Part D. Chapter 5: Food Sustainability and Safety

INTRODUCTION

In this chapter, the DGAC addresses food and nutrition issues that will inform public health action and policies to promote the health of the population through sustainable diets and food safety. An important reason for addressing sustainable diets, a new area for the DGAC, is to have alignment and consistency in dietary guidance that promotes both health and sustainability. This also recognizes the significant impact of food and beverages on environmental outcomes, from farm to plate to waste disposal, and, therefore, the need for dietary guidance to include the wider issue of sustainability. Addressing this complex challenge is essential to ensure a healthy food supply will be available for future generations. The availability and acceptability of healthy and sustainable food choices will be necessary to attain food security for the U.S. population over time. Integral to this issue is how dietary guidance and individual food choices influence the nation's capacity to meet the nutritional needs of the U.S. population. Food sustainability and food safety are also interrelated in generating a secure food supply. This chapter focuses on both sustainable diets and food safety.

Food Sustainability

Two definitions are relevant to the material presented in this chapter. These terms were slightly modified from the Food and Agriculture Organization (FAO) definitions to operationalize them for the Committee's work.[1, 2]

<u>Sustainable diets</u>: Sustainable diets are a pattern of eating that promotes health and well-being and provides food security for the present population while sustaining human and natural resources for future generations.

<u>Food security</u>: Food security exists when all people now, and in the future, have access to sufficient, safe, and nutritious food to maintain a healthy and active life.

The topic of *current* food security was addressed in Chapter 3 and to some extent in Chapter 4, where federal food programs were discussed. The topic of *long-term* food security was addressed within this chapter through examination of the evidence on sustainable diets.

The environmental impact of food production is considerable and if natural resources such as land, water and energy are not conserved and managed optimally, they will be strained and potentially lost. The global production of food is responsible for 80 percent of deforestation, more than 70 percent of fresh water use, and up to 30 percent of human-generated greenhouse gas (GHG) emissions.[3] It also is the largest cause of species biodiversity loss.[3] The capacity to produce adequate food in the future is constrained by land use, declining soil fertility, unsustainable water use, and over-fishing of the marine environment.[4] Climate change, shifts in population dietary patterns and demand for food products, energy costs, and population growth will continue to put additional pressures on available natural resources. Meeting current and future food needs will depend on two concurrent approaches: altering individual and population dietary choices and patterns and developing agricultural and production practices that reduce environmental impacts and conserve resources, while still meeting food and nutrition needs. In this chapter, the Committee focuses primarily on the former, examining the effect of population-level dietary choices on sustainability.

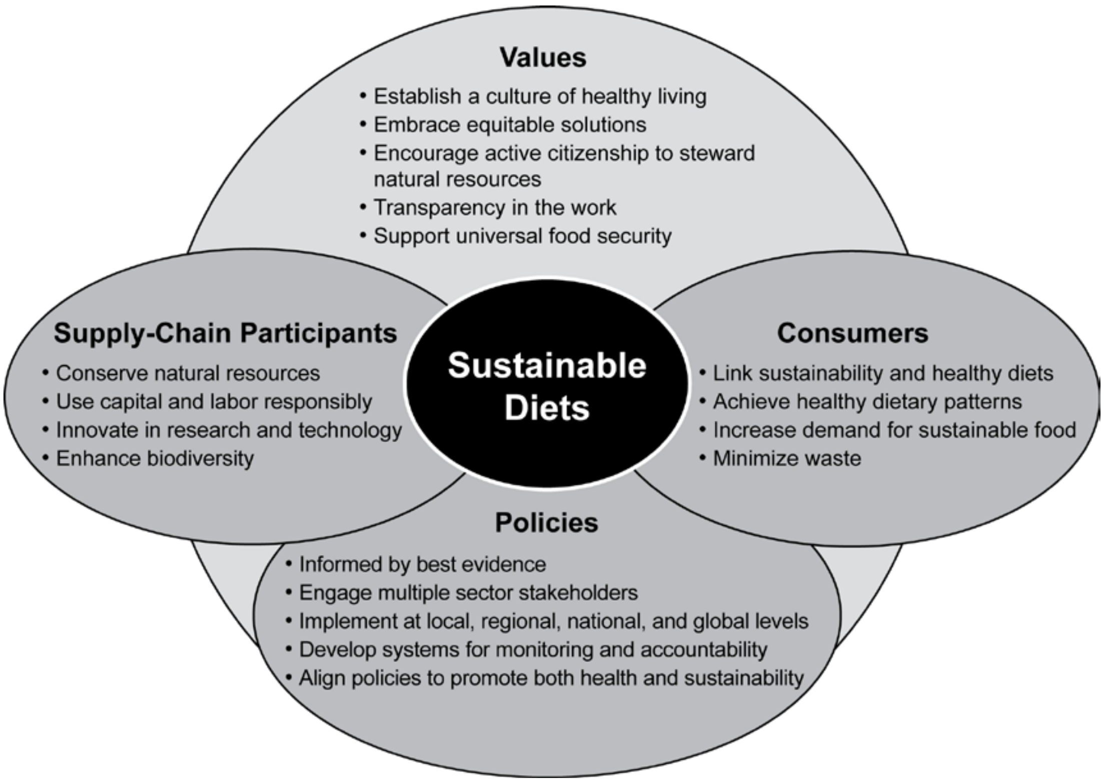
Foods vary widely in the type and amount of resources required for production, so as population-level consumer demand impacts food production (and imports) it will also indirectly influence how and to what extent resources are used.[3] As the focus of the dietary guidelines is to shift consumer eating habits toward healthier alternatives, it is imperative that, in this context, the shift also involve movement toward less resource-intensive diets. Individual and population-level adoption of more sustainable diets can change consumer demand away from more resource-intensive foods to foods that have a lower environmental impact. [3]

In this chapter, the DGAC has used an evidence-based approach to evaluate the foods and food components that improve the sustainability of dietary patterns as a step toward this desirable goal. The approach used was to determine dietary patterns that are nutritionally adequate and promote health, while at the same time are more protective of natural resources. This type of comprehensive strategy also has been used by intergovernmental organizations. For example, the FAO has identified the Mediterranean diet as an example of a sustainable diet due to its emphasis on biodiversity and smaller meat portions,[5] and the European Commission has developed a "2020 Live Well Diet" to reduce GHG emissions through diet change.[6]

It should be noted that research in the area of dietary patterns and sustainability is rapidly evolving and the methodologies for determining dietary patterns in populations and Life Cycle Analysis of foods/food components and environmental outcomes have made significant advances in recent years.[7, 8] This is exemplified by the size of evidence base for this question and the fact that several relevant articles have been published even since the close of the 2015 DGAC Nutrition Evidence Library (NEL) scientific review period for this topic.[9-11]

Figure D5.1 outlines the interconnected elements that the DGAC believes are necessary based on current evidence to develop sustainable diets. Sustainable diets are realized by developing a food system that embraces a core set of values illustrated in the figure. These values need to be implemented through robust private and public sector partnerships, practices and policies across the supply chain, extending from farms to distribution and consumption. New well-coordinated policies that include, but are not limited to, agriculture, economics, transportation, energy, water use, and dietary guidance need to be developed. Behaviors of all participants in the food system are central to creating and supporting sustainable diets.

Figure D5.1: Elements needed for sustainable diets



Although the addition of sustainability topics in the *Scientific Report of the 2015 Dietary Guidelines Advisory Committee* is new in 2015 it was acknowledged as a topic of strong relevance but not addressed by the 2010 DGAC. It has been a widely discussed aspect of nutrition policy for the past decade in countries such as Germany, Sweden and other Nordic countries, the Netherlands, Australia, and Brazil. For example, in the Netherlands, the Advisory report, *Guidelines for a Healthy Diet: The Ecological Perspective* focused on guidelines that inform both health and ecological benefits using an evidence-based strategy.[12] Nordic countries, such as Sweden, have been researching sustainability and dietary choice since the late 1990s with the most recent edition of the Nordic Nutrition Recommendations (NNR) including an emphasis on the environmental impact of dietary recommendations.[13] The German Dietary Guidelines developed a "sustainable shopping basket," which is a consumer guide for shopping in a more sustainable way.[14] Overall, the environmentally sustainable dietary guidance from these countries includes elements identified in this DGAC report as consistent with the extant data: a focus on decreasing meat consumption, choosing seafood from non-threatened stocks, eating more plants and plant-based products, reducing energy intake, and reducing waste. Non-governmental and international organizations, such as the United Nations, the FAO, the Sustainable Development Commission in the United Kingdom (UK), the Institute of Medicine (IOM), the Academy of Nutrition and Dietetics, and the National Research Council have all convened working groups and commissioned reports on sustainable diets.[2, 15-19] Overall, it is clear that environmental sustainability adds further dimensions to dietary guidance; not just what we eat but where and how food production, processing, and transportation are managed, and waste is decreased.

The DGAC focused on two main topic areas related to sustainability: dietary patterns and seafood. The identification of dietary patterns that are sustainable is a first step toward driving consumer behavior change and demand and supply-chain changes. Furthermore, dietary patterns were an overall focus area of the 2015 DGAC and allow for a more comprehensive approach to total diet and health. This approach is particularly well suited for assessing overall environmental impacts of food consumption, as all food components of a dietary pattern are identified, and keeping within the context of health outcomes that have been documented for different dietary patterns. The topic area of seafood was chosen because consumption has well-established health benefits and the 2010 DGAC report highlighted the concern for seafood sustainability and called for a better understanding of the environmental impact of aquaculture on seafood contaminants. Meeting these recommendations, however, increases demand for seafood production and this, in turn, poses challenges, as certain seafood species are depleted and marine waters are over fished, while most other species are at the limits of sustainable harvesting. To meet these challenges, as world capture fisheries production has leveled off, aquaculture production has increased to meet demand.[20] Therefore, building upon the 2010 DGAC report, the 2015 DGAC addressed the health benefits (nutrients) versus the risks (contaminants) of farm-raised (aquaculture) compared to wild-caught seafood and reviewed the evidence on the worldwide capacity to produce enough seafood to meet dietary guidelines. Overall, promoting sustainable fishing and aquaculture can provide an example for broader ecosystem stewardship.[20]

Food Safety

Food safety was first introduced in the *2000 Dietary Guidelines for Americans*, and the recognition of the importance of food safety continued through the 2010 report. This chapter updates the 2010 DGAC report related to food safety behaviors in the home environment and evaluates new topics of food safety concern with very current and/or updated evidence. The current/updated topics include the safety of beverages, specifically coffee and caffeine, and food additives, specifically aspartame, in the U.S. food supply.

In 2015, the DGAC addressed new topics of concern. For the first time, the DGAC addressed the safety of coffee/caffeine consumption, as well as the safety of consuming higher doses of caffeine in products such as some energy drinks. The food additive, aspartame, has been the only non-nutritive sweetener to be completely re-evaluated in recent years and the results of this reevaluation were deemed important because it includes the most recent science on aspartame and health. These topic areas were chosen for consideration because they are of high public health concern and very recent evidence has been published that significantly updates the knowledge base on health aspects related to caffeine and aspartame in the diet.

For 2015, the DGAC brought forward the updated food safety principles to reduce risk of foodborne illnesses. These principles—Clean, Separate, Cook and Chill—are cornerstones of the Fight BAC! (www.fightbac.org) educational messages developed by the Partnership for Food Safety Education, a collaboration with the Federal government. These messages are reinforced by other USDA educational materials, including the *Be Food Safe* (www.befoodsafe.gov) efforts; Is it Done Yet? (www.isitdoneyet.gov); and *Thermy* (www.fsis.usda.gov/thermy), which outline key elements in thermometer use and placement to ensure proper cooking of meat, poultry, seafood, and egg products. Additional consumer-friendly information on food safety is available at www.foodsafety.gov. The DGAC brought forward the guidance for consumers that has been updated since 2010 on recommended procedures for hand sanitation, washing fresh produce, preventing cross-contamination, and safe meat, poultry, seafood and egg cooking temperatures and thermometer use from the FDA, the Center for Disease Control (CDC) and the Food Safety and Inspection Service (FSIS). The updated food safety tables are located at the end of this chapter.

LIST OF QUESTIONS

Sustainable Diets

Dietary Patterns

1. What is the relationship between population-level dietary patterns and long-term food sustainability?

Seafood

2. What are the comparative nutrient profiles of current farm-raised versus wild caught seafood?
3. What are the comparative contaminant levels of current farm-raised versus wild caught seafood?
4. What is the worldwide capacity to produce farm-raised versus wild-caught seafood that is nutritious and safe for Americans?

Food Safety

5. What is the relationship between usual coffee/caffeine consumption and health?

6. What is the relationship between high-dose caffeine consumption and health?

7. What is the relationship between aspartame consumption and health?

8. What consumer behaviors prevent food safety problems? (Topic update from 2010 DGAC)

METHODOLOGY

Sustainable Diets

The topic of Question 1 is new for a DGAC review and involves an emerging area of scientific investigation that is not readily addressed by traditional study designs such as randomized controlled trials and prospective cohort studies. The literature related to sustainable diets and dietary patterns involves a combination of food pattern modeling, Life Cycle Assessment (LCA) methodology (examines all processes in the life cycle of each food component - from farm to plate to waste), and determination of the environmental outcomes of the full LCA inventory. Because of the unique nature of these studies, a modified NEL systematic review was conducted for Question 1 on dietary patterns and sustainability. Databases included PubMed, Cochrane, Navigator, and Embase and the search covered from January 2000 to March 2014. For this topic and question, it was necessary to use different methods from those described in an original NEL protocol because not all methods in the protocol could be applied. This is sometimes necessary, according to the Cochrane Collaboration, but requires that methods from the original protocol that could not be implemented in the current review be summarized.[21] Due to the nature of the evidence, the NEL 6-step process was tailored for the purposes of this systematic review, with modifications to step 3 – extract data and assess the risk of bias. A description of the NEL systematic review process is provided in ***Part C: Methodology***. A new data extraction grid was developed with emphasis on modeling studies, LCA methodology, and environmental outcomes. The LCA is a standardized methodological framework for assessing the environmental impact (or load) attributable to the life cycle of a food product. The customized grid was then used by NEL abstractors to extract data from the included articles and this informed the evidence synthesis (see ***Appendix E-2.37 Evidence Portfolio***). In addition, NEL abstractors used a different tool to assess individual study quality, not the NEL Bias Assessment Tool (BAT). This alternative tool, the Critical Appraisal Checklist used by the *British Medical Journal*, was appropriate for studies that used a modeling design. This checklist assesses studies that use modeling to extrapolate progression of clinical outcomes, transform final outcomes from intermediate measures, examine relations between inputs and outputs to apportion resource use, and extrapolate findings from one clinical setting or population to another. To attain a high score, studies must report the variables that have been modeled rather than directly observed; what additional variables have been included or excluded; what statistical relations have been assumed; and what evidence supports these assumptions.[22-24] The checklist included key components of the *British Medical Journal* checklist for economic evaluations, together with the

Eddy checklist on mathematical models. This Critical Appraisal Checklist was reviewed and tested for applicability by two sustainability experts who served as consultants to the DGAC.

