time/temperature treatments in terms of log reduction or D-value.
58	1598	…1 second) (*121*).
58	1599	Water blanching at 190 ^{0} F for 4 minutes reportedly reduced *Salmonella* spp. by >5.4 log CFU/g in potato slices and by 4.6-5.1 log CFU/g in carrots (55).
58	1605	…juice were thermally...than 1 minute when held at 144ºF…
59	1635	… represent all ages of the U.S. population. Dietary records are from the WWEIA/NHANES report of foods consumed by survey participants.
59	1641	…recipes, food forms…
59	1645	…in Appendix 2)…
59	1648	…commodities are provided…
60	1654	…calculated the sum total number…
60	1668	The assumption in this key is that…
60	1671	…rate has a…
61	1679	…may decrease the likelihood…
61	1687	…outcomes and likelihood of illness.
61	1691	Where severity of the hazard…

Page	Paragraph or Line #	Comment or Question
61	1694	The following assumptions (L1694-1699) are false: "For the purposes of this assessment, we make the assumption that the likelihood of exposure is directly proportional to the risk of illness, meaning that we assume that there is not a dose-response relationship and any amount of contamination would be expected to cause illness. We also assume that any contamination that may occur while on farm will carry through to the point of consumption, and that the level of contamination neither increases nor decreases unless contamination is minimized through consumer or retail handling practices, as described in section IV.D.1., above." The scientific literature contains considerable information on the survival, growth, and death of pathogens on produce after harvest, including during processing and extended storage which could be considered.
62		In Table 2, the specific severe hazards associated with those products that are identified as posing a low risk of illness (e.g., apples, pears, peaches, etc.) are unclear.
64	1737	…literature establishes that…
References		The reference titles differ in terms of style/capitalization. All organism names should be italicized. Some of the reports and other documents are in need of web links for easy access. The date of accession should also be included.

REVIEWER #5

Peer Review Comments on FDA's Draft Qualitative Assessment of Risk (QAR)

Reviewer #5

I. GENERAL IMPRESSIONS

Overall, my general impression of the document is that it is well written, reasonable, transparent, and clear. The authors have done a good job of addressing an important and complex topic, and presenting the material in a way that is accessible to a wide audience, while simultaneously presenting sufficient technical information to generally support the methods and findings. I do have a number of specific comments that I hope will be helpful to bolster the basis and soundness of the work.

I am confident that the documents will, upon minor revision, meet its stated goal "to provide support for risk management decisions that are responsive to Section 419 of the FD&C Act, which directs FDA to establish science-based minimum standards for the safe production and harvesting of those types of fruit and vegetable raw agricultural commodities for which we determine that such standards minimize the risk of serious adverse health consequences or death (section 419(a)(1)(A) of the FD&C Act)."

II. RESPONSE TO CHARGE QUESTIONS

1. ***1. Are the risk analysis framework and the risk management approach appropriate for the intended purpose of the QAR?***

   I do believe that the risk analysis framework is appropriate for the QAR. The framework is one of the standard and accepted frameworks within the field of microbial risk assessment. While there are other frameworks that could have been applied, the selected one is reasonable and consistent with standard practice.

   In terms of the risk management approach, I have two thoughts. First, I believe that basing risk management off of a qualitative assessment is reasonable in this case. I believe that a lack of data and extensive uncertainty and variability prohibit the conduct of a defensible quantitative microbial risk assessment for this purpose. Second, I think that in fact, the actual risk management approach being applied by FDA for this work is happening outside of the scope of this document. Little actual risk management is documented here. However, I do not believe that the separation of risk management from risk assessment detracts from the merit of this report.

2. ***Are the scope and purpose of the QAR clearly identified? If not, what additional information should be provided?***

   Yes, the scope and purpose of the QAR are clearly identified.

3. ***Are the questions to be addressed in the QAR appropriate, given the scope and purpose of the QAR? If not, what changes would you suggest?***

Yes. However, the answer to Q1 is not sufficiently justified within the context of the assessment. See my specific comments below. The use of reference pathogens is fine for this purpose, but more justification is needed regarding their selection for this assessment.

4. Does the QAR adequately cover the routes of contamination found on farms during the growing, harvesting, handling, packing and storing of produce? If not, what other routes or considerations should be addressed?

This question is outside of my scope of expertise.

5. Does the selection of commodities in the QAR appear to adequately represent those commodities expected to fall within the scope of this document?

It seems to me that the selection of commodities in the QAR does appear to adequately represent those commodities expected to fall within the scope of this document. However, this question is outside of my scope of expertise.

6. Considering the scope and purpose of the QAR, are the approaches to hazard identification, characterization, exposure assessment, and risk characterization appropriate?

Yes. However, I have a number of specific comments listed below. In particular, I have a few questions about the methodology used in the exposure assessment and the implications on the overall findings. See comments below regarding sensitivity of the overall findings on assumptions employed in the exposure assessment.

7. Is the approach for determining the qualitative risk of each route/produce item combination in the draft QAR reasonable, given the purpose of the QAR? If not, how might this be revised?

I like the approach that was taken. However, I question how sensitive the overall results of the assessment are to the assumptions employed. Either a discussion on this point or a sensitivity analysis would provide an answer to this question. See comments below.

8. Do the conclusions drawn seem appropriate given the information presented during the identification, characterizations, and assessments within this document?

The conclusions do seem appropriate. As noted above, I would be more comfortable with the overall conclusions if it were clear that the results are robust to the specific assumptions employed.

9. Is the report written in a transparent and clear manner? If not, how might the report be revised?

Yes, in fact I believe that this is one of the strengths of the document.

10. Does the report adequately address the questions and stated objectives?

I believe that the report does a good job of addressing the questions and stated objectives, subject to minor modifications, as indicated below in my specific comments.

11. Are there further data gaps or research needs that are necessary to address in order to further refine this assessment?

I am not aware of additional data gaps that need to be addressed.

12. Do you have any additional comments that might improve the document?

Yes, please refer to my specific comments below.

III. SPECIFIC OBSERVATIONS

Page	Paragraph or Line #	Comment or Question
2	97-107	It appears that the time periods described were selected to complement each other and extend the "time lens" evaluated. If this is the case, please state this specifically. If not, please explain why these time periods were selected.
3	114	How many outbreaks does this represent?
5	190-202	This is a critical section of this report. Within the field of microbial risk assessment, "reference pathogens" are commonly used as they are in this report. The selection of reference pathogens is one of the most important aspects of planning and scoping of a risk assessment. While I do not necessarily disagree with the selected reference pathogens, the justification for their selection (lines 197-199) is inadequate. I suggest a much more thorough discussion is needed here because the technical merit of the report hinges on the selection of these reference pathogens.
6	221 (and many other locations in report such as lines 243 and 262)	The use of the term "infectious dose" must be corrected in this report. An "infectious dose", as used in this report, implies that a dose below the reported value will not cause infection. That concept not in line with the current science supporting dose response relationships. Either refer to relative levels of infectivity or values such as an ID_{50} for any specific pathogen. This is a critical point so that there is no misunderstanding about the process that can lead to infection and illness from exposure to microbial pathogens.
7	224	Citation needed after "8 days."
11	388-394	I would like to see this discussion framed within the context of "extreme events." It appears that some produce products are likely candidates for outbreaks (cantaloupe, berries, leafy greens, etc.), whereas others very rarely occur. This type of phenomenon is common to other media also. I suggest that connecting these types of events (for example, wet weather events and recreational water contamination) will broadly support the basis for approach taken.

Page	Paragraph or Line #	Comment or Question
22-23	673-690	I urge a little caution in this section. There are several types of water systems in the US (all of which I believe are defined as public water systems), some of which exhibit varying likelihoods of contamination. For example, there are transient community water systems, non-transient community water systems, large community water systems, etc. I suggest a review of US EPA drinking water regulations would ensure that the write-up in this section is accurate.
25-26	786-810	This section should mention the possibility of regrowth of bacterial pathogens. If regrowth is not of concern, then a justification and explanation should be provided.
26	812-816	This section needs a little more detail to be clear.
26	828	Need to define agricultural tea here.
31	979-981	This is a little misleading in that the reference is for the Part 503 rule which is specifically for biosolids. I think you need to indicate that treatment is included in the requirements and that there are several classes of biosolids and restrictions that correspond to each of the classes.
31	1010-1012	This sentence should state that "We assume….." rather than "We consider…." You may consider adding a sentence indicating why you assume this (for example, is this simply a health protective assumption).
32	1050	I suggest that "years" is sufficient, and you remove indefinitely, unless it is strongly supported by the literature.
33	1063	A little caution is needed here. For example, Class A biosolids are materials (according to the regulation) that are pathogen free (or nearly pathogen free). So, you may consider the wording in this line or the supporting statements in the text.
34 and 39	1091-1092 and 1308-1309, for example	Units are needed. 10^7 per what?
43	1424-1458	This section causes concern for me. In this section you have gone from a qualitative assessment to a quantitative scaling, but you have done so without technical support. I understand why you have done this, but how does this scaling impact your findings. For example, if your scaling were different, would the overall results change? I would like to see either a sensitivity analysis on this point or a robust discussion explaining the technical justification for the relative scaling.
43	1442-1451	Need an explanation justifying the selection of these cut points.
45		Table 9 needs to be more transparent regarding how the "route score" is computed for each row. I was able to duplicate them, but doing so requires specifically going back to the text to see what each cell value is. I think the table needs to be easier to understand as a stand-alone entity.

