National Cattlemen's Beef Association
a contractor to the Beef Checkoff

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IARC
Lyon, France

Re: Volume 114: Red Meat and Processed Meat – Call for Data – Evidence regarding Benzo[a]pyrene (BaP) content in foods is weakened by critical research gaps that call into question the ability to assess BaP as a mechanistic link associated with red and processed meat and cancer

Dear Drs. Bouvard and Straif:

Thank you for the opportunity to submit data for the upcoming monograph review of red and processed meat. Benzo[a]pyrene (BaP) is the most studied of the polycyclic aromatic hydrocarbons (PAHs) and is found in foods as a result of both environmental contamination and exposure to smoke and/or flame during processing or cooking (Demeyer et al., 2015). While red and processed meat contains varying amounts of BaP and other PAHs, which may increase with various cooking methods, epidemiologic evidence fails to clearly demonstrate a significant relationship between BaP intake from meat and colorectal cancer risk. In fact, Sinha and co-workers (2005) report that after adjustment for confounding variables and total dietary BaP, risk estimates for the association between grilled meat and colorectal adenoma with the first quintile as reference, were 0.40 (0.08-2.12) for the second quintile and 1.07 (0.48-2.42) for the highest quintile of intake. In contrast, after adjustment for confounding variables and grilled meat, the relationship between BaP from all foods was significantly and substantially higher, OR 4.06 (1.70-9.70) for the highest quintile of intake with the first quintile as reference. These results are not surprising, as the major contributors to human BaP intake in a typical diet include cooking oils and fats, cereals, fruits and vegetables (EFSA, 2007).

Nonetheless, in an effort to support determination of the relevance of BaP as a potential mechanism for red and processed meat to promote cancer, we have summarized the relevant data for BaP content in the current food supply (**Appendix Tables 1-6**). In an earlier evidence submission to IARC, we concluded that "evidence is weak and inadequate in both humans and animals concerning the mechanistic relationship between dietary BaP exposure and human colorectal cancer" (McNeill, July 29, 2015). In the current submission, we report BaP content in foods as the result of various cooking methods and as the content released in cooking fumes. We offer several key observations from our review and identify critical research gaps that limit our understanding of the content of BaP in red and processed meat. We recognize that substance content is one aspect of human exposure, with frequency and amount of intake of a particular food also contributing. Therefore, in a series of separate

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submissions, The Beef Checkoff along with member countries of the International Meat Secretariat, will provide IARC current intake data for red and processed meat. As outlined below, the results of our current review further support our earlier conclusions that evidence is weak and inadequate for a mechanistic relationship between BaP from red and processed meat and cancer.

Evidence regarding Benzo[a]pyrene (BaP) content in foods is weakened by critical research gaps that call into question the ability to assess BaP as a mechanistic link associated with red and processed meat and cancer

EXECUTIVE SUMMARY

Observations

- With the exception of fish, pan and deep fried meats do not contain significant amounts of BaP.
- Exposure to flame and smoke, as occurs during grilling, particularly at extremes of temperature and duration, increases the BaP content of foods. This is NOT unique to red and processed meat.
- Smoked fish is the greatest contributor of BaP among smoked meats regardless of smoking method.
- BaP concentrations in plant-based foods, in particular bread and/or toasted bread, are equal to or exceed those reported for well-done grilled meats.
- The vast majority of foods, regardless of degree of doneness when cooked, do not exceed established regulatory limits for BaP in foods.

Research Gaps and Recommendations

- Continuous updating of food PAH/BaP analyses is required to reflect advancements in detection equipment and methodology and changes in the food supply.
- Terminology for cooking methods varies around the world. Standardization of cooking methods and terminology is needed in order to make comparisons between studies and across regions.
- Experimental cooking methods may not represent typical in-home preparation making it difficult to derive practical recommendations from laboratory experiments.

Conclusions

- Critical research gaps indicate significant shortfalls and barriers to accurately assess exposure to BaP from all foods. There is a need to update existing databases, through an assessment of the current food supply and typical in-home preparation methods, using recent methodology, in order to better evaluate exposure to BaP from red and processed meat, as well as other foods.
- **Significant evidence limitations call into question the relevance of BaP as a possible mechanism associated with cancer risk and red and processed meat intake.**

EVIDENCE IDENTIFICATION

A search of the PubMed database was conducted to identify studies published ≥ 2000 that measured BaP in meats and other foods formed during cooking, as well as in cooking fumes. Studies published in or after 2000 were selected as they more likely reflect analysis of foods consistent with today's food supply as well as better analytical methods. This is a particularly relevant consideration for red and processed meat, which has seen steady declines in fat and sodium content over the past several decades (McNeill et al., 2012; Higgs, 2000; Jacobson et al., 2013). Food preparation methods and levels of exposure that are applicable to the individual consumer, rather than a particular occupation, were of primary interest. Additional studies were identified from study bibliographies. Data were extracted from the resulting studies and reported in Tables 1-6 of the accompanying Appendix.