Question 2 on nutrient profiles in farm-raised versus wild-caught seafood was addressed using data analysis from the USDA-Agricultural Research Service (ARS) National Nutrient Database for Standard Reference, Release 27 (http://www.ars.usda.gov/ba/bhnrc/ndl).[25] The section on finfish and shellfish products included nutrient profiles for both farm-raised and wild-caught seafood for some species. These data were augmented using a USDA-funded report on fatty-acid profiles of commercially available fish[*] in the United States that assessed additional farmed species and compared results with the USDA-ARS NND.[26] Because this question was answered using data analysis, it was not graded (as described in ***Part C: Methodology***). For Question 3 on contaminants in farm-raised versus wild-caught seafood, the DGAC used an expert report, the *Report of the Joint Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) Expert Consultation on the Risks and Benefits of Fish Consumption, 2011*.[27] This report was chosen as the most updated and comprehensive source of scientific information on the net health assessment of seafood consumption, including a comparison between wild-caught and farm-raised seafood related to contaminants. Data on levels of chemical contaminants (methyl mercury and dioxins) in a large number of seafood species were reviewed, as well as recent scientific literature covering the risks and benefits of seafood consumption. The sections of the report that were used to address the question were "Data on the composition of fish" and "Risk-benefit comparisons." Lastly, to address Question 4 on the worldwide capacity to produce enough nutritious seafood, the Committee used the FAO's report on the *State of World Fisheries and Aquaculture, 2012*.[20] This was considered the most current and comprehensive source on this topic, specifically the sections on "Selected Issues in Fisheries and Aquaculture" and the "Organization for Economic Cooperation and Development (OECD)-FAO Agricultural Outlook: chapter on fish." The DGAC focused on matters that directly address world production as it affects the supply of seafood for the U.S. population, particularly as the U.S. relies on significant amounts of imported seafood (~90 percent).

Food Safety

For Question 5, the DGAC used an overview of systematic reviews (SRs)/meta-analyses (MA) to address the relationship between usual caffeine/coffee consumption and health. This approach allowed the DGAC to address the broad scope of the evidence on usual caffeine and health, which heretofore had not been addressed by a DGAC. The DGAC used a modification of the method described by the Cochrane Collaboration to conduct the review.[28] The steps included development of analytical framework, determination of inclusion/exclusion criteria, description of search strategy and databases used, determination of methodological quality using the

[*] The term "fish" in this chapter refers to finfish, which includes aquatic species such as salmon, tuna, and trout.

Assessment of Multiple Systematic Reviews (AMSTAR) tool, data extraction, summary of results and key findings, and development of conclusion and grade for each outcome, as well as implications of the evidence and research recommendations. Overlap of studies included across the SRs/MA for the same health outcome was determined and recorded; however, SRs/MA were not excluded for overlap. This approach allowed the Committee to assess and consider whether SRs/MA on the same topic *independently* assessed similar results and arrived at generally similar conclusions. The focus of this review was to summarize the existing SRs/MA on this question, *not* to re-synthesize the evidence or to conduct a new meta-analysis or meta-synthesis.

For the overview on usual caffeine/coffee consumption and health, the target population was healthy adults and adults at risk of chronic disease, as well as youth ages 2 years and older. The intervention or exposure was caffeine/coffee consumption. The outcomes were clinical endpoints: 1) chronic diseases, including cardiovascular, type 2 diabetes, and cancer, and total mortality, 2) neurologic and cognitive diseases, including Alzheimer's and Parkinson's disease, and 3) pregnancy outcomes, including miscarriage and low birth weight. The included studies were SRs/MA and qualitative SRs; the date range was from 2000 to 2014. Data were extracted for all SRs/MA with emphasis on MA results, including categorical and dose-response MA, fixed or random effects models, heterogeneity and sources of heterogeneity, sub-group analysis, and publication bias (see ***Appendix E-2.39b Systematic Review/Meta-Analysis Data Table***). The methodological quality of the included SRs/MA was determined using AMSTAR. Overlap of studies included across the SRs/MA for the same health outcomes was determined and recorded; however, SRs/MA were not excluded for overlap. Rather, the emphasis was to determine consistency across studies.

For Question 6 on high-dose caffeine and health, a duplication assessment found two SRs and these were used in lieu of conducting a full NEL SR. The details of duplication assessment are provided in ***Part C: Methodology***, and the Review of the Evidence for this question provide further detail.

For Question 7 on aspartame and health, the European Food Safety Authority (EFSA) *Scientific Opinion on the Re-evaluation of Aspartame as a Food Additive* was used. This was conducted by the EFSA Panel of Food Additives and Nutrient Sources Added to Food (ANS).[29] The Panel based its evaluation on original study reports and information submitted following public calls for data as well as previous evaluations and additional literature that was available up to February 2013. The 2015 DGAC considered only the human studies and related conclusions from the EFSA report; animal studies and *in vitro* studies were not considered.
Lastly, this chapter provides a topic update from the 2010 DGAC on consumer behaviors and food safety. Tables on this topic were updated to include the most recent recommendations. Federal sources that were used for the update include: 1) Centers for Disease Control and Prevention (CDC) - Hand washing: Clean Hands Save Lives;[30] 2) Food and Drug Administration

(FDA) - Food Facts, Raw Produce: Selecting It and Serving It Safely, 2012; Food Safety for Moms-to-Be: Safe Eats - Meat, Poultry & Seafood;[31] and 3) USDA/Food Safety and Inspection Service (FSIS) – Food Safety Fact Sheets.[32]

SUSTAINABLE DIETS

Evaluating the link between sustainability and dietary guidance will inform policies and practice to ensure food security for present and future generations. The DGAC concentrated its review on the inter-relatedness between human health and food sustainability, with a focus on dietary patterns, a theme of the 2015 DGAC.

Dietary Patterns and Sustainability

Question 1: What is the relationship between population-level dietary patterns and long-term food sustainability?

Source of Evidence: Modified NEL systematic review

Conclusion

Consistent evidence indicates that, in general, a dietary pattern that is higher in plant-based foods, such as vegetables, fruits, whole grains, legumes, nuts, and seeds, and lower in animal-based foods is more health promoting and is associated with lesser environmental impact (GHG emissions and energy, land, and water use) than is the current average U.S. diet. A diet that is more environmentally sustainable than the average U.S. diet can be achieved without excluding any food groups. The evidence consists primarily of Life Cycle Assessment (LCA) modeling studies or land-use studies from highly developed countries, including the United States.
DGAC Grade: Moderate

Implications

A moderate to strong evidence base supports recommendations that the U.S. population move toward dietary patterns that generally increase consumption of vegetables, fruits, whole grains, legumes, nuts and seeds, while decreasing total calories and some animal-based foods. This can be achieved through a variety of dietary patterns, including the Healthy USDA-style Pattern, the Healthy Vegetarian Pattern, and the Healthy Mediterranean-style Pattern (for more details on the patterns, see ***Part D. Chapter 1: Food and Nutrient Intakes, and Health: Current Status and Trends***). Each of these patterns provides more plant-based foods and lower amounts of meat than are currently consumed by the U.S. population.

Sustainability considerations provide an additional rationale for following the Dietary Guidelines for Americans and should be incorporated into federal and local nutrition feeding programs when possible. Using sustainability messaging in communication strategies should be encouraged. The application of environmental and sustainability factors to dietary guidelines can be accomplished because of the compatibility and degree of overlap between favorable health and environmental outcomes.

Much has been done by the private and public sectors to improve environmental policies and practices around production, processing, and distribution *within* individual food categories. It will be important that *both* a greater shift toward healthful dietary patterns and an improved environmental profile across food categories are achieved to maximize environmental sustainability now and to ensure greater progress in this direction over time.

Consumer friendly information that facilitates understanding the environmental impact of different foods should be considered for inclusion in food and menu labeling initiatives.

Careful consideration will need to be made to ensure that sustainable diets are affordable for the entire U.S. population.

Promoting healthy diets that also are more environmentally sustainable now will conserve resources for present and future generations, ensuring that the U.S. population has access to a diet that is healthy as well as sustainable and secure in the future.

Review of the Evidence

A total of 15 studies met the inclusion criteria for this systematic review.[33-48] The body of evidence consisted primarily of dietary pattern modeling studies that assessed related environmental outcomes. These studies were conducted between the years 2003 and 2014 in the U.S., the UK, Germany, the Netherlands, France, Spain, Italy, Australia, Brazil, and New Zealand. Dietary patterns that were examined included vegetarian, lacto-ovo vegetarian, and vegan dietary patterns; the average and dietary guidelines-related dietary patterns of respective countries examined; Mediterranean-style dietary patterns; and sustainable diets. The most frequent comparison diet was the average dietary pattern of the country, although numerous studies made additional comparisons across many of the above dietary patterns. Another approach was to examine diet "scenarios" that modeled different percentage replacements of meat and dairy foods with plant-based foods. The modeling studies used cross-sectional assessment of dietary intake from national nutrition surveys of representative adult populations; for example, the British National Diet and Nutrition Survey (NDNS) from studies in the UK,[34, 39] the National Nutrition Surveys (NNS) in Germany,[40] or the Australian National Nutrition Survey[38] were used to determine the observed average dietary patterns. The average dietary patterns were then compared with other modeled dietary patterns, such as vegetarian or Mediterranean- style patterns, as described in detail below. All of the countries were highly developed countries with dietary guidelines and, therefore, generalizable to the U.S. population. The study quality for the body of evidence ranged from scores of 7/12 to 12/12 (indicating the evidence was of high quality) using a modified Critical Appraisal Checklist (see ***Appendix E-2.37 Evidence Portfolio***).

Health outcomes associated with the dietary patterns were most often documented based on adherence to dietary guidelines-related patterns, variations on vegetarian dietary patterns, or Mediterranean-style dietary patterns. Diet quality was assessed in some studies using an a priori index, such as the Healthy Eating Index (HEI) or the WHO Index. In some studies, health outcomes also were modeled. For example Scarborough et al. used the DIETRON model to estimate deaths delayed or averted for each diet pattern.[46] One study assessed the synergy between health and sustainability scores using the WHO Index and the LCA sustainability score to assess combined nutritional and ecological value.[46]

The environmental impacts that were most commonly modeled were GHG emissions and use of resources such as agricultural land, energy, and water. In many studies, the environmental impact for each food/food category was obtained using the LCA method. The LCA is a standardized methodological framework for assessing the environmental impact (or load) attributable to the life cycle of a food product. The life cycle for a food typically includes agricultural production, processing and packaging, transportation, retail, use, and waste disposal.[33, 49-51] An inventory of all stages of the life cycle is determined for each food product and a “weight” or number of points is then attributed to each food or food category, based on environmental impacts such as resource extraction, land use, and relevant emissions. These environmental impact results can be translated into measures of damage done to human health, ecosystem quality, and energy resources using programs such as Eco-Indicator.[52] In addition to the health assessment approaches listed above, some studies used LCA analysis with a standardized approach to determine damages from GHG emissions and use of resources; these damage outcome included human health as an environmental damage component, such as the number and duration of diseases and life years lost due to premature death from environmental causes.

Few studies assessed food security. These studies assessed food security in terms of the cost difference between an average dietary pattern for the country studied and a sustainable dietary pattern for that population.[36, 39, 48] The basic food basket concept was used in some studies, representing household costs for a two-adult/two-child household.

Identified Dietary Patterns and Health and Sustainability Outcomes

Vegetarian and Meat-based Diets

Several studies examined variations on vegetarian diets, or a spectrum from vegan to omnivorous dietary patterns, and associated environmental outcomes.[34, 35, 37, 41] Peters et al. examined 42 different dietary patterns and land use in New York, with patterns ranging from low-fat, lacto-ovo vegetarian diets to high fat, meat-rich omnivorous diets; across this range, the diets met U.S. dietary guidelines when possible.[41] They found that, overall, increasing meat in the diet increased per capita land requirements; however, increasing total dietary fat content of low-meat diets (i.e. vegetarian alternatives) increased the land requirements compared to high-meat diets. In other words, although meat increased land requirements, diets including meat could feed more people than some higher fat vegetarian-style diets. Aston et al. assessed a pattern that was modeled on a feasible UK population in which the proportion of vegetarians in the survey was doubled, and the remainder adopted a diet pattern consistent with the lowest category of red and processed meat (RPM) consumers. They found the combination of low RPM + vegetarian diet had health benefits of lowering the risk of diabetes and colorectal cancer, determined from risk relationships for RPM and CHD, diabetes, and colorectal cancer from published meta-analyses.[53-55] Furthermore, the expected reduction in GHG for this diet was ~3 percent of current total carbon dioxide (CO_2) emissions for agriculture. De Carvalho et al. also examined a high RPM dietary pattern with diet quality assessed using the Brazilian Healthy Eating Index.[37] They found that excessive meat intake was associated not only with poorer diet quality but also with increased projected GHG emissions (~ 4 percent total CO_2 emitted by agriculture). Taken together, the results on RPM intake indicate that reduced consumption is expected to improve some health outcomes and decrease GHG emissions, as well as land use compared to current RPM consumption. Baroni et al. examined vegan, vegetarian, and omnivorous diets, both organically and conventionally grown, and found that the organically grown vegan diet had the most potential health benefits; whereas, the conventionally grown average Italian diet had the least.[37] The organically grown vegan diet also had the lowest estimated impact on resources and ecosystem quality, and the average Italian diet had the greatest projected impact. Beef was the single food with the greatest projected impact on the environment; other foods estimated to have high impact included cheese, milk, and seafood.

Vegetarian diets, dietary guidelines-related diets, and Mediterranean-style diets were variously compared with the average dietary patterns in selected countries.[38, 40, 42, 46] Overall, the estimated greater environmental benefits, including reduced projected GHG emissions and land use, resulted from vegan, lacto-ovo vegetarian, and pesco-vegetarian diets, as well as dietary guidelines-related and Mediterranean-style dietary patterns. These diets had higher overall predicted health scores than the average diet patterns. Moreover, for the most part, the high health scores of these dietary patterns were paralleled by high combined estimated sustainability scores. According to van Doreen et al., the synergy measured across vegetarian, Mediterranean-style, and dietary guidelines-related scores could be explained by a reduction in consumption of meat, dairy, extras (i.e., snacks and sweets), and beverages, as well as a reduction in overall food consumption.[42]

Mediterranean-Style Dietary Patterns

The Mediterranean-style dietary pattern was examined in both Mediterranean and non-Mediterranean countries.[44, 46] In all cases, adherence to a Mediterranean-style dietary pattern—compared to usual intake—reduced the environmental footprint, including improved GHG emissions, agricultural land use, and energy and water consumption. Both studies limited either red and processed meat[40] or meat and poultry[42] to less than 1 serving per week, and increased seafood intake. The authors concluded that adherence to a Mediterranean-style dietary pattern would make a significant contribution to increasing food sustainability, as well as increasing the health benefits that are well-documented for this type of diet (see ***Part D. Chapter 2: Dietary Patterns, Foods and Nutrients, and Health Outcomes***).

Diet Scenarios

Other studies examined different diet "scenarios" that generally replaced animal foods in various ways with plant foods.[43, 45, 47] Scarborough et al. found that a diet with 50 percent reduced total meat and dairy replaced by fruit, vegetables, and cereals contributed the most to estimated reduced risk of total mortality and also had the largest potential positive environmental impact.[13] This diet scenario increased fruit and vegetable consumption by 63 percent and decreased saturated fat and salt consumption; micronutrient intake was generally similar with the exception of a drop in vitamin B_{12}.

Pradhan et al. examined 16 global dietary patterns that differed by food and energy content, grouped into four categories with per capita intake of low, moderate, high, and very high kcal diets. They assessed the relationship of these patterns to GHG emissions.[43] Low-energy diets had less than 2,100 kcal/cap/day and were composed of more than 50 percent cereals or more than 70 percent starchy roots, cereals, and pulses. Animal products were minor in this group (<10 percent). Moderate, high, and very high energy diets had 2,100-2,400, 2,400-2,800, and greater than 2,800 kcal/cap/day, respectively. Very high calorie diets had high amounts of meat and alcoholic beverages. Overall, very high calorie diets, common in the developed world, exhibited high total per capita CO_{2eq} emissions due to high carbon intensity and high intake of animal products; the low-energy diets, on the other hand, had the lowest total per capita CO_{2eq} emissions.