Page	Paragraph or Line #	Comment or Question
55		The discussion before and after Table 11 is needed to understand what is in the Table. You may consider moving the supporting text to before Table 11 in the document so that the context is presented before the Table. That will make the table easier to understand for the reader. Also, the table needs a color key in a legend. Much like my previous comments, I believe these tables should serve as stand-alone entities and not rely on the text that supports them.
60	1656-1659	Need to justify the selected cut points.
60	1668	Need to explain why this assumption is made for the key in Table 12.
92	2439-2443	Some additional text here would be beneficial explaining why the results from this comparison are so different (only 44% scored similarly) from the main text and what the implications are.

V. PEER REVIEWER COMMENT TABLE

I. GENERAL IMPRESSIONS		
REVIEWER	**COMMENT**	**RESPONSE**
Reviewer #1	The QAR provides a foundation for understanding the potential hazards and likely routes of contamination for produce that may be eaten raw and an assessment the risk of illness from consuming a specific commodity. The QAR concludes that the likelihood of a commodities contamination is due to agricultural practices more than characteristics of the commodity. Sprouts may be an exception to this as the commodity may not be separated from the agricultural practice due to the possibility of seed contamination and their production. Seeds as a verified route of contamination are noted in the QAR, but they should be elevated to a route of contamination equivalent to water, soil, etc. The QAR calculates the likelihood of exposure using produce consumption rates which might be misleading. The QAR calculation as calculated may reflect the risk of the general consumer, but may under estimate the risk of the consumer of a specific commodity. For example, Table 11 has a medium rate of consumption for sprouts, but its likelihood of contamination is higher. Thus, the calculated likelihood of exposure is medium, when in truth for a consumer of sprouts, their exposure is higher. It is noteworthy that results from the MDP were critical to determine the likelihood of exposure and the subsequent assessment of the risk of illness. Since the MDP includes a limited number of commodities, a continuation of the MDP or expansion should be included in the data gaps. Finally, the QAR lists survival and growth of pathogens on produce under data gaps and research needs, but makes no mention of plant pathogens, recognized biological multipliers of human pathogens on plants. How plant disease contributes to contamination of produce with human pathogens is unknown, yet important due to their role in pathogen growth and survival.	
Reviewer #2	In Section 419 of the FD&C Act, FDA was tasked with providing minimum standards for the safe production and harvesting of fruit and vegetable raw agricultural commodities. To provide transparency to this task as to how these standards were derived, the FDA drafted this document, "Qualitative Assessment of Risk to Public Health from On-Farm Contamination of Produce," summarizing the currently available scientific data on routes of on-farm contamination and potential interventions that could affect the risk of raw agricultural commodities. In addition, they attempted to categorize the different raw agricultural commodities as to their relative risk of contamination so that the severity of applied standards would be in proportion to that level of risk. Although the FD&C Act stipulates that biological, chemical and physical hazards be addressed in their setting of standards, they have rightfully focused on biological hazards that present the greatest risk to public health. Utilization of a risk analysis framework and risk management	

I. GENERAL IMPRESSIONS		
REVIEWER	**COMMENT**	**RESPONSE**
	approach is moreover the best structured means by which presentation of the scientific data on biological hazards proceeds in a linear and logical fashion. Tables and bulleted lists are, for the most part, used effectively to illustrate the approach and document evidence and decisions. In my opinion, where the document fell a little short in this area is the decision to place summary tables before tables that explained how that table was derived (see Specific Comments section for affected tables). My preference would be the opposite as I need to understand the process before I see the outcome. Overall, the presentation of information is clear; however, referencing in the document could be improved. Specifically, there was a large section that was incorrectly numbered, several references had insufficient information to allow the reviewer to access that publication, and there were several other instances, as noted in the Specific Comments section, where references were incorrect or another reference would be more appropriate. The bulleted conclusions made for each of the five identified sources of contamination were reasonable given the current body of knowledge regarding on-farm contamination of raw agricultural commodities. As noted in charge question #4, it would be prudent to also discuss the potential for bioaerosols to be a contributing source of contamination. Definitely, there is less conclusive proof that bioaerosols serve as a route of contamination but if more definitive proof were to come to light in the future, its inclusion in this document would provide a clearer path toward implementing standards to minimize that potential route. To account for the large disparity in commodity types and production practices, risk assessments were conducted on 46 different commodities that primarily took into account the likelihood of contamination on the farm and their rate of consumption for each commodity. As noted in charge question #7, I'm concerned that increasing the score of suspected sources that were found in epidemiological investigations of outbreaks, to be inherently biased. This bias is not so evident in commodities that one would expect to be at very high risk (i.e., leafy greens, tomatoes) or very low risk (i.e. citrus fruits), but could affect the relative risk of commodities in between these two extremes. I suspect that many different scoring systems were considered in this task and the scoring system used for the QAR was considered the best for the datasets currently available. It would be prudent, however, to point out the limitations in their scoring system and	

I. GENERAL IMPRESSIONS		
REVIEWER	**COMMENT**	**RESPONSE**
	make note that future scoring iterations may involve a different scale that is reflective of new information collected to fill the data gaps.	
Reviewer #3	The described scope of the document is to provide a qualitative risk assessment (eg., ranking the probability as low, medium, or high) of the potential for adverse human health consequences related to the consumption of a variety fresh fruits and vegetables contaminated prior to harvest (on the farm) with microbial pathogens (bacteria, viruses, and parasites). Biological hazards of concern are listed, current knowledge of how fruits and vegetables become contaminated during the pre-harvest stages of production are outlined, and the likelihood of contamination of specific produce items, and subsequent illness attributed to specific produce commodities, are reviewed and ranked. This task, although clearly defined, is enormous and daunting. The lack of supporting data in many of the areas of investigations leave numerous gaps in our understanding of the process of microbial contamination of produce and therefore requires some degree of scientific inference to be applied to achieve qualitative risk rankings. Notwithstanding these inherent limitations of the available scientific literature, the document provided is comprehensive, clearly written with logical flow and is based on the science that is available. It is a valuable summary document that may be useful in guiding the development of risk mitigation and management strategies surrounding known issues pertaining to vegetable production.	
Reviewer #4	This document describes a qualitative risk assessment for on-farm contamination of fresh fruits and vegetables. A total of nine microbial pathogens have been targeted based on the top five pathogens found in produce (*Salmonella,* enterohemorrhagic *Escherichia coli, Shigella, Cyclospora cayetanesis*, *Hepatitis A)* or severity of illness (*Listeria monocytogenes*, *Norovirus, Cryptosporidium parvum,* and *Giardia lamblia*) as evidenced from other produce-associated outbreaks that have been documented in the literature. Hence, pathogens that have been chosen and characterized are appropriate given the overall intent. The strength of this risk assessment lies in the identification of the on-farm routes of contamination which have been categorized as water, soil amendments, animals, worker health and hygiene, and equipment and buildings, with these routes of contamination well-documented through both the scientific literature and investigative reports from various produce-associated outbreaks. The document includes an assessment of the likelihood of potential contamination from these on-farm routes for 43 different types of produce (Table 9 in the report) along with a likelihood of exposure assessment based on	

I. GENERAL IMPRESSIONS		
REVIEWER	**COMMENT**	**RESPONSE**
	a national food consumption survey and finally a determination of the risk of illness from these same 43 types of produce. While the overall conclusions from this qualitative risk assessment are generally appropriate, the current report does not adequately address the changes in pathogen levels that may occur during subsequent processing (e.g., conveying, washing, peeling, slicing, dicing, drying), shipping, retail storage/display, and storage in the home by consumers. Nonetheless, this risk assessment represents an important first step in determining the relative risks associated with the vast majority of products that are most widely consumed by the public.	
Reviewer #5	Overall, my general impression of the document is that it is well written, reasonable, transparent, and clear. The authors have done a good job of addressing an important and complex topic, and presenting the material in a way that is accessible to a wide audience, while simultaneously presenting sufficient technical information to generally support the methods and findings. I do have a number of specific comments that I hope will be helpful to bolster the basis and soundness of the work. I am confident that the documents will, upon minor revision, meet its stated goal "to provide support for risk management decisions that are responsive to Section 419 of the FD&C Act, which directs FDA to establish science-based minimum standards for the safe production and harvesting of those types of fruit and vegetable raw agricultural commodities for which we determine that such standards minimize the risk of serious adverse health consequences or death (section 419(a)(1)(A) of the FD&C Act)."	