Lastly, Vieux et al. examined dietary patterns with different indicators of nutritional quality and found that despite containing large amounts of plant foods, not all diets of the highest nutritional quality were those with the lowest GHG emissions.[47] For this study, the diet pattern was assessed by using nutrient-based indicators; high quality diets had energy density below the median, mean adequacy ratio above the median, and a mean excess ratio (percentage of maximum recommended for nutrients that should be limited – saturated fat, sodium, and free sugars) below the median. Four diet patterns were identified based on compliance with these properties to generate one high quality diet, two intermediate quality diets, and one low quality diet. In this study, the high quality diets had higher GHG emissions than did the low quality diets. Regarding the food groups, a higher consumption of starches, sweets and salted snacks, and fats was associated with lower diet-related GHG emissions and an increased intake of fruit and vegetables, was associated with increased diet-related GHG emissions. However, the strongest positive association with GHG emissions was still for the ruminant meat group. Overall, this study used a different approach from the other studies in this review, as nutritional quality determined the formation of dietary pattern categories.

Sustainable Diets and Costs

Three studies examined sustainable diets and related costs.[36, 39, 48] Barosh et al. examined food availability and cost of a health and sustainability (H&S) food basket, developed according to the principles of the Australian dietary guidelines as well as environmental impact.[36] The food basket approach is a commonly used method for assessing and monitoring food availability and cost. The typical food basket was based on average weekly food purchases of a reference household made up of two adults and two children. For the H&S basket, food choices were based on health principles and environmental impact. The H&S basket was compared to the typical Australian basket and it was determined that the cost of the H&S basket was more than the typical basket in five socioeconomic areas; the most disadvantaged spent 30 percent more for the H&S basket. The authors concluded that the most disadvantaged groups at both neighborhood and household levels experienced the greatest inequality in accessing an affordable H&S basket. Macdiarmid et al. examined a sustainable diet (met all energy and nutrient needs and maximally decreased GHG emissions), a "sustainable with acceptability constraints" diet (added foods commonly consumed in the UK; met energy, nutrient, and seafood recommendations as well as recommended minimum intakes for fruits and vegetables and did not exceed the maximum recommended for red and processed meat), and the average UK diet.[7] They found that the sustainable diet that was generated would decrease GHG emissions from primary production (up to distribution) by 90 percent, but consisted of only seven foods. The acceptability constraints diet included 52 foods and was projected to reduce GHG emissions by 36 percent. This diet included meat and dairy but less than the average UK diet. The cost of the sustainable + acceptability diet was comparable to that of the average UK diet. These results showed that a sustainable diet that meets dietary requirements and has lower GHG can be achieved without eliminating meat or dairy products completely, or increasing the cost to the consumer. Lastly, Wilson et al. examined 16 dietary patterns modeled to determine which patterns would minimize estimated risk of chronic disease, cost, and GHG emissions.[48] These patterns included low-cost and low-cost + low GHG diet patterns, as well as healthy patterns with high vegetable intakes including Mediterranean or Asian patterns, as well as the average New Zealand pattern. The authors found that diets that aimed to minimize cost and estimated GHG emissions also had health advantages, such as the simplified low-cost Mediterranean-style and simplified Asian-style diets, both of which would lower cardiovascular disease and cancer risk, compared to the average New Zealand diet. However, dietary variety was limited and further optimization to lower GHG emissions increased cost.

Overall, the studies were consistent in showing that higher consumption of animal-based foods was associated with higher estimated environmental impact, whereas consumption of more plant-based foods as part of a lower meat-based or vegetarian-style dietary pattern was associated with estimated lower environmental impact compared to higher meat or non-plant-based dietary patterns. Related to this, the total energy content of the diet was also associated with estimated environmental impact and higher energy diets had a larger estimated impact. For example, for fossil fuel alone, one calorie from beef or milk requires 40 or 14 calories of fuel, respectively, whereas one calorie from grains can be obtained from 2.2 calories of fuel.[42] Additionally, the evidence showed that dietary patterns that promote health also promote sustainability; dietary patterns that adhered to dietary guidelines were more environmentally sustainable than the population's current average level of intake or pattern. Taken together, the studies agreed on the environmental impact of different dietary patterns, despite varied methods of assessing environmental impact and differences in components of environmental impact assessed (e.g. GHG emissions or land use). The evidence on whether sustainable diets were more or less expensive than typically consumed diets in some locations was limited and inconsistent.

Three additional reports on the relationship between dietary patterns and sustainability were published after this systematic review was completed. Two of these reports were consistent with, and provided more evidence to support the Committee's findings that dietary guidelines-related diets, Mediterranean-style diets, and vegetarian (and variations) diets are associated with improved environmental outcomes. Tilman and Clark showed that following a Mediterranean, vegetarian (lacto-ovo), or pesco-vegetarian dietary pattern would decrease both current and projected GHG emissions and land use.[11] Eshel et al. reported on the five main animal-based categories in the U.S. diet – dairy, beef, poultry, pork, and eggs – and their required feeds including crops, byproducts, and pasture. They found that beef production required more land and irrigation water and produced more GHG emissions than dairy, poultry, pork, or eggs.[9] In addition, as a standard comparator, staple plant foods had lower land use and GHG emissions than did dairy, poultry, pork, or eggs. In contrast, a report from Heller and Keoleian suggests that an isocaloric shift from the average U.S. diet (at current U.S. per capita intake of 2,534 kcals/day from Loss-Adjusted Food Availability (LAFA) data) to a pattern that adheres to the *2010 Dietary Guidelines for Americans* would result in a 12 percent increase in diet-related GHG emissions.[10] This result was modified, however, by their finding that if Americans consumed the recommended pattern within the recommended calorie intake level of 2,000 kcal/day, there would be a 1 percent *decrease* in GHG emissions. This finding reinforces the overriding 2010 DGA recommendation that all of the guidelines need to be followed, including appropriate calorie intake levels for age, gender, and activity level. Furthermore, in contrast to the findings of

Eshel et al. regarding dairy, Heller and Keoleian suggest that increases in dairy to follow 2010 DGA recommendations contribute significantly to increased GHG emissions and counters the modeled benefits of decreased meat consumption.[10]

For additional details on this body of evidence, visit: Appendix E-2.37

Seafood Sustainability

Background

Seafood is recognized as an important source of key macro- and micronutrients. The health benefits of seafood, including support of optimal neurodevelopment and prevention of cardiovascular disease, are likely due in large part to long-chain n-3 polyunsaturated fatty acids (PUFA), docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), although seafood also are good sources of other nutrients including protein, selenium, iodine, vitamin D, and choline.[27] Currently, seafood production is in the midst of rapid expansion to meet growing worldwide demand, but the collapse of some fisheries due to overfishing in past decades raises concerns about the ability to produce safe and affordable seafood to supply the U.S. population and meet current dietary intake recommendations of at least 8 ounces per week.[20, 56] Capture fisheries (wild caught) production has leveled-off as a proportion of fully exploited stocks, and this is due in part to national and international efforts on seafood sustainably (e.g., the U.S. Magnuson-Stevens Fishery Conservation and Management Act (2006) mandating annual catch limits, managed by the U.S. National Oceanographic and Atmospheric Administration). In contrast, the increased productivity of worldwide aquaculture (farm-raised) is expected to continue and will play a major role in expanding the supply of seafood.[20] Expanding farm-raised seafood has the potential to ensure sufficient amounts of seafood to allow the U.S. population to consume levels recommended by dietary guidelines.[57] Productivity gains should be implemented in a sustainable manner with greater attention to maintaining or enhancing the high nutrient density characteristic of captured seafood. Consistent with overall sustainability goals, farm-raised finfish (e.g., salmon and trout) is more sustainable than terrestrial animal production (e.g., beef and pork) in terms of GHG emissions and land/water use.[58, 59] Currently, the United States imports the majority of its seafood (~90 percent), and approximately half of that is farmed.[60] The major groups commonly referred to as finfish, shellfish, and crustaceans include more than 500 species, and thus, generalizations to all seafood must be made with caution.

Question 2: What are the comparative nutrient profiles of current farm-raised versus wild caught seafood?

Source of evidence: USDA Agriculture Research Service (ARS) National Nutrient Database (NND)[25] updated with USDA-funded survey of most commonly consumed species in the United States.[26]

Conclusion

For commonly consumed fish species in the United States, such as bass, cod, trout, and salmon, farmed-raised seafood has as much or more of the omega-3 fatty acids EPA and DHA as the same species captured in the wild. In contrast, farmed low-trophic species, such as catfish and crawfish, have less than half the EPA and DHA per serving than wild caught, and these species have lower EPA and DHA regardless of source than do salmon. Farm-raised seafood has higher total fat than wild caught. Recommended amounts of EPA and DHA can be obtained by consuming a variety of farm-raised seafood, especially high-trophic species, such as salmon and trout.

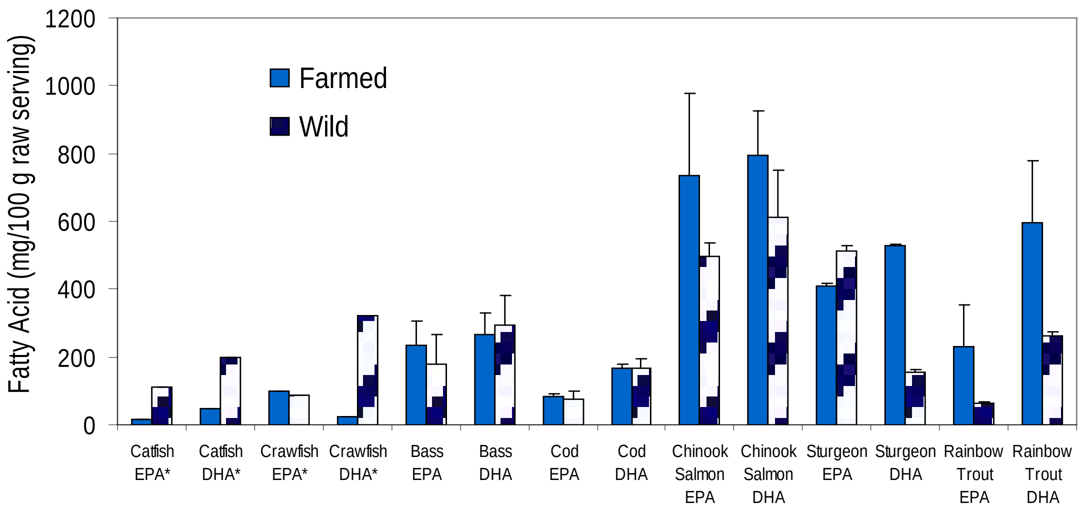
Implications

The U.S. population should be encouraged to eat a wide variety of seafood that can be wild caught or farmed, as they are nutrient-dense foods that are uniquely rich sources of healthy fatty acids. It should be noted that low-trophic farm-raised seafood, such as catfish and crayfish, have lower EPA and DHA levels than do wild-caught. Nutrient profiles in popular low-trophic farmed species should be improved through feeding and processing systems that produce and preserve nutrients similar to those of wild-caught seafood of the same species.

Review of the Evidence

The USDA-Agricultural Research Service (ARS) National Nutrient Database (NND) for Standard Reference, Release 27 was used to address this question (http://www.ars.usda.gov/ba/bhnrc/ndl).[25] The section on finfish and shellfish products included nutrient profiles for both farm-raised and wild-caught seafood for some species. These data were augmented using a USDA-funded report on fatty-acid profiles of commercially available fish in the United States that assessed additional farmed species and compared results[26] with the USDA-ARS NND.[25] The samples collected were from different regions of the United States during different seasons. For wild-caught species, the nutrient profile is determined by changes in environmental conditions, whereas, for farmed species, the nutrient profile is dependent on the amount, timing, and composition of the feed.[26] Because aquaculture diets can be continually modified, updates are important to monitor EPA and DHA in commercial seafood species, to provide consumers with the most accurate information. The NND provided nutrient profiles for six seafood species with data on both wild-caught and farm-raised versions: four fish (rainbow trout, Atlantic and Coho salmon, and catfish), eastern oysters, and mixed species crayfish. The key nutrients EPA and DHA were on average comparable or greater for farmed trout, salmon, and oysters compared to wild capture, reflecting the higher total fat content of these farmed species. On the other hand, low-trophic species, such as catfish and crayfish, when farmed, were lower in EPA and DHA compared to wild capture. Cladis et al. determined EPA and DHA levels for five farmed and wild fish species (rainbow trout, white sturgeon, Chinook salmon, Atlantic cod, striped bass), providing an update and comparison for some of these species (Figure D5.2)[26]. Farmed Atlantic salmon was similar between the NND and the update and most other species compared well; however, Chinook salmon and sturgeon showed differences in EPA and DHA content (although farmed and wild were not distinguished in the NND). Overall, these data showed that existing DGAC recommendations to consume a variety of seafood can be met by consuming a diverse range of species, including farmed species.

Figure D5.2. Comparison of EPA and DHA drawn from data in USDA National Nutrient Database[25] and update from Cladis et al.[26]



For additional details on this body of evidence, visit: Appendix E-2.38 Evidence Portfolio and http://www.ars.usda.gov/ba/bhnrc/ndl

Question 3. What are the comparative contaminant levels of current farm-raised versus wild caught seafood?

Source of evidence: Report of the Joint United Nations Food and Agriculture Organization/World Health Organization Expert Consultation on the Risks and Benefits of Fish Consumption. Rome, 25–29 January 2010. FAO Fisheries and Aquaculture Report No. 978.[27]

Conclusion

The DGAC concurs with the Consultancy that, for the majority of commercial wild and farmed species, neither the risks of mercury nor organic pollutants outweigh the health benefits of seafood consumption, such as decreased cardiovascular disease risk and improved infant neurodevelopment. However, any assessment evaluates evidence within a time frame and contaminant composition can change rapidly based on the contamination conditions at the location of wild catch and altered production practices for farmed seafood. **DGAC Grade: Moderate**

Implications

Based on risk/benefit comparisons, either farmed or wild-caught seafood are appropriate choices to consume to meet current Dietary Guidelines for Americans for increased seafood consumption. The DGAC supports the current FDA and EPA recommendations that women who are pregnant (or those who may become pregnant) and breastfeeding should not eat certain types of seafood—tilefish, shark, swordfish, and king mackerel—because of their high methyl mercury contents. Attention should be paid to local seafood advisories when eating seafood caught from local rivers, streams, and lakes.

Based on the most current evidence on mercury levels in albacore tuna provided in the Report of the Joint United Nations Food and Agriculture Organization/World Health Organization Expert Consultation on the Risks and Benefits of Fish Consumption, 2010,[27] the DGAC recommends that the EPA and FDA re-evaluate their current recommendations[61] for women who are pregnant (or for women who may become pregnant) or breastfeeding to limit white albacore tuna to not more than 6 ounces a week.

Review of the Evidence

The Report of the FAO/WHO Expert Consultation on the Risks and Benefits of Fish Consumption[27] was used to address this question. This report was chosen as the most current and comprehensive source on contaminants in wild-caught and farm-raised seafood, and the DGAC focused on data that addressed the specific comparison between the two. The sections of the report that were used to address the question were "Data on the composition of fish" and "Risk-benefit comparisons." The consultancy took a net effects approach, balancing benefits of seafood, especially benefits associated with EPA and DHA, against the adverse effects of mercury and persistent organic pollutants (POPs), including polychlorinated biphenyls, polychlorinated dibenzo-*p*-dioxins, and polychlorinated dibenzofurans, collectively referred to as dioxins. The Expert Consultancy compiled EPA and DHA, mercury, and dioxins compositional data from national databases of the United States, France, Norway, and Japan, as well as an international database. Together, these provided information on total fat, EPA and DHA, total mercury, and dioxins for a large number of seafood species, including three farmed and wild species (salmon, rainbow trout, and halibut). Two specific outcomes were considered for risk/benefit: 1) prenatal exposure and offspring neurodevelopment, and 2) mortality from cardiovascular diseases and cancer.

Overall, for the species examined, levels of mercury and dioxins were in the same range for farmed and wild seafood. Related to risk/benefit, at the same level of mercury content (lowest [≤ 0.1 μg/g] and 2nd lowest [0.1 - 0.5 μg/g] levels), farmed seafood had the same or higher levels of EPA and DHA as wild-caught. At the same level of dioxin content (2nd lowest [0.5 – 4 pg toxic equivalents (TEQ)/g] level), farmed seafood had the same or higher levels of EPA and DHA as wild-caught. Only wild-caught Pacific salmon had the lowest level of dioxins (<0.5 pg TEQ/g). Overall, the quantitative risk/benefit analysis was not different for farmed compared to wild-caught seafood. For both, using the central estimate for benefits of DHA and for harm from mercury, the neurodevelopmental risks of not eating seafood exceeded the risks of eating seafood. Similarly, for coronary heart disease (CHD) in adults, there were CHD mortality benefits from eating seafood and CHD risks from not eating seafood, except for seafood in the highest dioxin category and lowest EPA and DHA category, which did not include any of the farm-raised species considered.

Albacore tuna, produced only from wild marine fisheries, is a special case of a popular fish highlighted by the 2004 FDA and EPA advisory.[61, 62] For all levels of intake including more than double the 12 ounces per week recommendation, all evidence was in favor of net benefits for infant development and CHD risk reduction.

Limitations in the evidence included the small number of farmed and wild seafood species comparisons considered by the Expert Consultancy, and the possibility of rapid change that may occur in the concentration of contaminants locally. In addition, seafood contaminants are closely linked to levels of contaminants in feed.

For additional details on this body of evidence, visit: *Report of the Joint Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) Expert Consultation on the Risks and Benefits of Fish Consumption, 2011*. Available at http://www.fao.org/docrep/014/ba0136e/ba0136e00.pdf

Question 4: What is the worldwide capacity to produce farm-raised versus wild-caught seafood that is nutritious and safe for the U.S. population?

Source of evidence: United National (UN) Food and Agriculture Organization (FAO) report on *The State of World Fisheries and Agriculture.*[20]

Conclusions

The DGAC concurs with the FAO report that consistent evidence demonstrates that capture fisheries increasingly managed in a sustainable way have remained stable over several decades. However, on average, capture fisheries are fully exploited and their continuing productivity relies on careful management to avoid over-exploitation and long-term collapse. **DGAC Grade: Strong**

The DGAC endorses the FAO report that capture fisheries production plateaued around 1990 while aquaculture has increased since that time to meet increasing demand. Evidence suggests that expanded seafood production will rely on the continuation of a rapid increase in aquaculture output worldwide, projected at 33 percent increase by 2021, which will add 15 percent to the total supply of seafood.[20] Distributed evenly to the world's population, this capacity could in principle meet Dietary Guidelines recommendations for consumption of at least 8 ounces of seafood per week. Concern exists that the expanded capacity may be for low-trophic level seafood that has relatively low levels of EPA and DHA compared to other species. Under the current production, Americans who seek to meet U.S. Dietary Guidelines recommendations must rely on significant amounts of imported seafood (~90 percent). **DGAC Grade: Moderate**

Implications

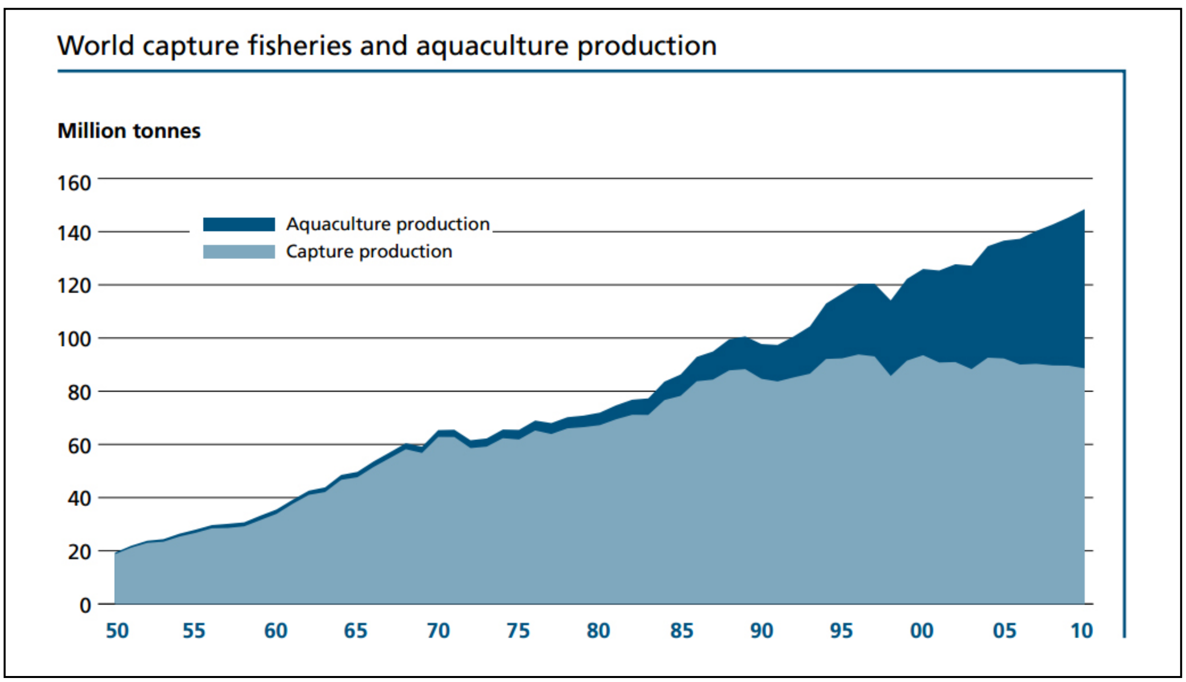
Both wild and farmed seafood are major food sources available to support DGAC recommendations to regularly consume a variety of seafood. Responsible stewardship over environmental impact will be important as farmed seafood production expands. Availability of these important foods is critical for future generations of Americans to meet their needs for a healthy diet. Therefore, strong policy, research, and stewardship support are needed to increasingly improve the environmental sustainability of farmed seafood systems. From the standpoint of the dietary guidelines this expanded production needs to be largely in EPA and DHA rich species and supporting production of low-trophic level species of similar nutrient density as wild-caught.

Review of the Evidence

The UN FAO report on *The State of World Fisheries and Agriculture* issued in 2012 formed the basis of the DGAC's evidence review on this topic.[20] The FAO report addresses a wide variety of issues affecting capture fisheries and aquaculture, including economics, infrastructure, and labor and government policies. The DGAC focused on matters that directly address the world production of one important food—seafood—as a first attempt by a DGAC committee to consider the implications of dietary guidelines for production of a related group of foods.

The production of capture fisheries has remained stable at about 90 million tons from 1990-2011 (Figure D5.3).[20] At the same time, aquaculture production is rising and will continue to increase. FAO model projections indicate that in response to the higher demand for seafood, world fisheries and aquaculture production is projected to grow by 15 percent between 2011 and 2021. This increase will be mainly due to increased aquaculture output, which is projected to increase 33 percent by 2021, compared with only 3 percent growth in wild capture fisheries over the same period. It is predicted that aquaculture will remain one of the fastest growing animal food-producing sectors and will exceed that of beef, pork, or poultry. Aquaculture production is expected to expand on all continents with variations across countries and regions in terms of the seafood species produced. Currently, the United States is the leading importer of seafood products world-wide, with imports making up about 90 percent of seafood consumption. Continuing to meet Americans needs for seafood will require stable importation or substantial expansion of domestic aquaculture.

Figure D5.3. Comparison of fishery production and aquaculture, 1950-2010



For additional details on this body of evidence, visit: UN FAO report on *The State of World Fisheries and Agriculture, 2012.* Available at http://www.fao.org/fishery/sofia/en

FOOD SAFETY

The DGAC reviewed evidence of food safety topics was limited to usual coffee/caffeine consumption, high dose caffeine consumption, and aspartame. Coffee is one of the most widely consumed beverages in the U.S. and represents a major source of caffeine.[63] The effects of coffee/caffeine consumption have not been evaluated by any prior DGAC. The Committee reviewed the evidence on normal and excessive coffee/caffeine intake and health outcomes. In addition, the DGAC reviewed evidence on health outcomes and aspartame; the most widely used nonnutritive sweetener.

Given the importance of food-borne illness prevention, the Committee reviewed the 2010 DGAC report content related to consumer behaviors and updated the key food safety behavior principles.

Question 5: What is the relationship between usual coffee/caffeine consumption and health?

Source of Evidence: Overview of systematic reviews and meta-analyses

Coffee/Caffeine and Chronic Disease

Conclusion

Strong and consistent evidence shows that consumption of coffee within the moderate range (3 to 5 cups/d or up to 400 mg/d caffeine) is not associated with increased risk of major chronic diseases, such as cardiovascular disease (CVD) and cancer and premature death in healthy adults. **DGAC Grade: Strong**

Consistent observational evidence indicates that moderate coffee consumption is associated with reduced risk of type 2 diabetes and cardiovascular disease in healthy adults. In addition, consistent observational evidence indicates that regular consumption of coffee is associated with reduced risk of cancer of the liver and endometrium, and slightly inverse or null associations are observed for other cancer sites. **DGAC Grade: Moderate**

Implications

Moderate coffee consumption can be incorporated into a healthy lifestyle, along with other behaviors, such as refraining from smoking, consuming a nutritionally balanced diet, maintaining a healthy body weight, and being physically active. However, it should be noted that coffee, as it is normally consumed, frequently contains added calories from cream, milk, and added sugars. Care should be taken to minimize these caloric additions. Furthermore, individuals who do not consume caffeinated coffee should not start to consume it for health benefits alone.

Review of the Evidence

Total Mortality

Evidence suggests a significant inverse relationship between coffee consumption of 1 to 4 cups/day with total mortality, especially CVD mortality. This evidence is based on three meta-analyses of more than 20 prospective cohort studies.[64-66] In general, results were similar for men and women. The risk reduction associated with each cup of coffee per day was between 3 to 4 percent. In addition, Je and Giovannucci found a significant inverse association between coffee consumption and CVD mortality.[65] This association was stronger in women (16 percent lower risk) than in men (8 percent lower risk). However, no association was found for cancer mortality. Crippa et al. found that the lowest risk was observed for 4 cups/day for all-cause mortality (16%, 95% CI: 13, 18) and 3 cups/day for CVD mortality (21%, 95% CI: 16, 26).[64]

Cardiovascular Disease

A large and current body of evidence directly addressed the relationship between normal coffee consumption and risk of CVD. The evidence included 12 systematic reviews with meta-analyses, all of which had high quality ratings (AMSTAR scores 8/11 – 11/11). CVD incidence and mortality, as well as CHD, stroke, heart failure, and hypertension were assessed by meta-analyses that consisted primarily of prospective cohort studies. Intermediate outcomes such as blood pressure, blood lipids, and blood glucose were assessed by meta-analyses of randomized controlled trials.

CVD risk was assessed by a current meta-analysis of 36 prospective cohort studies on long-term coffee consumption.[67] This analysis showed a non-linear association, such that the lowest risk of CVD was seen with moderate coffee consumption (3 to 5 cups/day), but higher intakes (>5 cups/day) were neither protective nor harmful. Overall, moderate consumption of caffeinated, but not decaffeinated, coffee was associated with a 12 percent lower risk of CVD.

Results from the assessment of CHD risk in three meta-analyses were not entirely consistent.[67-69] Ding et al. found 10 percent lower CHD risk with moderate coffee consumption (3 to 5 cups/day) in a meta-analysis of 30 prospective cohort studies, whereas Wu et al. and Sofi et al. in meta-analyses of 21 and 10 prospective cohort studies, respectively, found no association between coffee consumption and CHD risk. [67-69] However, in sub-group analysis, Wu et al. found that habitual moderate coffee consumption (1 to 4 cups/day) was associated with an 18 percent lower risk of CHD among women.[69] Overall, the meta-analyses of Sofi et al. and Wu et al. were conducted with smaller bodies of evidence and Ding et al. assessed several more recent studies.[67-69] Of note, coffee brewing methods have changed over time and the filter method has become more widely used, replacing unfiltered forms of coffee such as boiled coffee that were more widely reported by participants in earlier studies. Thus, the findings by Ding et al. are more up to date, reflecting health effects of coffee consumed in recent cohorts.

Risk of stroke was assessed in two systematic reviews with meta-analyses of prospective cohort studies with consistent findings.[70, 71] Kim et al. found that coffee intake of 4 or more cups/day had a protective association on risk of stroke.[70] Larsson et al. documented a non-linear association such that coffee consumption ranging from 1 to 6 cups/day was associated with an 8 percent to 13 percent lower risk of stroke, and higher intakes were not associated with decreased or increased risk.[71] The inverse associations were limited to ischemic stroke and no association was seen with hemorrhagic stroke.

Regarding blood pressure, three meta-analyses evaluated the effect of coffee and caffeine on systolic and diastolic blood pressure using controlled trials.[72-74] The most recent meta-analysis of 10 randomized controlled trials by Steffen et al. showed no effect of coffee on either systolic or diastolic blood pressure. Similarly, in another meta-analysis of 11 coffee trials and 5 caffeine trials, caffeine doses of <410 mg/day had no effect on systolic and diastolic blood pressure, while doses of 410 or more mg/day resulted in a net increase.[73] A third meta-analysis showed that among individuals with hypertension, 200 to 300 mg of caffeine (equivalent to ~2 to 3 cups filtered coffee) resulted in an acute increase of systolic and diastolic blood pressure.[72] Additionally, two meta-analyses quantified the effect of coffee on incidence of hypertension[74, 75] and found no association between habitual coffee consumption and risk of hypertension. However, Zhang et al. documented a slightly elevated risk for light to moderate consumption (1 to 3 cups/day) of coffee compared to less than 1 cup/day.[75]

Regarding blood lipids, meta-analyses of short-term randomized controlled trials revealed that coffee consumption contributed significantly to an increase in total cholesterol and LDL-cholesterol, but cholesterol-raising effects were primarily limited to unfiltered coffee and filtered coffee appeared to have minimal effects on serum cholesterol levels.[76, 77]

In a meta-analysis of observational study data, including prospective, retrospective, and case-control studies, higher amounts of coffee or caffeine had no association with risk of atrial fibrillation, but low doses of caffeine (<350 mg/day) appeared to have a protective association.[78] In addition, coffee consumption of 1 to 5 cups/day was found to be inversely associated with risk of heart failure in a meta-analysis of five prospective studies.[79] A non-linear association was documented and the lowest risk was observed for 4 cups/day.[79]

Type 2 Diabetes

Coffee consumption has consistently been associated with a reduced risk of type 2 diabetes. In four meta-analyses of prospective cohort studies[80-83] and cross-sectional studies,[83] coffee consumption was inversely associated with risk of type 2 diabetes in a dose-response manner. Compared to non-drinkers, risk for type 2 diabetes was 33 percent lower for those consuming 6 cups/day in the analysis by Ding et al. while the risk was 37 percent lower for those consuming 10 cups/day in the analysis by Jiang et al.[67, 82] Using a sub-set of the prospective cohorts in the

Ding et al. and Jiang et al. meta-analyses, Huxley et al. documented that each cup of coffee was associated with a 7 percent lower risk of type 2 diabetes.[81] Similarly, van Dam and Hu noted that consumption of ≥6 or ≥7 cups/day was associated with a 35 percent lower risk of type 2 diabetes.[83] Three meta-analyses[80-82] also found protective associations for decaffeinated coffee. Moderate decaffeinated coffee consumption (3 to 4 cups/day) was associated with a 36 percent lower risk of type 2 diabetes.[81] Each cup of decaffeinated coffee was associated with a 6 percent lower risk[80] while every 2 cups were associated with a 11 percent lower risk.[82] Both reports also documented a dose-response association between caffeine and type 2 diabetes risk such that every 140 mg/day was associated with an 8 percent lower risk in the Ding et al. meta-analysis, while every 200 mg/day was associated with a 14 percent lower risk in the analysis by Jiang et al.[80, 82] However, it remains unclear if this inverse association is independent of coffee consumption, as Ding et al. indicated that none of the studies included in the caffeine dose-response analysis adjusted for total coffee.