II. RESPONSE TO CHARGE QUESTIONS

CHARGE QUESTION 1: ***Are the risk analysis framework and the risk management approach appropriate for the intended purpose of the QAR?***		
REVIEWER	**COMMENT**	**RESPONSE**
Reviewer #1	Yes.	
Reviewer #2	Yes, a risk analysis framework and risk management approach was the most logical avenue for utilizing scientific and epidemiological data to identify the risks where contamination of produce on the farm occurs and which risks could be minimized through the application of regulatory standards.	

CHARGE QUESTION 1: ***Are the risk analysis framework and the risk management approach appropriate for the intended purpose of the QAR?***		
REVIEWER	**COMMENT**	**RESPONSE**
Reviewer #3	A risk analysis approach is ideal for evaluating the risk of developing infectious disease associated with the consumption of contaminated produce. Some of the hallmarks of this method are that they are: 1) data supported, 2) transparent, 3) systematic, 4) documented, and 5) reproducible. It is recognized that this is an iterative process and as new information becomes available it will be necessary to update and re-evaluate the document. Other skilled individuals with access to the same data should be able to develop a risk model, and hopefully achieve comparable results.	
Reviewer #4	The risk analysis framework and approaches being proposed are generally appropriate given the overall intent.	
Reviewer #5	I do believe that the risk analysis framework is appropriate for the QAR. The framework is one of the standard and accepted frameworks within the field of microbial risk assessment. While there are other frameworks that could have been applied, the selected one is reasonable and consistent with standard practice. In terms of the risk management approach, I have two thoughts. First, I believe that basing risk management off of a qualitative assessment is reasonable in this case. I believe that a lack of data and extensive uncertainty and variability prohibit the conduct of a defensible quantitative microbial risk assessment for this purpose. Second, I think that in fact, the actual risk management approach being applied by FDA for this work is happening outside of the scope of this document. Little actual risk management is documented here. However, I do not believe that the separation of risk management from risk assessment detracts from the merit of this report.	

CHARGE QUESTION 2: ***Are the scope and purpose of the QAR clearly identified? If not, what additional information should be provided?***		
REVIEWER	**COMMENT**	**RESPONSE**
Reviewer #1	Yes.	
Reviewer #2	In the first page of the document, the scope and purpose of the QAR are clearly delineated.	
Reviewer #3	The stated goal of the QAR is to "provide a scientific evaluation of potential adverse health effects resulting from human exposure to hazards in produce, with a focus on public health risk associated with on-farm microbial contamination."	

CHARGE QUESTION 2: ***Are the scope and purpose of the QAR clearly identified? If not, what additional information should be provided?***		
REVIEWER	**COMMENT**	**RESPONSE**
	What is provided is a Risk Assessment. It is not a complete risk analysis in the classical sense, as it does NOT address risk management nor risk communication. It is indeed a good start on the risk assessment. In general, including the word "potential" in the framework makes this work too broad, less appropriate, and it is not fulfilled by the narrative that follows. First, there are many "potential" microbes that could contaminate produce and make them deleterious to health. What is provided is a risk assessment of the likelihood of becoming ill following the consumption of produce. The document does not sufficiently emphasize the level of uncertainty and variability inherent in the model due to the absences of data in some aspects.	
Reviewer #4	Both the scope and purpose of the QAR are clear.	
Reviewer #5	Yes, the scope and purpose of the QAR are clearly identified.	

CHARGE QUESTION 3: ***Are the questions to be addressed in the QAR appropriate, given the scope and purpose of the QAR? If not, what changes would you suggest?***		
REVIEWER	**COMMENT**	**RESPONSE**
Reviewer #1	Yes.	
Reviewer #2	The four questions encompass the major issues that serve to define the level of risk associated with different raw agricultural produce commodities and the on-farm activities that would impact risk.	
Reviewer #3	There were four questions posed: 1. What are the hazards? 2. How does produce become contaminated (on the farm)? 3. Is the likelihood of contamination different among different commodities? 4. Does the likelihood of illness depend upon type of produce consumed? Hazards identification is performed by listing foodborne disease outbreaks associated with produce and fruits. Two databases were used for the hazard identifications: a CDC and an FDA database. Although it is presumed that this QAR is tailored for the USA, it might be beneficial to look at other databases describing sources of disease, both within and outside the US, to attempt to make it as comprehensive as possible. The section on data limitations II, A, 3 is good, However, in addition, the section on data	

CHARGE QUESTION 3: ***Are the questions to be addressed in the QAR appropriate, given the scope and purpose of the QAR? If not, what changes would you suggest?***		
REVIEWER	**COMMENT**	**RESPONSE**
	limitations could be expanded to include the implications of relying only on outbreak data and the fact that many foodborne disease outbreaks do not have a known pathogen etiology. The primary pitfall of this approach is that the attributable fraction of produce contamination that pre-harvest and post harvest is not precisely known. Although extensive investments are being made to better understand (and subsequently intervene) during the pre-harvest stages of production, if pre-harvest contamination accounts for only 10% of the contamination events, then, even with 100% elimination of these routes of contamination, 90% of the contamination will still remain within the system. Thus, it is important that a holistic approach be used to assess contamination and illness at all stages of production, storage and preparation so resources and intervention strategies can be directed at the stages of within the food chain that would receive the greatest magnitude of enhancement. Question 2: The routes of contamination are outlined to the extent that available knowledge is available. It would be valuable to indicate that this list may not be exhaustive and other routes of contamination may be identified. Like, it is important to indicate the gaps in knowledge in respect to the lack of data regarding which of these routes contribute the most to vegetable contamination. For example, irrigation water may occasionally be contaminated with pathogens, but if they do not reach the edible portions of the produce and do not survive, then extensive mitigation strategies to completely eliminate them from irrigation sources may have negligible impacts on contamination rates and subsequent illnesses. It is not possible to answer question 3 (variability of contamination among produce types) with the information provided. The method used to prioritize/rank likelihood of contamination is flawed; it was based on the commodities that had been linked to outbreaks. The incidence of outbreaks associated with a particular commodity is not necessarily directly proportional to the frequency and magnitude of contamination. In fact, it is likely there is much more contamination that occurs on the farm that never results in disease outbreaks because of a number of other factors (which are described elsewhere in the document, such as die-off). Other factors, such as lower pathogenicity of certain strains, magnitude of contamination and host immunity, also likely play important roles in governing whether an outbreak will occur, such as the frequency of consumption and preferred method of preparation and storage. These factors are accounted for in	

CHARGE QUESTION 3: ***Are the questions to be addressed in the QAR appropriate, given the scope and purpose of the QAR? If not, what changes would you suggest?***		
REVIEWER	**COMMENT**	**RESPONSE**
	the risk model and including the number of outbreaks as a surrogate measure of contamination is redundant. Information, at least on a limited number of produce commodities, is available in the USDA Microbiological Data Program, the MDP. However, even here it is limited, as MDP samples were collected at retail, and could be indicative of contamination at any point, including off-farm sources, prior to collection. In reference to the fourth question, it is important to prioritize where the interventions could be focused to reduce the greatest number of illnesses. The produce most likely contaminated may not be the ones responsible for the largest number of illnesses because of the factors mentioned above, especially consumption rates. It is not clear how the proposed model for assigning risk is superior to the FDA-RTI 2011 risk ranking model (or any explanation of why there are differences) or how this method is better than simply determining the number of illnesses attributed to contaminated tomatoes (or whatever commodity) and dividing by the per/person estimate of tomato consumption.	
Reviewer #4	The four questions posed are appropriate given the focus of this risk assessment on on-farm contamination of produce. However, in the broader sense, risk to consumers cannot be fully addressed without also considering the impact of post-harvest off-farm processing (e.g., value-added products that are commercially washed, sliced/diced, and packaged) on contamination levels, and the time/temperature histories that products encounter during transport, retail storage/display and consumer storage.	
Reviewer #5	Yes. However, the answer to Q1 is not sufficiently justified within the context of the assessment. See my specific comments below. The use of reference pathogens is fine for this purpose, but more justification is needed regarding their selection for this assessment.	

CHARGE QUESTION 4: ***Does the QAR adequately cover the routes of contamination found on farms during the growing, harvesting, handling, packing and storing of produce? If not, what other routes or considerations should be addressed?***		
REVIEWER	**COMMENT**	**RESPONSE**
Reviewer #1	By not including <u>seeds</u> in Section IV. Exposure Assessment, B. Routes of Contamination, the importance of this <u>confirmed</u> route of contamination is diminished. The page 41 discussion of seeds states "…has not been demonstrated to be relevant..." Perhaps the question should be: Have seeds been considered a route of contamination for crops other than sprouts?	