Only one systematic review of nine randomized controlled trials examined the effects of caffeine on blood glucose and insulin concentrations among those with type 2 diabetes.[84] Ingestion of 200 to 500 mg of caffeine acutely increased blood glucose concentrations by 16 to 28 percent of the area under the curve and insulin secretions by 19 to 48 percent of the area under the curve when taken before a glucose load. At the same time, these trials also noted a decrease in insulin sensitivity by 14 to 37 percent. Although no study has examined whether the effects of caffeine on blood glucose and insulin persist in the long term, evidence from prospective cohorts indicates that the acute effects of caffeine do not translate into long-term risk of type 2 diabetes. Furthermore, the inverse association between decaffeinated coffee and diabetes risk suggests that the observed benefit is likely to be due to other constituents in coffee rather than caffeine.

Cancer

Several systematic reviews and meta-analyses examined the association between coffee consumption and risk of cancer. Types of cancer examined by the DGAC included total cancer, cancers of the lung, liver, breast, prostate, ovaries, endometrium, bladder, pancreas, upper digestive and respiratory tract, esophagus, stomach, colon, and rectum.

In a quantitative summary of 40 prospective cohort studies with an average follow-up of 14.3 years, Yu et al. found a 13 percent lower risk of total cancer among coffee drinkers compared to non-drinkers or those with lowest intakes.[85] Risk estimates were similar for men and women. In sub-group analyses, the authors noted that coffee drinking was associated with a reduced risk of bladder, breast, buccal and pharyngeal, colorectal, endometrial, esophageal, hepatocellular, leukemic, pancreatic, and prostate cancers.

Tang et al. evaluated five prospective cohorts and eight case-control studies and found that, overall, those with the highest levels of coffee consumption had a 27 percent higher risk for lung cancer compared to never drinkers or those with least consumption.[86] An increase in coffee consumption of 2 cups/day was associated with a 14 percent higher risk of developing lung cancer. However, because smoking is an important confounder, when analyses were stratified by smoking status, coffee consumption was marginally protective in non-smokers and was not associated with lung cancer among smokers. When estimates from two studies that examined decaffeinated coffee were summarized, a protective association with lung cancer was seen. No association was seen with lung cancer when only case-control studies were considered.

Results from two meta-analyses indicate that coffee consumption is associated with a 40 to 50 percent lower risk of liver cancer,[87 88] when considering both cohort and case-control studies. In one meta-analysis, the associations were significant in men but not in women.[87]

Three meta-analyses of observational studies found no association between coffee consumption,[89-91] caffeine consumption, or decaffeinated coffee consumption and risk of breast cancer. In all three reports, each 2 cup/day of coffee was marginally associated with a 2 percent lower risk of breast cancer. However, in sub-group analyses, coffee consumption was protective against breast cancer risk in postmenopausal women,[89] BRCA1 mutation carriers,[89] and women with estrogen receptor negative breast tumors .[90]

The association between coffee consumption and risk of prostate cancer was mixed. Cao et al. and Zhong et al. found that regular or high coffee consumption, compared to non- or lowest levels of consumption, was associated with a 12 percent to 17 percent lower risk of prostate cancer in prospective cohort studies.[92, 93] Further, each 2 cups of coffee per day was associated with a 7 percent lower risk of prostate cancer. However, no associations were seen with case-control data alone or when these studies were examined together with prospective cohort studies. Using a combination of both prospective cohort and case-control data, Discacciati et al. found that each 3 cups/day of coffee was associated with a 3 percent lower risk of localized prostate cancer and an 11 percent lower risk of mortality from prostate cancer.[94] On the other hand, after summarizing data from 12 prospective cohort and case-control studies, Park et al. found a 16 percent higher risk of prostate cancer.[95] However, in sub-group analyses by study design, the higher risk was observed in case-control but not in cohort studies.

Consumption of coffee was not associated with risk of ovarian cancer in a meta-analysis of seven prospective cohort studies with more than 640,000 participants.[96] Two meta-analyses confirmed an inverse association between coffee consumption and risk of endometrial cancer.[97, 98] In the most recent and updated meta-analysis of prospective cohort and case-control studies, compared to those in the lowest category of coffee consumption, those with the highest intakes of coffee had a 29 percent lower risk of endometrial cancer.[98] Each cup of coffee per day was associated with an 8 percent lower risk of endometrial cancer. Similar results were found in the meta-analysis by Bravi et al. that included a sub-set of the studies in Je et al. and documented a 20 percent lower risk of endometrial cancer overall, and a 7 percent decrease for each cup of coffee per day.[97, 98] However, the association was significant only in case-control studies but not in cohort studies, most likely due to lower statistical power.

A recent meta-analysis of 23 case-control studies by Zhou et al. found coffee was a risk factor for bladder cancer. There was a smoking-adjusted increased risk of bladder cancer for those in the highest (45 percent), second highest, (21 percent), and third highest (8 percent) groups of coffee consumption, compared to those in the lowest intake group.[99] No association was, however, seen in cohort studies.

Two meta-analyses of coffee consumption and pancreatic cancer risk provided mixed results.[85, 100] Using both prospective cohort and case-control studies, Turati et al. found that coffee consumption was not associated with risk of pancreatic cancer.[100] However, an increased risk was seen in case-control studies that did not adjust for smoking. Using a sub-set of prospective cohorts included in the Turati et al. meta-analysis, Dong et al. found that coffee drinking was inversely associated with pancreatic cancer risk but did not separate studies based on their adjustment for smoking status.[101] Sub-group analyses revealed a protective association in men, but not in women.

Turati et al. quantified the association between coffee consumption and various upper digestive and respiratory tract cancers using data from observational studies.[102] Coffee consumption was associated with a 36 percent lower risk of oral and pharyngeal cancer but not with risk of laryngeal cancer, esophageal squamous cell carcinoma, or esophageal adenocarcinoma. In a meta-analysis of prospective cohort and case-control studies, Zheng et al. noted that coffee was inversely, but non-significantly, associated with risk of esophageal cancer.[103] Regarding gastric cancer, no association between coffee consumption and risk was seen in a meta-analysis of observational studies by Botelho et al.[104]

Three meta-analyses on the association between coffee consumption and colorectal cancer risk have yielded mixed findings.[105-107] Results from case-control studies suggested coffee consumption was associated with lower risk of colorectal (15 percent lower) and colon cancer (21 percent lower), especially in women. However, this inverse association was non-significant for cohort studies. Using all but one of the case-control studies, Galeone et al. arrived at similar conclusions as a Li et al. analysis, although associations were in general stronger.[105, 107] Galeone et al. also provided suggestive evidence for a dose-response relationship between coffee and colorectal cancer such that each cup of coffee was associated with a 6 percent lower risk of colorectal cancer, 5 percent lower risk of colon cancer, and 3 percent lower risk of rectal cancer.[105] Using several prospective cohort studies, as in the Li et al. meta-analysis, Je et al. found no significant association of coffee consumption with risk of colorectal cancer.[106, 107] Interestingly, no differences were seen by sex but the suggestive inverse associations were slightly stronger in studies that adjusted for smoking and alcohol.

For additional details on this body of evidence, visit: Appendix E-2.39a Evidence Portfolio, Appendix E-2.39b Systematic Review/Meta-Analysis Data Table, and References 64-107

Caffeine and Neurodegenerative Disease

Conclusion

Consistent evidence indicates an inverse association between caffeine intake and risk of Parkinson's disease. **DGAC Grade: Moderate**

Limited evidence indicates that caffeine consumption is associated with a modestly lower risk of cognitive decline or impairment and lower risk of Alzheimer's disease. **DGAC Grade: Limited**

Implications

Moderate coffee consumption can be incorporated into a healthy lifestyle, along with other behaviors, such as refraining from smoking, consuming a nutritionally balanced diet, maintaining a healthy body weight, and being physically active. However, it should be noted that coffee as it is normally consumed can contain added calories from cream, milk, and added sugars. Care should be taken to minimize these caloric additions. Furthermore, individuals who do not consume caffeinated coffee should not start to consume it for health benefits alone.

Review of the Evidence

Parkinson's Disease

Evidence from two systematic reviews[108, 109] and one quantitative meta-analysis[110] confirmed an inverse association between coffee, caffeine, and risk of Parkinson's disease. Qi et al. evaluated six case-control studies and seven prospective articles and documented a non-linear relationship between coffee and risk of Parkinson's disease, overall.[110] The lowest risk was observed at about 3 cups/day (smoking-adjusted risk reduction was 28 percent). For caffeine, a linear dose-response was found and every 200 mg/day increment in caffeine intake was associated with a 17 percent lower risk of Parkinson's disease. Using a combination of cohort, case-control, and cross-sectional data, Costa et al. summarized that the risk of Parkinson's disease was 25 percent lower among those consuming the highest versus lowest amounts of caffeine.[108] Like Qi et al., Costa et al. documented a linear dose-response with caffeine intake such that every 300 mg/day was associated with a 24 percent lower risk of Parkinson's disease. In both reports, associations were weaker among women than in men.

Cognition

Two systematic reviews[111, 112] and one meta-analysis[112] examined the effects of caffeine from various sources, including coffee, tea, and chocolate, on cognitive outcomes. Arab et al. systematically reviewed six longitudinal cohort studies evaluating the effect of caffeine or caffeine-rich beverages on cognitive decline.[111] Most studies in this review used the Mini Mental State Examination Score as a global measure of cognitive decline. The review concluded that estimates of cognitive decline were lower among caffeine consumers, although there was no clear dose-response relationship. Studies also showed stronger associations among women than men. In a meta-analysis of nine cohort and two case-control studies, caffeine intake from various sources was associated with a 16 percent lower risk of various measures of cognitive impairment/decline. Specifically, data from four studies indicate that caffeine is associated with a 38 percent lower risk of Alzheimer's disease.

For additional details on this body of evidence, visit: Appendix E-2.39a Evidence Portfolio, Appendix E-2.39b Systematic Review/Meta-Analysis Data Table, and References 108-112

Caffeine and Pregnancy Outcomes

Conclusion

Consistent evidence from observational studies indicates that moderate caffeine intake in pregnant women is not associated with risk of preterm delivery. **DGAC Grade: Moderate**

Higher caffeine intake is associated with a small increased risk of miscarriage, stillbirth, low birth weight, and small for gestational age (SGA) births. However, these data should be interpreted cautiously due to potential recall bias in the case-control studies and confounding by smoking and pregnancy signal symptoms. The DGAC recognizes that there is limited data to identify a level of caffeine intake beyond which risk increases. Based on the existing data, the risk of miscarriage, stillbirth, low birth weight, and SGA births is minimal given the average caffeine intake of pregnant women in the United States. **DGAC Grade: Limited**

Implications

Overall, the evidence supports current recommendations to limit caffeine intake during pregnancy as a precaution. Based on existing evidence, women who are pregnant or planning to become pregnant should be cautious and adhere to current recommendations of the American Congress of Obstetricians and Gynecologists regarding caffeine consumption, and not consume more than 200 mg caffeine per day (approximately two cups of coffee per day).

Review of the Evidence

Two SRs/MA assessed observational studies on the association of caffeine intake with adverse pregnancy outcomes.[113, 114] The pregnancy outcomes included miscarriage, pre-term birth, stillbirth, SGA, and low birth weight. The most recent SR/MA by Greenwood et al. quantified the association between caffeine intake and adverse pregnancy outcomes from 60 publications from 53 separate cohort (26) and case-control (27) studies.[113] The evidence covered a variety of countries with caffeine intake categories that ranged from non-consumers to those consuming more than 1,000 mg/day. They found that an increment of 100 mg caffeine was associated with a 14 percent increased risk of miscarriage, 19 percent increased risk of stillbirth, 10 percent increased risk of SGA, and 7 percent increased risk of low birth weight. The risk of pre-term delivery was not increased significantly. The magnitude of these associations was relatively small within the range of caffeine intakes of the majority women in the study populations, and the associations became more pronounced at higher range (≥300 mg/day). The authors also note the substantial heterogeneity observed in the meta-analyses shows that interpretation of the results should be cautious. In addition, the results from prospective cohort studies and case-control studies were mixed together. Because coffee consumption is positively correlated with smoking, residual confounding by smoking may have biased the results toward a positive direction.

The other SR/MA assessed pre-term birth and the results were in agreement with Greenwood et al.[113] Maslova et al. reviewed 22 studies (15 cohort and 7 case-control studies) and found no significant association between caffeine intake and risk of pre-term birth in either case-control or cohort studies.[114] For all of the observational studies assessed across the SRs/MA, most studies did not adequately adjust for the pregnancy signal phenomenon, i.e. that nausea, vomiting, and other adverse symptoms are associated with a healthy pregnancy that results in a live birth, whereas pregnancy signal symptoms occur less frequently when the result is miscarriage. Coffee consumption decreases with increasing pregnancy signal symptoms, typically during the early weeks of pregnancy, and this severely confounds the association.[115] Greenwood et al. state that this potential bias is the most prominent argument against a causal role for caffeine in adverse pregnancy outcomes.[113] Only one randomized controlled trial of caffeine/coffee reduction during pregnancy has been conducted to date.[116] The study found that in pregnant women who consumed at least three cups of coffee a day and were less than 20 weeks pregnant, a reduction of 200 mg of caffeine intake (~ 2 cups) per day did not significantly influence birth weight or length of gestation, compared to those with no decrease in caffeine consumption. The trial did not examine other outcomes.

For additional details on this body of evidence, visit: Appendix E-2.39a Evidence Portfolio, Appendix E-2.39b Systematic Review/Meta-Analysis Data Table, and References 113, 114

Question 6: What is the relationship between high-dose coffee/caffeine consumption and health?