CHARGE QUESTION 4: ***Does the QAR adequately cover the routes of contamination found on farms during the growing, harvesting, handling, packing and storing of produce? If not, what other routes or considerations should be addressed?***		
REVIEWER	**COMMENT**	**RESPONSE**
Reviewer #2	The routes of contamination that are discussed in this document would be the ones that are likely to be the most prevalent as well as the ones where some degree of control may be asserted to minimize the contamination. The only other route of contamination that could be addressed is bioaerosols which I would rank as the 6th most probable route of contamination. There are limited studies addressing this route and of those that have been conducted, the scientific data appears conflicting as to whether they would contribute significantly to contamination of produce fields. Despite this inconclusive data, it seems plausible that produce on a farm could be contaminated on a regular basis if there are wind patterns that consistently blow across a heavily populated cattle operation or manure composting operation immediately before it reaches the produce farm.	
Reviewer #3	Known routes of contamination are covered. Again, there should be sufficient description of the data gaps and uncertainty, including the statement that for most outbreaks and contaminated product, the source of the contamination is never identified.	
Reviewer #4	The primary routes for on-farm contamination of produce have been adequately covered with the information presented being well-supported from the scientific literature and various outbreak investigations. A few additional areas that could be considered would include dust and air-borne contaminants (e.g., produce fields down-wind from cattle feed lots), leakage from septic tanks, flies, insect infestations (related to climactic conditions and overall health of the crop), wooden vs. plastic totes, conveyor belting materials (continuous smooth vs. interlocking belts), and the impact of biofilms on equipment as related to improper cleaning, sanitizing and equipment maintenance.	
Reviewer #5	This question is outside of my scope of expertise.	

CHARGE QUESTION 5: ***Does the selection of commodities in the QAR appear to adequately represent those commodities expected to fall within the scope of this document?***		
REVIEWER	**COMMENT**	**RESPONSE**
Reviewer #1	Yes.	
Reviewer #2	To the best of my knowledge, the commodities selected for consideration in this QAR appear to address the major ones consumed and produced in the U.S. and that would fall within the scope of this document.	
Reviewer #3	Yes.	

CHARGE QUESTION 5: ***Does the selection of commodities in the QAR appear to adequately represent those commodities expected to fall within the scope of this document?***		
REVIEWER	**COMMENT**	**RESPONSE**
Reviewer #4	The 43 commodities chosen comprise a highly diverse group of fruits and vegetables and represent the vast majority of such products that are regularly consumed by the public.	
Reviewer #5	It seems to me that the selection of commodities in the QAR does appear to adequately represent those commodities expected to fall within the scope of this document. However, this question is outside of my scope of expertise.	

CHARGE QUESTION 6: ***Considering the scope and purpose of the QAR, are the approaches to hazard identification, characterization, exposure assessment, and risk characterization appropriate?***		
REVIEWER	**COMMENT**	**RESPONSE**
Reviewer #1	The exposure assessment includes rate of consumption. Thus, if a crop is less likely to be eaten, then the likelihood of exposure was calculated as lower. However, the likelihood of exposure to a consumer is for every crop consumed, not just those commonly eaten by the entire populace.	
Reviewer #2	The approaches used for hazard identification, characterization, exposure assessment and risk characterization were fundamentally sound and appropriate. The inclusion of Table 13, however, was not needed as no change in the relative rankings of the commodities occurred and in every case, the likelihood of exposure equaled the risk of illness. Therefore, the right-most column in Table 11 could easily have been labeled "Likelihood of Exposure or Risk of Illness." Moreover, including Table 13 could lead some readers to question why a high severity of hazard and a medium likelihood of exposure would lead to only a medium risk of illness and not a high risk of illness as would be taken if a worst case scenario approach were being used.	
Reviewer #3	ID - adequate. Exposure - see above. The inclusion of food commodity specific consumption rates is an excellent idea. However, this document assigns level of contamination of particular products based on outbreak frequency and then uses that data to predict risk of illness (outbreak frequency). This is a circular argument. Problematic is that the predicted level of contamination does not always coincide with available data from the MDP database. Characterization - the lack of dose response and the assumption that the likelihood of disease is directly proportional to the exposure assessment is a serious limitation of the risk model.	

CHARGE QUESTION 6: ***Considering the scope and purpose of the QAR, are the approaches to hazard identification, characterization, exposure assessment, and risk characterization appropriate?***		
REVIEWER	**COMMENT**	**RESPONSE**
Reviewer #4	The approaches to hazard identification, characterization, exposure assessment, and risk characterization are appropriate. However, as mentioned earlier, the weak links in this risk assessment include post-harvest processing (value-added fresh-cut produce), distribution, retail storage/display, and consumer storage practices prior to consumption, with this risk assessment assuming that any on-farm contamination will carry through to the point of consumption, and that the level of contamination neither increases nor decreases unless contamination is minimized through consumer (cooking or peeling – not washing) or retail handling practices.	
Reviewer #5	Yes. However, I have a number of specific comments listed below. In particular, I have a few questions about the methodology used in the exposure assessment and the implications on the overall findings. See comments below regarding sensitivity of the overall findings on assumptions employed in the exposure assessment.	

CHARGE QUESTION 7: ***Is the approach for determining the qualitative risk of each route/produce item combination in the draft QAR reasonable, given the purpose of the QAR? If not, how might this be revised?***		
REVIEWER	**COMMENT**	**RESPONSE**
Reviewer #1	Yes.	
Reviewer #2	At first glance, I found the approach used to classify the qualitative risk associated with each route/produce item to be reasonable. In particular, I agree that the supporting information found in Table 10 for commodity/practice ranking pair decisions in Table 9 is practical; however, I would suggest that under the category Soil Amendments and Tree Crops that an acknowledgment be made that indirect contamination to tree fruit by climbing animals (i.e. squirrels) and birds would increase if a contaminated soil amendment were to be placed on top of the soil beneath the trees. Such an acknowledgment would not change the relative ranking of that practice. There would still be greater risk for soil amendments being applied to soil where contact with the crop could occur and a lower risk for pasteurized soil amendments being used for the cultivation of mushrooms. On further examination of the other portion of the scoring scheme (differentiating between relatively higher and medium rankings), I did find some limitations. More specifically, by applying a higher score for all the routes identified as deficient when an outbreak investigation was conducted, a higher total score may occur for that commodity than for a commodity which	

CHARGE QUESTION 7: ***Is the approach for determining the qualitative risk of each route/produce item combination in the draft QAR reasonable, given the purpose of the QAR? If not, how might this be revised?***		
REVIEWER	**COMMENT**	**RESPONSE**
	may have identified fewer potential routes. For example, according to reference "ix", municipal water that supplied the packing shed of parsley was unchlorinated and workers had limited sanitary facilities available on the farm at the time of the outbreak. Since workers at Farm A were involved in both harvest and postharvest activities, the total score for parsley increased by 6 instead of just by 3 and led to it being placed in the category of higher relative likelihood of contamination on-farm. In contrast, grapes for which one outbreak had been recorded in 2001, was placed in a lower relative likelihood of contamination on-farm because the epidemiology investigation failed to identify the farm and potential sources of contamination. Therefore, the scoring system appears to be dependent more on the relative success or strength of the epidemiological investigation rather than on the routes that actually contributed to the contamination in an outbreak. In essence, finding more deficiencies at a farm, even though only one deficiency may have been the culprit, increases the route score risk of that commodity. Another limitation in using their scoring system is that it appeared that they only considered epidemiological investigations associated with outbreaks that occurred in the U.S. One epidemiological investigation that explored an outbreak of *Salmonella* in contaminated papaya in Australia found that untreated river water was used for washing papaya and therefore it was considered as a suspected vehicle. If this study had been included in this rating exercise, papaya would have received a total route score placing it in the category of having a medium relative likelihood of contamination on-farm rather than the lower relative likelihood of contamination on-farm. Given the disparity in epidemiological investigations and the associated bias they introduce to this scoring system, I would suggest that the scoring system used for medium, relatively lower, and not applicable continue, but that higher risk commodities perhaps be based on the number of outbreaks that has occurred with that product.	
Reviewer #3	Given that certain pathogen:commodity pairs are overrepresented as a cause of outbreaks, grouping all pathogens together for each commodity may introduce some biases. For example, the dose response to *E. coli* O157 is different than that of *Salmonella*. *Salmonella* has been reported as a cause of far more illnesses than E. coli in tomatoes. Virulence differences among pathogens associated with different commodities is not accounted for in the model. More weight should be placed on the more likely pathogen to cause a disease.	

CHARGE QUESTION 7: ***Is the approach for determining the qualitative risk of each route/produce item combination in the draft QAR reasonable, given the purpose of the QAR? If not, how might this be revised?***		
REVIEWER	**COMMENT**	**RESPONSE**
Reviewer #4	Use of the ordinal scale to assign risk (Table 9) appears to be a reasonable approach with N/A = 0, Lower = 1, Medium = 3, and Higher = 6. Except for a few commodity/contamination routes as noted later, the assigned risks (lower, medium, higher) and the resulting scores also generally seem to be appropriate.	
Reviewer #5	I like the approach that was taken. However, I question how sensitive the overall results of the assessment are to the assumptions employed. Either a discussion on this point or a sensitivity analysis would provide an answer to this question. See comments below.	