Source of Evidence: Systematic reviews[117, 118]

Conclusion

Evidence on the effects of excessive caffeine intake on the health of adults or children (>400 mg/day for adults; undetermined for children and adolescents) is limited. Some evidence links high caffeine intake in the form of energy drinks to certain adverse outcomes, such as caffeine toxicity and cardiovascular events. Randomized controlled trials (RCTs) on the relationship between high-caffeine energy drinks and cardiovascular risk factors and other health outcomes report mixed results. Evidence also is limited on the health effects of mixing alcohol with energy drinks, but some evidence suggests that energy drinks may mask the effects of alcohol intoxication, so an individual may drink more and increase their risk of alcohol-related adverse events. **DGAC Grade: Limited**

Implications

Early safety signals consisting of case reports of adverse events associated with high-caffeine drink consumption, including increased emergency room visits, indicate a potential public health problem. The DGAC agrees with the American Academy of Pediatrics and the American Medical Association that until safety has been demonstrated, limited or no consumption of high-caffeine drinks, or other products with high amounts of caffeine, is advised for vulnerable populations, including children and adolescents. High-caffeine energy drinks and alcoholic beverages should not be consumed together, either mixed together or consumed at the same sitting. This is especially true for children and adolescents.

Background

According to the FDA, the upper limit of moderate caffeine intake in healthy adult populations (barring pregnant women) is 400 mg/day, with intakes higher than this being considered excessive caffeine consumption. The FDA has not defined moderate and excessive intake levels for children and adolescents. However, according to Health Canada, children should not consume more than 2.5 mg of caffeine per kg bodyweight per day.[119] Although this guideline pertains only to children up to the age of 12 years, in the literature it is usually applied to children and adolescents of all ages. A caffeine threshold of 2.5 mg/kg/day would translate into around 37.5 mg/day for children ages 2 to 5 years with an average weight of 15 kg, 75 mg/day for youth ages 6 to 12 years with an average weight of 30 kg, and 137.5 mg/day for youth ages 13 to 17 years with an average weight of 55 kg.

The main sources of caffeine among both adults and children are coffee, tea, and carbonated soft drinks. Another product, which has received a lot of attention recently as a potential source of excessive caffeine intake, especially among younger populations, is energy drinks.[120] An energy drink is a beverage that contains caffeine as its active ingredient, along with other ingredients such as taurine, herbal supplements, vitamins, and sugar. It is usually marketed as a product that can improve energy, stamina, athletic performance, or concentration.[121] Energy drinks are relatively new to the market and have evaded oversight and regulation by the FDA due to their classification as dietary supplements, or because their components are generally recognized as safe.[121] Overall, these drinks are highly variable in caffeine content and some products have excessively high caffeine content (from 50 to 505 mg per can/bottle, with caffeine concentrations anywhere between 2.5 to 171 mg per fluid ounce).[122]

Health organizations including the American Academy of Pediatrics, the International Society of Sports Nutrition, and the American Medical Association have issued position statements on energy drinks, advising limited or no consumption among children and adolescents. Given the increasing evidence pointing toward harmful effects of excessive caffeine consumption,[105-107] the FDA requested the IOM to convene a workshop examining the science behind safe levels of caffeine intake. A report summarizing this workshop was recently published.[123] Its main conclusions were: 1) Children and adolescents are a potential vulnerable group, in whom caffeine intake could have detrimental health consequences. This is particularly important given insufficient data on caffeine consumption in this demographic, which is increasingly getting exposed to new modes of caffeine intake such as energy drinks, 2) not enough is understood about potential interactions between caffeine and other ingredients commonly found in caffeine-containing foods and beverages, and 3) more research is needed to identify individual differences in reactions to caffeine, especially in vulnerable populations, including children with underlying heart conditions and individuals with genetic predispositions to heart conditions.

The Center for Disease Control (CDC) recently reported on trends in caffeine intake over the past decade (1999-2010) among U.S. children, adolescents, and young adults.[124] The CDC found that although energy drinks were not widely available before 1999, energy drinks made up nearly 6 percent of caffeine intake in 2009-2010, indicating fast growth in U.S. consumption over a short period of time. When energy drink consumption was assessed in a nationally representative sample of U.S. secondary school students,[125] 35 percent of 8th graders, 30 percent of 10th graders, and 31 percent of 12th graders consumed energy drinks or shots, and consumption was higher for adolescent boys than girls. Furthermore, energy drink use was associated with higher prevalence of substance use, as assessed for all grades of U.S. secondary students.

Furthermore, a serious issue of public health concern has been the popular trend of combining energy drinks with alcoholic beverages. In 2010, the FDA determined that caffeine added to alcoholic beverages was not generally recognized as safe (GRAS), leading to withdrawal of premixed, caffeinated alcoholic beverages from the market.[126] Currently, Health Canada caps caffeine levels for energy drinks at 100 mg/250 ml (~1 cup) and has determined that an energy drink container that cannot be resealed be treated as a single-serving container, because the total volume is usually consumed. They also have mandated that manufacturers add a warning to labels that energy drinks should not be combined with alcohol. Recently, the CDC has made public statements on the dangers of mixing alcohol and energy drinks. They indicate that high amounts of caffeine in energy drinks can mask the intoxicating effects of alcohol, while at the same time having no effect on the metabolism of alcohol by the liver. Therefore, high amounts of caffeine in energy drinks may result in an "awake" state of intoxication, thus increasing the risk of alcohol-related harm and injury (http://www.cdc.gov/alcohol/fact-sheets/cab.htm, March 2014).[127]

Review of the Evidence

Several case reports of adverse events related to energy drink use have been published. A recent systematic review of case reports of adverse cardiovascular events related to consumption of energy drinks documented 17 such published case reports.[118] The cardiovascular events documented included atrial fibrillation, ventricular fibrillation, supraventricular tachycardia, prolonged QT, and ST elevation. In 41 percent of the cases, the person had consumed large amounts of energy drinks, and 29 percent of the cases were associated with consumption of energy drinks together with alcohol or other drugs. In 88 percent of the cases, no underlying cardiac condition was found that could potentially explain the cardiovascular event, although other cardiovascular risk factors co-occurred with energy drink consumption before the onset of the event in most cases. Of the cases that presented with serious adverse events, including cardiac arrest, the majority occurred with either acute heavy consumption of energy drinks or consumption in combination with alcohol or other drugs. Overall, the authors concluded that causality cannot be inferred from this case series, but physicians should routinely inquire about energy drink consumption in relevant cases and vulnerable consumers should be cautioned against heavy consumption of energy drinks or concomitant alcohol (or drug) ingestion. This systematic review is consistent with a recent report from the Drug Abuse Warning Network (DAWN) on energy drink-related emergency room visits that showed U.S. emergency room visits temporally related to energy drink consumption doubled between 2007 and 2011.[128] These visits were attributed mainly to adverse reactions to energy drinks, but also to combinations with alcohol or drugs. It is generally agreed that adverse events associated with energy drink consumption are underreported.

Several short-term RCTs have examined the health effects of energy drink consumption. All of these have been carried out in adult populations, probably due to ethical constraints in providing energy drinks to children. Burrows et al. recently published a systematic review of RCTs examining this question.[117] They found 15 such RCTS, examining the effect of variable doses of energy drinks (mean dose: one and a half 250 ml cans per study session) with differing ingredient combinations and concentrations on a number of different health outcomes. The high variability in exposure and outcome definitions made a meta-analysis infeasible. Overall, they found no consistent effects of energy drinks on cardiorespiratory outcomes (heart rate, arrhythmias, blood pressure), pathological outcomes (blood glucose, blood lactate, free fatty acids, clinical safety markers), and body composition, with some studies showing positive, some inverse, and some no associations. For many of these outcomes, consistent results could not be stated due to only one study reporting on them. There was a slight indication of a potential positive effect of energy drinks on physiological outcomes (run time to exhaustion, peak oxygen uptake, resting energy expenditure). However, the authors concluded that more studies were needed before arriving at a definitive conclusion. Two of the studies assessed the simultaneous ingestion of alcohol and energy drinks.[129, 130] One found that when compared with the ingestion of alcohol alone, the addition of an energy drink reduced individuals' perception of impairment from alcohol, while at the same time, objective measures indicated ongoing deficits in motor coordination and visual acuity.[129] Nor did energy drinks reduce breath alcohol concentration, indicating no change or increase in alcohol metabolism by the liver. Another study on energy drinks in combination with alcohol and exercise showed that during post-exercise recovery there was no effect on arrhythmias within 6 hours of energy drink ingestion in healthy young adults.[130]

Many of the these studies have methodological limitations, such as lack of a true control group (water or no drink), a very short follow-up duration of only a few hours, and small sample sizes, which could explain the inconsistent findings. In addition, many of these studies did not report whether they were commercially funded. Several of those that did report funding sources had financial conflicts of interest. Lastly, the doses of energy drinks used in these studies were not too high, resulting in caffeine intake levels that fell within the normal range. It is possible that excessive caffeine intake due to heavy energy drink consumption adversely affects several health outcomes, but this hypothesis was not clearly addressed by these studies. Hence it is difficult to ascertain the impact of excessive caffeine intake on health outcomes on the basis of these RCTs. In addition, very little data are available on the health effects of excessive caffeine consumption in pediatric populations.

For additional details on this body of evidence, visit: Appendix E-2.40 Evidence Portfolio and References 117, 118

Question 7: What is the relationship between consumption of aspartame and health?

Source of Evidence: *Scientific Opinion on the re-evaluation of aspartame (E 951) as a food additive (2013),* European Food Safety Authority (EFSA) Panel on Food Additives and Nutrient Sources added to Food [29]

Conclusion

The DGAC generally concurs with the European Food Safety Authority (EFSA) Panel on Food Additives that aspartame in amounts commonly consumed is safe and poses minimal health risk for healthy individuals without phenylketonuria (PKU). **DGAC Grade: Moderate**

Limited and inconsistent evidence suggests a possible association between aspartame and risk of some hematopoietic cancers (non-Hodgkin lymphoma and multiple myeloma) in men, indicating the need for more long-term human studies. In addition, limited and inconsistent evidence indicates a potential for risk of preterm delivery. Due to very limited evidence it is not possible to draw any conclusions on the relationship between aspartame consumption and headaches. **DGAC Grade: Limited**

Implications

If individuals choose to drink beverages that are sweetened with aspartame, they should stay below the aspartame Acceptable Daily Intake (ADI) of no more than 50 mg/kg/day (a 12-ounce diet beverage contains approximately 180 mg of aspartame).[131] To be cautious, adults and children should be aware of the amount of aspartame they are consuming, given the need for more long-term human studies. Currently, most Americans are well below the ADI.[132]

Background

Aspartame is the most common low-calorie sweetener used in the United States. It is found in numerous dietary sources. Although most commonly associated with low-calorie/low-sugar versions of carbonated and non-carbonated beverages, it also is found in low-calorie/low-sugar versions of canned fruits and juices; instant cereals; baked goods; ice cream and frozen ices; candy and chocolate products; jams, jellies, syrups, and condiments; yogurt; and beer. Non-nutritive sweeteners are regulated by the FDA. The FDA has concluded that aspartame is safe as a general purpose sweetener in food.[133] Given the high interest of the public in the safety of aspartame, the DGAC reviewed the EFSA report on the sweetener and health outcomes.

Review of the Evidence

The most recent European Food Safety Authority report on the re-evaluation of aspartame as a food additive was used to address this question.[29] The EFSA report based its evaluation on original study reports and information submitted following public calls for data, previous evaluations, and additional literature that became available up until the end of public consultation on November 15, 2013. The DGAC focused on results from human studies, not animal studies or studies conducted *in vitro*. The Mode of Action (MoA) analysis on reproductive and developmental toxicity of aspartame also was included. Although the EFSA report considered both published and unpublished studies, the DGAC considered only published studies.

Cancer

A relatively limited body of evidence on human studies has directly addressed the relationship between aspartame consumption and cancer risk. The most consistent finding in six U.S. and European case-control studies[134-139] was the absence of an adverse relationship between consumption of low-calorie sweeteners, including aspartame, and risk of some cancers. An exception was one study in Argentina that found a positive association between long-term use (≥10 y) of artificial sweeteners and risk of urinary tract tumors (UTT), compared to non-users; although for short-term users, no association was observed.[134]

The findings of two prospective cohort studies[140, 141] were not consistent. Lim et al. examined a large cohort of men and women from the NIH-AARP Diet and Health study and found no association between consumption of aspartame-containing beverages and risk of overall hematopoietic cancers, brain cancers, or their subtypes.[140] A second large prospective cohort study by Shernhammer et al. involved the Nurses' Health Study (NHS) and Health Professionals Follow-up Study (HPFS) cohorts followed over 22 years with dietary intake measured every 4 years.[141] In this study, the highest category of aspartame intake (≥143 mg/day from diet soda and aspartame packets) was associated with significantly elevated risk of non-Hodgkin lymphoma (NHL) and of multiple myeloma in men, but not in women. Both of the prospective cohort studies that addressed cancer risk had limitations regarding generalizability. The NIH-AARP cohort had an age range of 50 to 71 years and was, therefore, not generalizable to the overall adult population. Additionally, the Panel considered the positive findings in Shernhammer et al. to be preliminary and require replication in other populations because the positive association between aspartame consumption and NHL was limited to men and lacked a clear dose-response relationship.[29]

Further investigation should be considered to ensure that no association exists between aspartame consumption and specific cancer risk.

Preterm Delivery

Two European cohort studies were used in this evaluation. A large prospective cohort study by Halldorsson et al.[142] from the Danish National Birth Cohort investigated associations between consumption of artificially sweetened and sugar-sweetened soft drinks during pregnancy and subsequent pre-term delivery. Also, a large prospective cohort study of Norwegian women by Englund-Ögge et al.[143] investigated the relationship between consumption of artificially sweetened and sugar-sweetened soft drinks during the first 4 to 5 months of pregnancy and subsequent pre-term delivery. In addition, La Vecchia combined these two studies in a meta-analysis that the Panel considered.[144]

Regarding the Halldorsson study, significant trends in risk of pre-term delivery with increasing consumption of artificially sweetened drinks (carbonated and non-carbonated) were found, but not for sugar-sweetened drinks.[142] In the highest exposure groups (≥ 4 servings/d) the odds ratios relative to non-consumption were 1.78 (95% CI: 1.19-2.66) and 1.29 (95% CI: 1.05-1.59), respectively, for carbonated and non-carbonated artificially sweetened drinks. Associations with consumption of artificially sweetened carbonated drinks did not differ according to whether delivery was very early (less than 32 weeks) or only moderately or late pre-term.[142] The EFSA Panel noted that the prospective design and large size of the study sample were major strengths, and that the methods used had no important flaws.[29] The Panel agreed with the authors who concluded that replication of their findings in another setting was warranted.