CHARGE QUESTION 8: ***Do the conclusions drawn seem appropriate given the information presented during the identification, characterizations, and assessments within this document?***		
REVIEWER	**COMMENT**	**RESPONSE**
Reviewer #1	Yes.	
Reviewer #2	Given the state of our knowledge on the subject area and the discussion provided in this document on identification, characterization and assessment of risks associated with raw agricultural commodities, the conclusions drawn are fundamentally sound and reasonable.	
Reviewer #3	Most of the conclusions reported are supported by the narrative and cited references.	
Reviewer #4	The first four conclusions on page 64 are appropriate based on analysis of the data presented. However, the last conclusion states that "Postharvest practices such as cooking (and, possibly certain peeling practices) before consumption may have an impact on the likelihood of contamination of the edible portion and the likelihood of illness." While this is true, washing, which typically removes 90 – 99% of the microbial contamination, will also decrease the likelihood of foodborne illness, particularly for those pathogens having a higher oral infectious dose. If this latter notion is not considered, the common consumer practice of washing could potentially decrease for certain types of produce.	
Reviewer #5	The conclusions do seem appropriate. As noted above, I would be more comfortable with the overall conclusions if it were clear that the results are robust to the specific assumptions employed.	

CHARGE QUESTION 9: ***Is the report written in a transparent and clear manner? If not, how might the report be revised?***		
REVIEWER	**COMMENT**	**RESPONSE**
Reviewer #1	Yes.	
Reviewer #2	The discussion within the report was written in a clear manner and it followed a logical progression toward understanding the various components that would affect the risk of a raw agricultural produce commodity. The one component to this report that I felt weakened the report in terms of its transparency was the reference section. As noted under specific observations, there were several citations that I could not find (to confirm the accuracy of the information presented) because the article title was not given (#31 and #38). One of the references that was noted to have additional details on sampling activities within it was also inaccessible (#184). In addition, there was a huge section of the document where most of the references cited did not match the subject matter being discussed. As an example, an article on thermal resistance of *E. coli* in apple juice was referenced for domestic and wild animals as being carriers of human pathogens. While these errors may be easily corrected in the revised draft, for my review, I was unable to verify that the proper references were being provided for the information they presented.	
Reviewer #3	Yes.	
Reviewer #4	The report has been well-prepared and appears to be free from any undue bias.	
Reviewer #5	Yes, in fact I believe that this is one of the strengths of the document.	

CHARGE QUESTION 10: ***Does the report adequately address the questions and stated objectives?***		
REVIEWER	**COMMENT**	**RESPONSE**
Reviewer #1	Yes.	
Reviewer #2	Overall, the report adequately addresses the four questions made at the beginning of the document and laid the foundation for generating practices and standards that would reduce the risk associated with the production and harvesting of raw agricultural produce commodities.	
Reviewer #3	See responses above.	
Reviewer #4	The questions and stated objectives have generally been adequately addressed except as previously noted.	
Reviewer #5	I believe that the report does a good job of addressing the questions and stated objectives, subject to minor modifications, as indicated below in my specific comments.	

CHARGE QUESTION 11: ***Are there further data gaps or research needs that are necessary to address in order to further refine this assessment?***		
REVIEWER	**COMMENT**	**RESPONSE**
Reviewer #1	The document does not take into account the role of plant disease as a multiplier of human pathogens. Whereas human pathogens grow poorly in the phyllosphere, since they cannot penetrate healthy plant tissue, plant pathogens can liberate nutrients from plants, thus, providing a nutrient source for human pathogens that can lead to subsequent increase in the human pathogen population.	
Reviewer #2	The areas listed are very broad and if they were to be read by themselves, it would give the impression that we are completely void of any knowledge of food safety risks that are associated with raw agricultural fruits and vegetables. More specificity and prioritization of those data gaps would ensure that scarce resources will be applied to areas that will have the greatest impact on reducing foodborne illness association with produce.	
Reviewer #3	The attributable fraction of contamination that occurs (and persists) from pre-harvest stages of production is essential in order to estimate the impact of pre-harvest control of pathogens.	
Reviewer #4	Additional data gaps include: 1) the origin, incidence and levels of pathogens in field-grown produce, 2) the distance between produce fields and livestock operations needed to minimize contamination, 3) on-farm routes for pathogen transfer (e.g., from soil to tractors / harvesters to produce to conveyors to bins), 4) post-processing routes for transfer (conveying, flume washing, shredding, slicing, dicing, drying), 5) sanitizer use and efficacy during flume washing, 6) extent to which contaminated products mix with uncontaminated products during commercial processing, 7) pathogen growth in/on produce during transport and retail storage/display, 8) consumer storage practices for fresh produce, and 9) consumer preparation practices (e.g., washing practices, slicing, dicing, cutting board).	
Reviewer #5	I am not aware of additional data gaps that need to be addressed.	

CHARGE QUESTION 12: ***Do you have any additional comments that might improve the document?***		
REVIEWER	**COMMENT**	**RESPONSE**
Reviewer #1	The document does not mention that infectivity of the biological hazards have not been assessed from contaminated plants, most relevant for bacteria.	
Reviewer #2	Numerous comments are provided in Section III below.	
Reviewer #3	Reference 52 is incomplete. Is it true the FDA surveillance had no reported outbreaks of disease associated with noroviruses between 1996-2010 (Table 2)?	

CHARGE QUESTION 12: ***Do you have any additional comments that might improve the document?***		
REVIEWER	**COMMENT**	**RESPONSE**
	References to websites should have url and access date.	
Reviewer #4	See below.	
Reviewer #5	Yes, please refer to my specific comments below.	

III. SPECIFIC OBSERVATIONS			
REVIEWER	**Page**	**Paragraph or Line #**	**Comment or Question**
Reviewer #1	5	175	Why other than sprouts? If they are left out, the reason should be explained.
	11	393	…such as "sprouts," tomatoes, and leafy greens.
	14	408	Sprout outbreak, 2006-*S. Braenderup*, bean sprouts
	16	441	Why is wildlife and livestock feces "nonpoint source?" Wouldn't a flood event be nonpoint source? Point source and nonpoint source should be defined.
	16	445-449	I'm not sure the most recent literature actually supports this statement. Both *Salmonella* and *E. coli* have been shown to survive "under a wide range of natural conditions." Winefied and Groisman, 2003. AEM.
	17	465	What about contaminated irrigation water as a "direct" route?
	24	728	Isn't it well accepted in 2013 that the so-called "indicator" organisms are in fact poorly or **not** correlated with actual pathogens?
	26	813	Typo? Shouldn't it read "…2 log decrease…" not increase?
	26	826 and 836	This sentence suggests that sprout irrigation water is important factor in sprout contamination…without references. Doesn't the data support the fact that contaminated seed, not contaminated irrigation water is the greatest (only) risk factor for contaminated sprouted seeds?
	30	971-975	This may be a "chicken or egg" argument. It is true that enteric pathogens replicate faster and to higher populations within animals; however, it seems naïve to state that they "…are not generally considered to be environmental…" Recent data supports the theory that the part of an enteric's life cycle outside an animal host could be equally important.
	41	1363-1385	Since seeds are a known route of contamination, this section should be included in Section IV. Exposure Assessment, B. Routes of Contamination.

III. SPECIFIC OBSERVATIONS			
REVIEWER	**Page**	**Paragraph or Line #**	**Comment or Question**
Reviewer #2	3	124-126	The sentence mentions an order of prevalence, but Table 1 only lists them. Should also refer to Table 2 here as that table prioritizes the pathogen agents by the number of outbreaks and illnesses.
	3	135-139	Replace "In many cases" with "In several cases" as only two outbreaks and two reference citations are used and several would be a more appropriate description.
	3	142-144	A reference citation for this potential mode of contamination should be given. The following reference could be used: Buchholz, A.L., G.R. Davidson, B.P. Marks, E.C.D. Todd, and E.T. Ryser. 2012. Transfer of *Escherichia coli* O157:H7 from equipment surfaces to fresh-cut leafy greens during processing in a model pilot-plant production line with sanitizer-free water. J. Food Prot. 75:1920-1929.
	5	198	*Listeria* needs to be italicized.
	Biological Hazards Section		Bacterial and viral agents were discussed individually in alphabetical order and then the three parasitic agents were included in their own section at the end. If the section on the parasitic agents was labeled "5. Parasitic agents: *Cryptosporidium parvum*, *Cyclospora cayetanensis*, *Giardia lamblia*", then it could be placed after the "4. Norovirus" section and before the "6. *Salmonella*" section.
	Biological Hazards Section		Some of the material presented for the different agents was inconsistent. As an example, the infective dose was listed for *E. coli* O157:H7 but not for *Shigella*.
	6	221-222	To be consistent on the information presented in the section on Biological Hazards, the reference citation for the infectious dose should be #79 instead of a book chapter.
	7	227	According to Table 3, the case fatality rate is 0.5% so either it could be specified as such, instead of using "approximately 1%" or for consistency, it should be presented as "less than 1%" as was stated for *Salmonella* which has the same case fatality rate of 0.5%.
	7	232-234	Reference #187 covers the outbreak with green onions only. References for outbreaks associated with frozen strawberries and frozen raspberries should also be given otherwise the reference number should follow immediately after listing green onions.
	7	249	Checked Reference #41 but did not find an article with that volume and page number and discussing the potential transfer of viruses through water or handling.
	8	267	The abbreviations Lm and RA had not been defined previously in the document so should be spelled out.
	8	297	"usually higher" is vague and should be more specific.