Regarding the Englund-Ögge study, no significant trends were found in risk of pre-term delivery with increasing consumption of artificially sweetened drinks or sugar-sweetened drinks.[143] Small elevations of risk were observed with higher consumption of artificially sweetened soft drinks, but after adjustment for covariates, these reached significance only when categories of consumption were aggregated to four levels, and then the odds ratio for the highest category (≥ 1 serving/day) was 1.11 (95% CI: 1.00-1.24) compared with non-consumption. This was driven by an increase in spontaneous but not medically induced pre-term delivery. Associations with sugar-sweetened soft drinks tended to be stronger, with an adjusted odds ratio of 1.25 (95% CI: 1.08-1.45) for consumption of at least 1 serving per day. The Panel noted that effects may have been underestimated because of inaccuracies in the assessment of dietary exposures, but the method was similar to that used by Halldorsson et al., and the same for sugar-sweetened as for artificially sweetened soft drinks.[29]

Behavior and Cognition

Children

Two RCTs[145, 146] and two non-randomized controlled trials[147, 148] conducted in the United States were included in the evidence on effects of aspartame on behavior and cognition in children. Wolraich et al. compared diets high in sucrose to diets high in aspartame in 25 preschool and 23 primary school-age children and found that even when intake exceeded typical dietary levels, neither dietary sucrose nor aspartame affected children’s behavior or cognitive function.[146] Shaywitz et al. examined the effect of large doses of aspartame (10 times usual consumption) on behavioral/cognitive function in children with attention deficit disorder (ages 5 to 13 years) and found no effect of aspartame on cognitive, attentive, or behavioral testing.[146] Roshon and Hagan examined 12 preschool children on alternate experimental days with a challenge of sucrose- or aspartame-containing drinks and found no significant differences in locomotion, task orientation, or learning.[148] Lastly, Kruesi et al. investigated the effect of sugar, aspartame, saccharin, and glucose on disruptive behavior in 30 preschool boys on four separate experimental days.[147] There was no significant difference in scores of aggression or observer’s ratings of behavior in response to any of the treatments. The limitations of this evidence were that all of the trials were approximately 20 to 30 years old, all had small sample sizes, and all were conducted over the short-term (1 day to 3 weeks). Overall, the Panel noted that no effects of aspartame on behavior and cognition were observed in children in these studies.[29]

Adults

Seven studies on the effect of aspartame on adult behavior and cognition were included in this body of evidence. Five RCTs, one non-randomized controlled trial, and one case-control study were conducted in the United States. Two of these trials examined a single experimental dose of aspartame on one day.[149, 150] Lapierre et al. examined 15 mg aspartame/kg body weight in 10 healthy adults and found no significant differences between aspartame and placebo in cognition or memory during the study.[149] Ryan-Harshman et al. tested 13 healthy adult men and found no change in any behavioral effects measured.[150] A third randomized crossover trial examined 48 adults over 20 days; half of the participants were given high dose aspartame (45 mg/kg/d) and half were given low dose aspartame (15 mg/kg/d).[151] This study found no neuropsychologic, neurophysiologic, or behavioral effects linked to aspartame consumption. Two trials were conducted with pilots or college students to test cognitive abilities related to aviation tasks.[152, 153] In the first study, 12 pilots were given aspartame (50 mg/kg) or placebo and tested for aviation-related information processing after a single treatment on one day. The authors detected no performance decrements associated with exposure to aspartame. In the follow-up study, college students were given repeated dosing of aspartame (50 mg/kg for 9 days) and tested for aviation-related cognitive tasks. No impaired performance was observed. One non-randomized crossover trial examined the effects of aspartame on mood and well-being in 120 young college women and found no difference in changes in mood after consuming a 12-ounce water or aspartame-sweetened beverage on a single day.[154] Lastly, a case-control study was conducted with 40 adults with unipolar depression and a similar number of subjects without a psychiatric history.[155] Participants were given aspartame (30 mg/kg) or placebo for 7 days and individuals with depression reported an increase in severity of self-scored symptoms between aspartame and placebo; whereas the non-depressed matched subjects reported no difference. This suggested that individuals with mood disorders may be sensitive to aspartame. Overall, the Panel noted the limited number of participants, the short duration of the studies, and the inconsistency of the reporting of the results in all adult studies. However, despite these limitations, the Panel concluded that there was no evidence that aspartame affects behavior or cognitive function in adults.[29]

Other (Headaches, Seizures)

Several studies examined headaches and seizures. A number of RCTs were conducted to assess the incidence of headache after consumption of aspartame. One RCT tested the effects of aspartame within 24 hours of consumption (30 mg/kg) on 40 subjects with a history of headache and found no difference in the incidence rate of headaches.[156] Another RCT looked at the effect of aspartame on frequency and intensity of migraine headaches in 10 subjects with medical diagnosis of migraine headaches over 4 weeks.[157] The authors found an increase in the frequency of migraine headaches with the aspartame treatment. In an RCT of 18 subjects with self-described sensitivity to aspartame, the participants reported headaches on 33 percent of the days, compared with 24 percent with placebo.[158] The authors concluded that a subset of the population may be susceptible to headaches induced by aspartame. Lastly, in a survey study of 171 patients at a headache unit, 8 percent reported that aspartame was a trigger of headaches compared to 2.3 percent for carbohydrates and 50 percent for alcohol.[159] Overall, the Panel concluded the possible effect of aspartame on headaches had been investigated in various studies which reported conflicting results, ranging from no effect to the suggestion that a small subset of the population may be susceptible to aspartame-induced headaches.[29] The number of existing studies was small and not recent and several studies had high dropout rates. The Panel noted that because of the limitations of the studies, it was not possible to draw a conclusion on the relationship between aspartame consumption and headaches.

Several small studies assessed seizures. One RCT in children investigated whether aspartame would induce the occurrence of petit mal seizures.[160] Ten children were given one treatment of aspartame at the ADI of 40 mg/kg and that treatment exacerbated the number of electroencephalogram spike waves per hour for these children without a history of seizures. In a second RCT, aspartame (34 mg/kg) was administered to 10 epileptic children over 2 weeks to examine the induction of seizures.[145] No difference was found in the occurrence of seizures between aspartame and placebo exposure. Another RCT studied 18 subjects who claimed to have experienced epileptic seizures due to aspartame.[161] One treatment (50 mg/kg) was administered on a single day and the authors reported no seizures or other adverse effect from aspartame treatment in this group. Overall, the Panel concluded that the available data do not provide evidence for a relationship between aspartame consumption and seizures.[29]

Pregnancy Outcomes: Mode of Action (MoA) analysis

The EFSA Panel considered that adverse effects on reproduction and development reported for aspartame in animal studies could be attributed to the metabolite phenylalanine.[29] They undertook a formal Mode of Action (MoA) analysis of the putative role of phenylalanine in developmental toxicity (as seen in animal studies).

Risk characterization was based on comparison of plasma phenylalanine levels following aspartame administration with plasma phenylalanine levels associated with developmental effects in children born from mothers with PKU. Current clinical practice guidelines recommend PKU patients restrict dietary intake of phenylalanine to keep plasma levels below 360µM. The EFSA Panel noted that intakes of aspartame as a food additive could occur at the same time as other dietary phenylalanine sources. Therefore, they considered the threshold used for comparisons should be lowered to allow for simultaneous intake of aspartame with meals. So plasma phenylalanine from the diet (120µM) was subtracted from 360µM to determine the maximum safe plasma concentration of phenylalanine that can be derived from aspartame (240μM).

The Panel considered that given these conservative assumptions, realistic dietary intake of aspartame and the confidence intervals provided by the modeling, the peak plasma phenylalanine levels would not exceed the clinical target threshold of 240μM when a normal individual consumed aspartame at or below the current ADI of 40 mg/kg body weight/day. Therefore, the Panel concluded there would not be a risk of adverse effects on pregnancy in the general population at the current ADI.[29]

For additional details on this body of evidence, visit: Appendix E-2.41 Evidence Portfolio and *Scientific Opinion on the re-evaluation of aspartame (E 951) as a food additive (2013),* European Food Safety Authority (EFSA) Panel on Food Additives and Nutrient Sources added to Food. Available at www.efsa.europa.eu/efsajournal

Question 8: What Consumer Behaviors Prevent Food Safety Problems? (Topic update from 2010)

Introduction and Methods

Food safety continues to be an issue of public health importance. Foodborne illness is a preventable, yet common issue affecting the U.S. population. Each year, approximately 1 in 6 people in the U.S. population become ill, 128,000 are hospitalized, and 3,000 die of foodborne illness.[162] It is critical to educate consumers and food producers on good techniques and behaviors for preventing food borne illness.

The 2010 DGAC conducted NEL systematic reviews for the Food Safety and Technology chapter and provided in-depth guidance on foodborne illness prevention. The 2015 DGAC reviewed the content related to consumer behavior and the prevention of food safety problems. The Committee determined that the majority of the 2010 food safety guidance was current and that only minor updates were necessary. For more information on the evidence review on food safety, refer to the DGAC 2010 report, Food Safety and Technology Section: (http://origin.www.cnpp.usda.gov/Publications/DietaryGuidelines/2010/DGAC/Report/D-8-FoodSafety.pdf).

The four food safety principles—Clean, Separate, Cook, and Chill are the foundation of the Fight BAC!® campaign (www.fightbac.org) and are reemphasized in this report. Data from the Centers for Disease Control and Prevention,[30] Food and Drug Administration,[31] and the Food Safety and Inspection Service[32] were used to update the 2010 DGAC tables on the following topics related to consumer behavior and food safety:

CLEAN and SEPARATE (Tables D5.1, D5.2, D5.3)

- Techniques for hand sanitation, washing fresh produce, and preventing cross-contamination.

COOK and CHILL (Table D5.4)

- Temperature control during food preparation and storage.

Table D5.3 includes updated guidance on preventing cross-contamination from shopping to serving foods. Table D5.4 lists recommended internal temperatures for meat, seafood, eggs, and leftovers. Additionally, Tables D5.5 and D5.6 provide recommended techniques for using food and refrigerator/freezer thermometers. Specific changes made to the 2010 tables are detailed in the footnotes of the tables.

Food Safety—Tables

Table D5.1. Recommended procedures for hand sanitation

When washing hands with soap and water:
• **Wet** your hands with clean, running water (warm or cold), turn off the tap, and apply soap.[1]
• **Lather** your hands by rubbing them together with the soap. Be sure to lather the backs of your hands, between your fingers, and under your nails.[2]
• **Scrub** your hands for at least 20 seconds. Need a timer? Hum the "Happy Birthday" song from beginning to end twice.[3]
• **Rinse** your hands well under clean, running water.
• Dry your hands using a clean towel or air dry them.[4]
If soap and clean, running water are not available, use an alcohol-based hand sanitizer that contains at least 60% alcohol[5]. Hand sanitizers are not as effective when hands are visibly dirty or greasy.[6] How do you use hand sanitizer:[7]
• Apply the product to the palm of one hand (read the label to learn the correct amount).
• Rub your hands together.
• Rub the product over all surfaces of your hands and fingers until your hands are dry.

Updates to the 2010 DGAC table

[1] Water temperature "warm or cold" and a conservation recommendation of 'turn off the tap' were added.

[2] The soap is to be help while lathering one's hands, then rub all together. "Scrub all surfaces" was clarified to "the backs of hands, between fingers, and under nails."

[3] "At least" was added to the 20 seconds time frame. To give a time reference, the suggestion to" hum the Happy Birthday song…" was added.

[4] The word 'paper' was removed as a modifier for towel, and instead it was specified to be a 'clean' towel. The option to 'air dry them' was added and the option of using an air dryer was removed from the phrase. Also removed was the direction to use your paper towel to turn off the faucet.

[5] The words 'clean' and 'running' were inserted in the directions for when water is not available. 'Hand sanitizer that contains at least 60% alcohol' replaces 'gel'.

[6] This guidance was added.

[7] The following step was added, "Read the label to learn the correct amount."

Source: Adapted from http://www.cdc.gov/handwashing/when-how-handwashing.html. Accessed June 2, 2014.[30]

Table D5.2. Recommended techniques for washing produce

When preparing any fresh produce, begin with clean hands. Wash your hands for at least 20 seconds with soap and warm water before and after preparation.
Cut away any damaged or bruised areas on fresh fruits and vegetables before preparing and/or eating. Produce that looks rotten should be discarded.
Wash all produce **thoroughly** under running water **before eating, cutting or cooking**. This includes produce grown conventionally or organically at home, or purchased from a grocery store or farmer's market. Washing fruits and vegetables with soap or detergent or using commercial produce washes is not recommended.
Even if you plan to peel the produce before eating, it is still important to wash it first so dirt and bacteria are not transferred from the peel via the knife to the fruit or vegetable [1].
Scrub firm produce, such as melons and cucumbers, with a clean produce brush.
Dry produce with a clean cloth towel or paper towel to further reduce bacteria that may be present.
Many pre-cut, bagged, or packaged produce items like lettuce are pre-washed and ready-to-eat. If so, it will be stated on the package and you can use the product without further washing.
If you do choose to wash a product marked "pre-washed" and "ready-to-eat," be sure to use safe handling practices to avoid any cross-contamination (see Table D5.3).

Updates to the 2010 DGAC table

[1] The following explanation was provided: ". . . so dirt and bacteria aren't transferred from the knife onto fruit or vegetable."

Source: Adapted from http://www.fda.gov/downloads/Food/ResourcesForYou/Consumers/UCM174142.pdf. Accessed June 2, 2014[31]

Table D5.3. Recommended techniques for preventing cross-contamination

When Shopping:
Separate raw meat, poultry, and seafood from other foods in your grocery-shopping cart. Place these foods in plastic bags to prevent their juices from dripping onto other foods. It is also best to separate these foods from other foods at check out and in your grocery bags.
When Refrigerating Food[1]:
Place raw meat, poultry, and seafood in containers or sealed plastic bags to prevent their juices from dripping onto other foods. Raw juices often contain harmful bacteria.
Store eggs in their original carton and refrigerate as soon as possible.
When Preparing Food:
Washing raw poultry, beef, pork, lamb, or veal before cooking it is not recommended. Bacteria in raw meat and poultry juices can be spread to other foods, utensils, and surfaces.
Wash hands and surfaces often. Harmful bacteria can spread throughout the kitchen and get onto cutting boards, utensils, and countertops. To prevent this:
• Wash hands with soap and warm water for 20 seconds before and after handling food, and after using the bathroom, changing diapers; or handling pets.
• Use hot, soapy water and paper towels or clean cloths to wipe up kitchen surfaces or spills. Wash cloths often in the hot cycle of your washing machine.
• Wash cutting boards, dishes, and counter tops with hot, soapy water after preparing each food item and before you go on to the next item.
• A solution of 1 tablespoon of unscented, liquid chlorine bleach per gallon of water may be used to sanitize surfaces and utensils.
Cutting Boards:
Always use a clean cutting board.
If possible, use one cutting board for fresh produce and a separate one for raw meat, poultry, and seafood.
Once cutting boards become excessively worn or develop hard-to-clean grooves, they should be replaced.
Marinating Food:
Always marinate food in the refrigerator, not on the counter.
Sauce that is used to marinate raw meat, poultry, or seafood should not be used on cooked foods, unless it is boiled just before using.
When Serving Food:
Always use a clean plate.
Never place cooked food back on the same plate or cutting board that previously held raw food.

Updates to the 2010 DGAC table

[1]This sentence was deleted, ""When not possible, store raw animal foods below ready-to-eat foods and separate different types of raw animal foods, such as meat, poultry, and seafood from each other so that they do not cross-contaminate each other."

Source: Adapted from http://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/safe-food-handling/washing-food-does-it-promote-food-safety/washing-food and http://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/safe-food-handling/be-smart-keep-foods-apart/ct_index Accessed June 3, 2014.[32]

Table D5.4. Recommended safe minimum internal temperatures

Cook to the minimum internal temperatures below, as measured with a clean food thermometer before removing meat from the heat source. For safety and quality, allow meat to rest for at least three minutes before carving or consuming. For reasons of personal preference, consumers may choose to cook meat to higher temperatures.[1] [c]

Food	Degrees Fahrenheit
Ground Meat and Meat Mixtures[a]	
Beef, Pork, Veal, Lamb	160
Turkey, Chicken	165
Fresh Beef, Pork, Veal, Lamb[a,2]	
Steaks, roasts, chops[a]	145
Poultry[a]	
Chicken and Turkey, whole	165
Poultry breasts, roasts	165
Poultry thighs, wings	165
Duck and Goose	165
Stuffing (cooked alone or in bird)	165
Fresh Pork[a]	160
Ham[a]	
Fresh (raw)[3]	145
Pre-cooked (to reheat)	140
Eggs and Egg Dishes[a]	
Eggs	Cook until yolk and white are firm.
Egg dishes	160
Fresh Seafood [b]	
Finfish	145
	Cook fish until it is opaque (milky white) and flakes with a fork.
Shellfish	Cook shrimp, lobster, and scallops until they reach their appropriate color. The flesh of shrimp and lobster should be an opaque (milky white) color. Scallops should be opaque (milky white) and firm.
	Cook clams, mussels, and oysters until their shells open. This means that they are done. Throw away the ones that didn't open.
	Shucked clams and shucked oysters are fully cooked when they are opaque (milky white) and firm[4].
Leftovers and Casseroles[a]	165

Updates to the 2010 DGAC table

1 An introductory paragraph was added on the topic of allowing for a three-minute rest period after cooking meat.
2 Pork was added to the list of fresh meats.
3 Fresh (raw) ham was added to the table.
4 Information on cooking status of shucked clams and oysters was added.