III. SPECIFIC OBSERVATIONS			
REVIEWER	**Page**	**Paragraph or Line #**	**Comment or Question**
	9	315	The references cited only refer to *Cyclospora* (#40) and *Giardia* (#74). Instead of having a separate reference for *Giardia* from the Bad Bug Book, the document should refer to reference #79 that would include both *Giardia* and *Cryptosporidium*.
	11		Greater emphasis to several statements and phrases made on this page should be made by bolding them: all of lines 378-379, "alone" on line 386, and "greater or lesser" on line 386.
	Table 5		This table is actually a compilation of bar graphs. Presentation of the data in tabular form would facilitate greater comparison among the commodities as well as be more space efficient.
	12	398-399	Since the point was made that outbreaks had been associated with both honeydew melon (smooth rind) and cantaloupe (netted rind), it would be advantageous to present the outbreak data for these two commodities separately.
	16	456-463	To emphasize the point that prediction of pathogen survival rates is difficult, a specific example, along with a reference where the pathogen did not survive for extended periods of time, should also be given.
	16	462	The original references for this data should be given instead of the citations listed. They are: • Islam, M., J. Morgan, M.P. Doyle, S.C. Phatak, P. Millner, and X. Jiang. 2004. Persistence of *Salmonella enterica* serovar Typhimurium on lettuce and parsley and in soils on which they were grown in fields treated with contaminated manure composts or irrigation water. Foodborne Path. Dis. 1:27-35. • Islam, M., M.P. Doyle, S.C. Phatak, P. Millner, and X. Jiang. 2004. Persistence of enterohemorrhagic *Escherichia coli* O157:H7 in soil and on leaf lettuce and parsley grown in fields treated with contaminated manure composts or irrigation water. J. Food Prot. 67:1365-1370.
	17	469	Reference #92 does not appear to be a correct citation for the statement as it deals with *Salmonella* contamination in surface waters.
	17	477-486	Given that the majority of the outbreaks where workers have been implicated as a source of contamination have been in the retail setting, it may be advantageous to clarify that human transfer of pathogens in that setting would be just as likely as human transfer during harvesting.
	18	503	Instead of reference #158 being cited, reference #159 would be more appropriate.

III. SPECIFIC OBSERVATIONS			
REVIEWER	**Page**	**Paragraph or Line #**	**Comment or Question**
	18	507-508	Only one study was cited (#99), whereas the sentence stated that "studies had demonstrated."
	18	526-527	Studies are described as "recent" but reference #130 was published in 2000 and the other citation (reference #147), while published in 2008, was compiling data from outbreaks occurring from 1991-2002. In the absence of truly more "recent" data, I would remove the word.
	19	552	Reference 10 is an incorrect citation for this statement as the paper is discussing variations in survival with plant cultivars not pathogen cultivars.
	19	555-557	This statement, regarding the lack of recovery from bell pepper when irrigated by subsurface drip or furrow irrigation, does not belong in this section as it relates to contamination of the crop, not survival or persistence in the crop.
	19	560	A more appropriate term to describe the surface characteristics of the commodity would be surface roughness, not surface texture.
	20	581-585	Previous discussion of attachment was dealing with cultivated plants whereas the observations of growth reported in this paragraph were conducted under postharvest conditions when the tissue has been severed from its source. It should be clarified that "postharvest plant colonization can occur at rapid rates."
	21	618	Given that more detail on how the inspections, investigations and surveillance sampling activities are to be found in the references cited, reference #184 has very little details to enable one to access that information.
	21	Table 6	Reference #50 should be listed at the end of the title.
	21-22	639-648	This paragraph listing limitations is almost word for word a repeat of what was stated in the last half of the previous paragraph. Rephrase if the point is to emphasize these limitations.
	23	708-709 and 712-714	The two sentences found within these lines are repetitive.
	24	730	The years in which the data were collected should be specified rather than just stating "during the last two reporting periods."
	26	809	For increased clarity of the experimental conditions, insert "unsanitized" before "water."

III. SPECIFIC OBSERVATIONS			
REVIEWER	**Page**	**Paragraph or Line #**	**Comment or Question**
	26	812-824	To provide a more logical presentation of the information that would be based on the order in which activities are experienced, move the last two sentences of this paragraph (dealing with contamination) to follow the first sentence. Activities that affect reduction of contaminated product would then follow.
	29	917	Instead of starting the sentence with "And" start with "In addition,"
	29	925	Italicize "*L. monocytogenes*."
	30	955	Reference #104 did not address asymptomatic shedders and should therefore be deleted.
	31	979	Since the maximum populations of *Salmonella* and *E. coli* O157:H7 in animal feces was later specified, it would also be valuable to specify here the value associated with "very large populations" of human pathogens in human waste.
	31-35	995-1128	More than half of the reference citations appeared to be incorrect (articles addressed a subject matter different from what was being discussed). With so many being wrong, I can only assume that reference numbers within the text were not changed when deletions or additions to the reference list were made.
	35	1156	For clarification, insert the word "Human" before workers and visitors.
	38	1236	A more appropriate reference for the information presented in this sentence would be the following: Zhou, B., Y.G. Lu, P. Millner, and H. Feng. 2012. Sanitation and design of lettuce coring knives for minimizing *Escherichia coli* O157:H7 contamination. J. Food Prot. 75:563-566.
	39	1308-1309	The mass unit that the pathogen populations encompass should be specified. I'm assuming it is per gram, but is that per gram wet weight or per gram dry weight?
	39	1309	Levels of *E. coli* O157:H7 in fresh cattle manures averaged 6 log/g wet weight in the following study and was as high as 8 log cfu/g wet weight: Hutchison, M.L., L.D. Walters, S.M. Avery, B.A. Synge, and A. Moore. 2004. Levels of zoonotic agents in British livestock manures. Lett. Appl. Microbiol. 39:207-214.
	Tables 9 and 10		Since Table 10 offers explanations on how Table's 9 categories of ranking were derived, it would be more logical to present Table 10 before presenting Table 9 as the reader of this document would then be capable of understanding the assigned scores.
	Tables 9 and 10		Since these tables span multiple pages, it would be advantageous for the headers to be included on each page.

III. SPECIFIC OBSERVATIONS			
REVIEWER	**Page**	**Paragraph or Line #**	**Comment or Question**
	Table 9		The column widths for the different sources of contamination varied and, therefore, it was difficult to match the source with their score on pages where the header was not included. Given that the routes of contamination were considered equivalent as factors contributing to the likelihood of contamination on-farm, the columns should have similar widths to reflect this assignment. Otherwise if the table is viewed alone, one could mistakenly assume that sources with wider columns, such as animals, present a greater risk than narrower columns, such as equipment.
	55-56		Although it is explicitly stated that the results of the analysis are presented first in Table 11 and is followed by the discussion of how those results were derived, my preference would be to present the discussion first before presenting the table. It was impossible for me to understand the table without going through the discussion first.
	57	1570-1571	An article just published in the January issue of Journal of Food Protection addresses the removal of viruses from contaminated produce by peeling and could be advantageous to include as a reference in this section. The article is: Wang, Q., M.C. Erickson, Y. Ortega, and J.L. Cannon. 2013. Physical removal and transfer of murine norovirus and hepatitis A virus from contaminated produce by scrubbing and peeling. J. Food Prot. 76:85-92.
	58	1599-1600	No reference was given for this data.
	68-83	References	Formatting of references was inconsistent. For example: • With article titles, in some cases the first letter of each major word was capitalized whereas in other cases, only the first word of the title was capitalized. • Pathogen names were not italicized. • In some cases, only the year was included whereas in other cases, the month, day, and year for the citation date was included. • MMWR was abbreviated whereas all other journal titles were spelled out. • A couple of the references that were found in Morbidity and Mortality Weekly Report did not list the article title (#31, #38) or page numbers (#31) and thus made it difficult to find the information that was cited.
	72	1959	Missing page numbers.
	73	2017	C in *coli* should not be capitalized.
	74	2020-2021	Should probably reference second edition that is now online.
	74	2045	Missing volume and page numbers.

III. SPECIFIC OBSERVATIONS			
REVIEWER	**Page**	**Paragraph or Line #**	**Comment or Question**
	75	2080	C in *coli* should not be capitalized.
	77	Ref #124 and #125	Listed page numbers in #124 but did not in #125.
	77	2152	Missing co-authors.
	78	2168	Missing page numbers.
	78	2179	C in *coli* should not be capitalized.
	78	Ref #138	The title was incomplete and the page numbers were incorrect. The title is: "… produce: A review." Page numbers should be 75-141.
	80	2234-2239	Reference #159 and Reference #160 are the same reference.
	82	2300	No title of publication given which could facilitate finding the information contained within it. Is this publication accessible on the internet? Indicated that additional details on sampling activities found within it.
	82	2311	Misspelled word.
	86	Table summarizing MPD data 2002 - 2009	Is it possible to separate the data collected for tomatoes and cantaloupes into those that were field packed and those that were shed packed? This division would be useful since the risk assessment in this document considered field packed and shed packed commodities as separate entities.
	92	2441	Based on table comparing the assessments of the two rankings, there were 11/27 that were scored similarly for a 41%.
	92	2443	"… two commodities received a higher score …" not "… one commodity..."
Reviewer #3			[This reviewer provided mark-ups with comments and specific suggestions for improvement on an electronic version of the document, which has been included as Attachment A of this report.]
Reviewer #4	1	68-69	…into fruit and vegetable RACs and…
	1	70	Section 402 or 419 of the FD&C Act?
	1	76	Suggest "for" rather than "in" since most microbial contaminants are found on the surface of fresh produce as opposed to the interior.
	2	87	…involved analyses for which…
	2	89-90	…data from these analyses were used.

III. SPECIFIC OBSERVATIONS			
REVIEWER	**Page**	**Paragraph or Line #**	**Comment or Question**
	3	106	The article mentions *E. coli* serotypes O6:NM and O11:H43 but not O145, O111 and O104:H4, with produce-related outbreaks from these last three serotypes only having been documented during the last few years.
	3	111	…chain from the farm to the point of…
	3	138	…its RAC form…
	4	Table 1	Reference 156 lists 5 outbreaks for *Campylobacter* which exceeds those from *L. monocytogenes*.
	5	172	…on farms.
	5	175	…fresh-cut…
	5	178	…regulated RACs other…
	5	183	…to be of continued concern…
	5	185	This Hazard Characterization…
	5	198	Italicize *Listeria.*
	5	199	…document) with the others ranking among the top five causes of produce-associated outbreaks.
	5	200	Several servings might also need to be consumed over time to ingest a sufficient number of organisms to cause illness (e.g., growth of *L. monocytogenes* in contaminated cantaloupe during refrigerated storage).
	6	213	…and deaths…
	6	217	for under-reporting and…
	6	228	…*coli* - part of the group called STEC, such as O145 (*49*), and O104 (*64*), are increasingly…
	7	232	…(*66*). Outbreaks of HAV have been linked…
	7	254	…experience mild listerial…
	7	261	…diarrhea (*69, 88*).
	8	267	The FDA/FSIS *L. monocytogenes* risk assessment showed …
	8	270	…food was that…
	8	279	Norovirus causes an intestinal illness (*79*). Symptoms of infection usually…
	8	286	*Salmonella enterica* - the bacterium…
	8	300	…approximately 3.6 percent…
	9	307	…raw fruits and…

III. SPECIFIC OBSERVATIONS			
REVIEWER	**Page**	**Paragraph or Line #**	**Comment or Question**
	9	308	…honeydew melon…
	9	311	…ranges from 8 – 50…
	9	320	…ranges from 1 – 2…
	9	321	Cryptosporidiosis has an onset time of 7 to…
	9	323	…individuals are at higher risk…
	10	356	…has been obtained from the CFSAN…
	10	361	…for the majority (77%) of all…produce-related…
	11	370	Although the harvestable portion grows in the ground, the tops of green onions are also consumed (unlike potatoes).
	11	382	While true for whole apples, numerous *E. coli* O157:H7 outbreaks have been traced to apple cider with the apples assumed to be the source of the pathogen (e.g., from deer droppings).
	16	457	…thrive. Various sites in production areas may provide safe harborage for pathogens and act as reservoirs from which food contamination may occur. When manure composts contaminated with S*almonella* and *E. coli* O157:H7 were applied in fields, survival times…
	16	465	Produce is subject to both direct (e.g., insanitary hand or equipment contact) and indirect (e.g., contaminated runoff) pathogen contamination.
	16	478	…of contaminating food during handling (*20*).
	17	488	…as a potential…
	17	498	…outbreak of listeriosis linked…
	19	570	…produce, pathogenic *E. coli* O157:H7 was…mechanisms exhibited poor attachment (*196*).
	19	575	…showed significantly different degrees of serovar-cultivar colonization…suggesting different colonization…
	20	581	…and is frequently…
	20	591	…see the FAO/WHO meeting report on…
	20	594	…and holding of produce on farms.
	20	597	…(1) water, (2) soil amendments, (3) animals, (4) worker health and hygiene, and (5) equipment and buildings.
	22	649	Delete this line
	23	684	…coliform-positive…
	23	707	…(*147*). In another…found that…
	23	712	This sentence is a repeat of 708 – 710 and can be deleted.

III. SPECIFIC OBSERVATIONS			
REVIEWER	**Page**	**Paragraph or Line #**	**Comment or Question**
	23	714	This sentence is unclear. Were these pathogens detected in well or groundwater samples?
	23	717	…*Campylobacter* contamination over… (Note: A well cannot be infected since the term infection relates to disease).
	24	750	*E. coli* O145 in all probability originated on the farm as an isolated contamination event, but was likely spread to many bags of product during commercial processing. While decreased efficacy of the sanitizer in the presence of a high organic load may have been partly responsible, recovery of the pathogen from the processing environment would be unlikely days or weeks later.
	24	755	…concentrated animal feeding operations;
	25	761	…this canal section…
	25	762	…was the most likely source of contamination.
	25	796	…reported that…
	26	805	… transportation, it is often disinfected to minimize contamination.
	26	807	…cross-contamination during washing…after a 1 minute wash… [Note: The impact or organic load on decreased sanitizer efficacy (particularly for chlorine-based sanitizers) cannot be overlooked.]
	26	817	CFU non-pathogenic *E. coli* per 100 ml (10,000 CFU non-pathogenic *E. coli*…
	26	828	Define "treated agricultural tea."
	27	866	…source for contamination…
	27	869	…despite the regulation of many U.S. public wells under the Ground Water Regulation.
	30	943	Agricultural teas that contain "amendments," such as molasses intended to enhance the growth of beneficial microorganisms, also reduce the expected die-off time of pathogens, and possibly…
	30	960	…common in…common in…
	30	968	A biological soil amendment of animal origin can spread pathogens to produce by either directly or indirectly contacting the food surface.
	30	977	…can all potentially infect new human hosts (*181*).
	31	980	40 CFR part 503 does not allow the use of human waste as a soil amendment.
	31	995	Also, biological soil amendments of animal origin are expected to have a high content of available nutrients and minerals, including those expected to support rapid and prolific microbial growth, provided that sufficient moisture is available (*109*).

III. SPECIFIC OBSERVATIONS			
REVIEWER	**Page**	**Paragraph or Line #**	**Comment or Question**
	31	1000	…excreta (e.g., *Shigella* and HAV)…
	31	1007	While not used as a soil amendment, calcium carbonate (used as a food ingredient) was recently recalled due to contamination with *Salmonella*. See http://ohsonline.com/articles/2012/11/09/salmonella-recall-hits-nesquik-powder.aspx
	31	1011	…to the likelihood…
	32	1037	…soil) (*100, 182*).
	32	1047	…interval, coupled…
	32	1050	… days, months, or years (*99, 103, 188, 196*). [Note: see also L1070.]
	32	1054	… while the above ground harvestable portion…
	33	1059	Soil amendments can be a source of produce contamination.
	33	1073	L1073 is a repeat of 1064
	33	1076	…above ground harvestable…
	34	1091	Animal excreta are a well-established source of pathogens (48, 119, 123, 145, 195), often at very high populations (such as *Salmonella* spp. up to 7 log (10^7) (*141*) and *E. coli* O157:H7 up to 5 log (10^5) (*95*) that, when present on farms, can…
	34	1102	Italicize (*37, 41, 82, 98-100, 150, 155*).
	34	1111	Italicize (*48, 123, 195*).
	34	1116	…and Dunn and colleagues reported that the prevalence of *E. coli* O157:H7 infection in white-tailed deer ranged from undetectable levels to 2.4 percent (*60*).
	35	1156	…such as norovirus, hepatitis A virus…
	36	1160	…lettuce, tomatoes, or…
	36	1167	Wearing jewelry in the field (e.g., a wrist watch) as well as eating or use of tobacco products would appear to present a lower risk in produce fields as compared to a post-processing facility where such actions are always banned.
	36	1184	Italicize（*4, 17, 38, 84, 125, 184*）.
	37	1208	Italicize (*89*) and (*18*)
	37	1214	…can contaminate produce or…
	37	1228	…iceberg…in simulated field coring (*167*).
	37	1230	…demonstrated to various extents…
	38	1235	…sanitizing would…