Sources:

[a] http://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/safe-food-handling/kitchen-companion-your-safe-food-handbook/ct_index. Accessed June 3, 2014.[32]
[b] http://www.fda.gov/Food/ResourcesForYou/HealthEducators/ucm082294.htm. Accessed June 3, 2014.[31]
[c] http://www.fsis.usda.gov/wps/wcm/connect/8e9f95a6-fd35-42d3-b6cb-b07a4b853992/Leftovers_and_Food_Safety.pdf?MOD=AJPERES. Accessed June 3, 2014.[32]

Table D5.5. Recommended techniques for food thermometers

To be safe, meat, poultry, and egg[a] and seafood[b] products must be cooked to a safe minimum internal temperature to destroy any harmful microorganisms that may be in the food.
A food thermometer should also be used to ensure that cooked food is held at safe temperatures until served. Cold foods should be held at 40°F or below. Hot foods should be kept hot at 140°F or above.[a]
Most available food thermometers will give an accurate reading within 2 to 4°F. The reading will only be correct, however, if the thermometer is placed in the proper location in the food. [a]
In general, the food thermometer should be placed in the thickest part of the food, away from bone, fat, or gristle.[a]
When the food being cooked is irregularly shaped, such as with a beef roast, check the temperature in several places. Egg dishes and dishes containing ground meat and poultry should be checked in several places.[a]
When measuring the temperature of a thin food, such as a hamburger patty, pork chop, or chicken breast, a thermistor or thermocouple food thermometer should be used, if possible. [a]
However, if using an "instant-read" dial bimetallic-coil food thermometer, the probe must be inserted in the side of the food so the entire sensing area (usually 2 to 3 inches) is positioned through the center of the food.[a]
To avoid burning fingers, it may be helpful to remove the food from the heat source (if cooking on a grill or in a frying pan) and insert the food thermometer sideways after placing the item on a clean spatula or plate.[a]
Food thermometers should be washed with hot soapy water. Most thermometers should not be immersed in water.[a]

Sources: [a] http://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/appliances-and-thermometers/kitchen-thermometers/ct_index., Accessed June 3, 2014.[32]
[b] http://www.fda.gov/Food/ResourcesForYou/HealthEducators/ucm082294.htm, Accessed June 3, 2014.[31]

Table D5.6. Recommended techniques for using refrigerator/freezer thermometers

For safety, it is important to verify the temperature of refrigerators and freezers.
Refrigerators should maintain a temperature no higher than 40°F.
Frozen food will hold its top quality for the longest possible time when the freezer maintains 0°F or below.
To measure the temperature in the refrigerator:
Put the thermometer in a glass of water and place in the middle of the refrigerator. Wait 5 to 8 hours. If the temperature is not 38 to 40°F, adjust the refrigerator temperature control. Check again after 5 to 8 hours.
To measure the temperature in the freezer:
Place the thermometer between frozen food packages. Wait 5 to 8 hours. If the temperature is not 0 to 2°F, adjust the freezer temperature control. Check again after 5 to 8 hours. An appliance thermometer can be kept in the refrigerator and freezer to monitor the temperature at all times. This can be critical in the event of a power outage. When the power goes back on, if the refrigerator is still 40°F and the freezer is 0°F or below, the food is safe[1].

Updates to the 2010 DGAC table
[1] When referring to the correct freezer temperature, 'or below' was added after 'zero degrees Fahrenheit.'

Source: http://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/appliances-and-thermometers/appliance-thermometers/appliance-thermometers. , Accessed June 3, 2014.[32]

CHAPTER SUMMARY

Access to sufficient, nutritious, and safe food is an essential element of food security for the U.S. population. A sustainable diet is one that assures this access for both the current population and future generations. This chapter focused on evaluating the evidence around sustainable diets and several topic areas of food safety.

The major findings regarding sustainable diets were that a diet higher in plant-based foods, such as vegetables, fruits, whole grains, legumes, nuts, and seeds, and lower in calories and animal-based foods is more health promoting (as discussed in ***Part B. Chapter 2: 2015 DGAC Themes and Recommendations: Integrating the Evidence***) and is associated with less environmental impact than is the current U.S. diet. This pattern of eating can be achieved through a variety of dietary patterns, including the "Healthy U.S.-style Pattern," the "Healthy Mediterranean-style Pattern," and the "Healthy Vegetarian Pattern" (see ***Part D. Chapter 1: Food and Nutrient Intakes, and Health: Current Status and Trends*** for a description of these patterns). All of these dietary patterns are aligned with lower predicted environmental impacts and provide food options that can be adopted by the U.S. population. Current evidence shows that the average U.S. diet has a potentially larger environmental impact in terms of increased GHG emissions, land use, water use, and energy use, compared to the above dietary patterns. This is because the current U.S. population intake of animal-based foods is higher and the plant-based foods are lower, than proposed in these three dietary patterns. Of note is that no food groups need to be eliminated completely to improve food sustainability outcomes.

A moderate amount of seafood is an important component of two of three of these dietary patterns, and has demonstrated health benefits. The seafood industry is in the midst of rapid expansion to meet worldwide demand, although capture fishery production has leveled off while aquaculture is expanding. The collapse of some fisheries due to overfishing in the past decades has raised concern about the ability to produce a safe and affordable supply. In addition, concern has been raised about the safety and nutrient content of farm-raised versus wild-caught seafood. To supply enough seafood to support meeting dietary recommendations, both farm-raised and wild caught seafood will be needed. The review of the evidence demonstrated, in the species evaluated, that farm-raised seafood has as much or more EPA and DHA per serving than wild caught. Low-trophic seafood, such as catfish and crawfish, regardless of whether wild caught or farm-raised seafood, have less than half the EPA and DHA per serving than high-trophic seafood, such as salmon and trout.

Regarding contaminants, for the majority of wild caught and farmed species, neither the risks of mercury nor organic pollutants outweigh the health benefits of seafood consumption. Consistent evidence demonstrated that wild caught fisheries that have been managed sustainably have remained stable over the past several decades; however, wild caught fisheries are fully exploited and their continuing productivity will require careful management nationally and internationally to avoid long-term collapse. Expanded supply of seafood nationally and internationally will be dependent upon the increase of farm-raised seafood worldwide.

The impact of food production, processing, and consumption on environmental sustainability is an area of research that is rapidly evolving. As further research is conducted and best practices evaluated, additional evidence will inform both supply-side participants and consumers on how best to shift behaviors locally, nationally, and globally to support sustainable diets. Linking health, dietary guidance and the environment will promote human health and the sustainability of natural resources and ensure current and long-term food security.

In regards to food safety, updated and previously unexamined areas of food safety were studied. No previous DGACs have reported on coffee/caffeine consumption and health. Currently, strong evidence shows that consumption of coffee within the moderate range (3 to 5 cups per day or up to 400 mg/d caffeine) is not associated with increased long-term health risks among healthy individuals. In fact, consistent evidence indicates that coffee consumption is associated with reduced risk of type 2 diabetes and cardiovascular disease in healthy adults. Moreover, moderate evidence shows a protective association between coffee/caffeine intake and risk of Parkinson's disease. Therefore, moderate coffee consumption can be incorporated into a healthy dietary pattern, along with other healthful behaviors. To meet the growing demand of coffee, there is a need to consider sustainability issues of coffee production in economic and environmental terms. However, it should be noted that coffee as it is normally consumed can contain added calories from cream, milk, and added sugars. Care should be taken to minimize the amount of calories from added sugars and high-fat dairy or dairy substitutes added to coffee.

The marketing and availability of high-caffeine beverages and products is on the rise. Unfortunately, only limited evidence is currently available to ascertain the safety of high caffeine intake (greater than 400 mg/day for adults and undetermined for children and adolescents), that may occur with rapid consumption of large-sized energy drinks. The limited data suggest adverse health outcomes, such as caffeine toxicity and cardiovascular events. Concern is heightened when caffeine is combined with alcoholic beverages. Limited or no consumption of high caffeine drinks, or other products with high amounts of caffeine, is advised for children and adolescents. Energy drinks with high levels of caffeine and alcoholic beverages should not be consumed together, either mixed together or consumed at the same sitting.

The DGAC also examined the food additive aspartame. At the level that the U.S. population consumes aspartame, it appears to be safe. However, some uncertainty continues about increased risk of hematopoietic cancers in men, indicating a need for more research.

Individual behaviors along with sound government policies and responsible private sector practices are all needed to reduce foodborne illnesses. To that end, the DGAC updated the established recommendations for handling foods at home.

NEEDS FOR FUTURE RESEARCH

Dietary Patterns and Sustainability

1. Conduct research to determine whether sustainable diets are affordable and accessible to all sectors of the population and how this can be improved, including how policy strategies could influence the supply chain (all steps from farm to plate) to affect this improvement.

   Rationale: Ensuring that sustainable diets are accessible and affordable to all sectors of the population is important to promote food security.

2. Develop, conduct, and evaluate in-depth analyses of U.S. domestic dietary patterns and determine the degree to which sustainability practices, domestically and internationally, are important to food choice and how to increase public awareness of the impact of food choices on environmental outcomes.

   Rationale: Understanding consumer choice across demographic groups and the degree to which either health and/or sustainability is a significant decisional criterion as well as the degree to which choice theory can be used to improve choices will be important to helping drive change.

3. Develop a robust understanding of how production practices, supply chain decisions, consumer behaviors, and waste disposal affect the environmental sustainability of various practices across the USDA food components of MyPlate.

   Rationale: Developing sustainable production and supply chain practices for all parts of MyPlate, especially meat and dairy products will be important to reduce their environmental impact.

4. Determine the potential economic benefits and challenges to supply chain stakeholders in relationship to findings in Research Recommendation 3.

   Rationale: Experience demonstrates that many practices over the past few decades that improve the environmental footprint of, for example, production practices, also have led to improved profit (e.g., Integrated Pest Management to reduce pesticide use in many fruit and vegetables). It is important to know how changes will affect profit to help enable future policy in both the private and public spheres.

Seafood Sustainability

5. Conduct research on methods to ensure the maintenance of nutrient profiles of high-trophic level farmed seafood and improve nutrient profiles of low-trophic farmed seafood concurrently with research to improve production efficacy.

   Rationale: The evidence supporting healthfulness of seafood consumption is based on consumption of predominantly wild caught species. Many popular low-trophic level farmed seafood have nutrient profiles that depend on feeds. Efficient production of seafood with nutrient profiles that are known to be healthful should be emphasized.

6. Conduct research to develop methods to ensure contaminant levels in all seafood remain at levels similar to or lower than at present. Maintain monitoring of contaminant levels for capture fisheries to ensure that levels caused by pollution do not rise appreciably. This research should include developing effective rapid response approaches if the quality of seafood supply is acutely affected.

   Rationale: Current research findings support the contention that contaminant levels are generally well below those that significantly alter the healthfulness of seafood. As industry naturally improves efficiency, feeds and environmental conditions should be monitored to maintain or reduce priority contaminants and insure significant new contaminants do not enter the seafood supply.

Usual Caffeine/Coffee Intake

7. Evaluate the effects of coffee on health outcomes in vulnerable populations, such as women who are pregnant (premature birth, low birth weight, spontaneous abortion).

   Rationale: Given the limited evidence of the effects of coffee/caffeine consumption on pregnancy outcomes, future studies need to establish safe levels of coffee/caffeine consumption during pregnancy.

8. Examine the effects of coffee on sleep patterns, quality of life, and dependency and addiction.

   Rationale: Because coffee is a known stimulant, future research should examine the effect of coffee/caffeine on sleep quality, dependency, addiction, and overall quality of life measures.

9. Evaluate the prospective association between coffee/caffeine consumption and cancer at different sites.

   Rationale: Large well-conducted prospective cohort studies that adequately control for smoking (status and dosage) and other potential confounders are needed to understand the association of coffee (caffeinated and decaffeinated) with cancer at different sites.

10. Examine prospectively the effects of coffee/caffeine on cognitive decline, neurodegenerative diseases, and depression.

    Rationale: Neurodegenerative diseases affect millions of people worldwide and more than five million Americans are living with Alzheimer's disease. Given the limited evidence of coffee/caffeine on neurodegenerative diseases, well-designed prospective studies should examine the association of coffee/caffeine consumption on cognitive decline, depression, and Alzheimer's disease.

11. Understand the mechanisms underlying the protective effects of coffee on diabetes and CVD.

    Rationale: Evidence for a biological plausibility for coffee on risk of type 2 diabetes and CVD stems primarily from animal studies. Randomized controlled trials in humans should evaluate the effect of coffee/caffeine on measures of glycemia, insulin sensitivity, endothelial dysfunction, and inflammation.

12. Understand the association between coffee and health outcomes in individuals with existing CVD, diabetes, cancer, neurodegenerative diseases, or depressive symptoms.

    Rationale: Strong evidence supports a protective effect of moderate coffee consumption on chronic disease risk in healthy adults, but its association among those with existing diseases has been less studied. Given that a substantial number of people suffer from these chronic diseases, the role of coffee in preventing other health outcomes in such groups remains understudied.

High-dose Caffeine Intake

13. Define excessive caffeine intake and safe levels of consumption for children, adolescents, and young adults.

    Rationale: Current research on caffeine and health outcomes has focused primarily on adults. Given the increasing prevalence of energy drink consumption among children, adolescents, and young adults, research is needed to identify safe levels of consumption in these groups.

14. Determine the prevalence of excessive caffeine intake in children and adults beyond intake of energy drinks.

    Rationale: Data on the sources (other than energy drinks) and doses of caffeine intake in children and adults are limited. Identifying the sources and safe levels of consumption will help in formulating policy and framing recommendations.

15. Examine the effect of excessive consumption of caffeine and energy drinks on health outcomes in both children and adults.

    Rationale: Prospective studies of associations of excessive caffeine and energy drink intake with health outcomes in children and adults are necessary, as randomized controlled trials are not be feasible given ethical constraints.

16. Conduct observational studies to examine the health effects of alcohol mixed with energy drinks.

    Rationale: In recent years, consumption of alcohol energy drinks by adolescents has resulted in emergency room admissions and deaths. No data exist on the prospective association between consumption of alcohol energy drinks and health outcomes in both adolescents and adults.

Aspartame

17. Examine the risks of aspartame related to some cancers, especially hematopoietic ones, and pregnancy outcomes.

    Rationale: Limited and inconsistent evidence suggests a possible association between aspartame and risk of hematopoietic cancers (non-Hodgkin lymphoma and multiple myeloma) in men, indicating the need for long-term human studies. Additionally, limited and inconsistent evidence indicates a potential for risk of preterm delivery, which warrants further research.

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