III. SPECIFIC OBSERVATIONS			
REVIEWER	**Page**	**Paragraph or Line #**	**Comment or Question**
	38	1248	Buildings and equipment that are not easily accessible and cleanable are less likely to be properly maintained and may therefore become a source or route of contamination (*80*)…in buildings in which multiple activities are conducted (*96*)…
	38	1253	Un-italicize "of"
	38	1271	Un-italicize "for"
	39	1305	…surfaces.
	40	1324	Food contact surfaces and equipment that are…
	40	1341	…Apples…Carrots…Green onions…Mushrooms…Onions…Peaches…Peppers, Tomatoes…Tomatoes… and Watermelon.
	41	1348	Isn't squash also typically cooked before consumption?
	41	1380	Operations that are…
	42	1391	Also note that our…
	42	1413	…growing habitat…
	42	1415	…is generally less…
	43	1424	delete
	43	1425	In order for us to obtain a total…
	45		Deer contact with apples has been strongly associated with outbreaks of *E. coli* O157:H7 from apple cider. Consider ranking as 6.
	52		Comment for water (direct) general – fluming may also lead to pathogen internalization in some products if the product temperature exceeds the water temperature by more than 10°C.
	54	1502	…other routes of…
	54	1510	…limitations. Further, although…
	54	1513	Table 11: In addition to peeling and cooking, washing before consumption (typically reduces bacterial populations ~90%) is also standard practice for many of the products listed in Table 11. This risk assessment also fails to consider the routes and spread of contamination during production of value-added/fresh-cut produce which may be substantial for certain products that are commercially processed prior to reaching retail markets. Some examples would include fresh-cut leafy greens, apples, tomatoes, carrots and blueberries. Concerning consumption, other items typically peeled would include grapefruit, oranges, and onions. Pineapples and melons are always cut with any contamination of the edible portion coming from the outer rind during cutting or slicing.

III. SPECIFIC OBSERVATIONS			
REVIEWER	**Page**	**Paragraph or Line #**	**Comment or Question**
	54	1555	As the organic load increases in wash water during washing of produce, the efficacy of chlorine-based sanitizers decreases.
	57	1573	…cutting and peeling provide…(21). One study…*Salmonella* Miami…
	58	1592	Please clarify these time/temperature treatments in terms of log reduction or D-value.
	58	1598	…1 second) (*121*).
	58	1599	Water blanching at 190 ^{0} F for 4 minutes reportedly reduced *Salmonella* spp. by >5.4 log CFU/g in potato slices and by 4.6-5.1 log CFU/g in carrots (55).
	58	1605	…juice were thermally...than 1 minute when held at 144ºF…
	59	1635	… represent all ages of the U.S. population. Dietary records are from the WWEIA/NHANES report of foods consumed by survey participants.
	59	1641	…recipes, food forms…
	59	1645	…in Appendix 2)…
	59	1648	…commodities are provided…
	60	1654	…calculated the sum total number…
	60	1668	The assumption in this key is that…
	60	1671	…rate has a…
	61	1679	…may decrease the likelihood…
	61	1687	…outcomes and likelihood of illness.
	61	1691	Where severity of the hazard…
	61	1694	The following assumptions (L1694-1699) are false: "For the purposes of this assessment, we make the assumption that the likelihood of exposure is directly proportional to the risk of illness, meaning that we assume that there is not a dose-response relationship and any amount of contamination would be expected to cause illness. We also assume that any contamination that may occur while on farm will carry through to the point of consumption, and that the level of contamination neither increases nor decreases unless contamination is minimized through consumer or retail handling practices, as described in section IV.D.1., above." The scientific literature contains considerable information on the survival, growth, and death of pathogens on produce after harvest, including during processing and extended storage which could be considered.
	62		In Table 2, the specific severe hazards associated with those products that are identified as posing a low risk of illness (e.g., apples, pears, peaches, etc.) are unclear.

III. SPECIFIC OBSERVATIONS			
REVIEWER	**Page**	**Paragraph or Line #**	**Comment or Question**
	64	1737	…literature establishes that…
	References		The reference titles differ in terms of style/capitalization. All organism names should be italicized. Some of the reports and other documents are in need of web links for easy access. The date of accession should also be included.
Reviewer #5	2	97-107	It appears that the time periods described were selected to complement each other and extend the "time lens" evaluated. If this is the case, please state this specifically. If not, please explain why these time periods were selected.
	3	114	How many outbreaks does this represent?
	5	190-202	This is a critical section of this report. Within the field of microbial risk assessment, "reference pathogens" are commonly used as they are in this report. The selection of reference pathogens is one of the most important aspects of planning and scoping of a risk assessment. While I do not necessarily disagree with the selected reference pathogens, the justification for their selection (lines 197-199) is inadequate. I suggest a much more thorough discussion is needed here because the technical merit of the report hinges on the selection of these reference pathogens.
	6	221 (and many other locations in report such as lines 243 and 262)	The use of the term "infectious dose" must be corrected in this report. An "infectious dose", as used in this report, implies that a dose below the reported value will not cause infection. That concept not in line with the current science supporting dose response relationships. Either refer to relative levels of infectivity or values such as an ID_{50} for any specific pathogen. This is a critical point so that there is no misunderstanding about the process that can lead to infection and illness from exposure to microbial pathogens.
	7	224	Citation needed after "8 days."
	11	388-394	I would like to see this discussion framed within the context of "extreme events." It appears that some produce products are likely candidates for outbreaks (cantaloupe, berries, leafy greens, etc.), whereas others very rarely occur. This type of phenomenon is common to other media also. I suggest that connecting these types of events (for example, wet weather events and recreational water contamination) will broadly support the basis for approach taken.

III. SPECIFIC OBSERVATIONS			
REVIEWER	**Page**	**Paragraph or Line #**	**Comment or Question**
	22-23	673-690	I urge a little caution in this section. There are several types of water systems in the US (all of which I believe are defined as public water systems), some of which exhibit varying likelihoods of contamination. For example, there are transient community water systems, non-transient community water systems, large community water systems, etc. I suggest a review of US EPA drinking water regulations would ensure that the write-up in this section is accurate.
	25-26	786-810	This section should mention the possibility of regrowth of bacterial pathogens. If regrowth is not of concern, then a justification and explanation should be provided.
	26	812-816	This section needs a little more detail to be clear.
	26	828	Need to define agricultural tea here.
	31	979-981	This is a little misleading in that the reference is for the Part 503 rule which is specifically for biosolids. I think you need to indicate that treatment is included in the requirements and that there are several classes of biosolids and restrictions that correspond to each of the classes.
	31	1010-1012	This sentence should state that "We assume….." rather than "We consider…." You may consider adding a sentence indicating why you assume this (for example, is this simply a health protective assumption).
	32	1050	I suggest that "years" is sufficient, and you remove indefinitely, unless it is strongly supported by the literature.
	33	1063	A little caution is needed here. For example, Class A biosolids are materials (according to the regulation) that are pathogen free (or nearly pathogen free). So, you may consider the wording in this line or the supporting statements in the text.
	34 and 39	1091-1092 and 1308-1309, for example	Units are needed. 10^7 per what?

III. SPECIFIC OBSERVATIONS			
REVIEWER	**Page**	**Paragraph or Line #**	**Comment or Question**
	43	1424-1458	This section causes concern for me. In this section you have gone from a qualitative assessment to a quantitative scaling, but you have done so without technical support. I understand why you have done this, but how does this scaling impact your findings. For example, if your scaling were different, would the overall results change? I would like to see either a sensitivity analysis on this point or a robust discussion explaining the technical justification for the relative scaling.
	43	1442-1451	Need an explanation justifying the selection of these cut points.
	45		Table 9 needs to be more transparent regarding how the "route score" is computed for each row. I was able to duplicate them, but doing so requires specifically going back to the text to see what each cell value is. I think the table needs to be easier to understand as a stand-alone entity.
	55		The discussion before and after Table 11 is needed to understand what is in the Table. You may consider moving the supporting text to before Table 11 in the document so that the context is presented before the Table. That will make the table easier to understand for the reader. Also, the table needs a color key in a legend. Much like my previous comments, I believe these tables should serve as stand-alone entities and not rely on the text that supports them.
	60	1656-1659	Need to justify the selected cut points.
	60	1668	Need to explain <u>why</u> this assumption is made for the key in Table 12.
	92	2439-2443	Some additional text here would be beneficial explaining why the results from this comparison are so different (only 44% scored similarly) from the main text and what the implications are.

ATTACHMENT A
Reviewer #3 – Review Document Mark-up