SUMMARY OF OBSERVATIONS

1) With the exception of fish, pan and deep fried meats are not significant sources of BaP. When comparing a variety of meats, across a variety of frying conditions, both in the lab and in restaurant/fast food settings, there is little difference in the reported BaP content of fried meat (Appendix, Table 1). The exception appears to be fried fatty fish and/or fish with added fat prior to frying (Olatunji et al., 2015) which can contain up to 70% of the mean BaP concentration calculated for all foods by the European Food Safety Authority (EFSA, 2007).

2) Increased exposure to BaP from grilled food is not limited to red and processed meat. In fact, studies report the same or higher BaP contents in well-done grilled chicken (with skin) and fish, as compared to grilled beef (Table 2). Importantly, however, it should be noted that reported cooking times and temperatures in many studies are excessively high (i.e., up to 30 minutes and 300° C) and would likely not represent typical in-home preparation or result in an edible cooked meat.

3) Smoked fish is the greatest contributor of BaP among smoked meats regardless of smoking method. Current data are limited regarding BaP content of smoked red and processed meat (Table 3). In general, however, smoked fish is reported to contain more BaP when compared to other smoked meats.

4) BaP concentrations in plant-based foods, in particular, bread and/or toasted bread, are just as high as those reported for well-done grilled meats. Consistent with previous observations regarding the high PAH content of cereal grains (EFSA, 2007), reports in the current literature confirm the high level of BaP in bread products (Table 4). Contamination of cereal grains likely occurs during technological processes such as direct fire drying where combustion products may come into contact with the grain used to formulate various bread products (EFSA, 2007).

5) The vast majority of foods, regardless of degree of doneness when cooked, fail to exceed established regulatory levels set for BaP in foods. EU (2011) has established regulatory limits for BaP for various food groups (Table 5). Generally speaking, concentrations of BaP for most foods reviewed in our survey of the literature fall below these established limits. While many studies provide limited details regarding preparation methodology, those that do, suggest that reports of BaP in excess of established limits are often the result of extensive heat exposure either due to excessively high temperature or duration of cooking.

6) Data regarding inhaled BaP from cooking of red and processed meat is exceedingly limited. Emissions from high temperature frying have been identified as probably carcinogenic to humans, however, data was considered insufficient to attribute risk to a specific chemical compound, to cooking oil alone, or a particular food being cooked (IARC, 2010). In our current review, only one study reported BaP exposure from red and processed meat (bacon) cooking fumes (Table 6). Generally, current evidence suggests that the type of oil used in cooking, in addition to the temperature and cooking time, has the greatest effect on the amount of BaP released in cooking fumes (Table 6). However, the levels vary greatly between studies.

CRITICAL RESEARCH GAPS IDENTIFIED

1) Continuous updating of food PAH/BaP analyses are required to reflect advancements in detection equipment and methodology and changes in the food supply. Few studies of BaP/PAH quantitation are available and those that are likely do not represent the current food supply or advances in detection methodology (ECEN, 2015). Databases used to estimate PAH/BaP exposure in humans may be limited by outdated analyses, thus calling into question links between exposure estimates and disease occurrence. Analysis of BaP in a variety of food types, as the result of a variety of cooking techniques, relies heavily on reports from only two sources (Kazerouni et al., 2001; EFSA, 2007). Both sources are nearly a decade old, making their relevance to the current food supply questionable. Newer evaluations are also likely to benefit from improvements in accuracy afforded by advancements in detection equipment and methodology.

2) Standardization of cooking methods and terminology are needed in order to make comparisons between studies and across regions. Failure to specify cooking conditions and variations in terminology for cooking methods used around the world has been recognized as a critical issue limiting comparison of the literature regarding heterocyclic amines (Alaejos and Afonso, 2011). The same is apparent in the PAH/BaP literature. For example, in some countries "grilling" may or may not expose foods to direct flame, but limited or unspecified cooking conditions reported in publications prohibits the ability to discern these differences. Limited methodologic details regarding cooking temperature, cooking duration, internal temperature reached at end of cooking, procurement procedures for food products, etc. limit the ability to replicate and compare results. Sound advice regarding preferred cooking methodologies designed to limit human exposure to PAHs depends on complete and detailed reporting of experimental methodologies and replication of findings.

3) Experimental cooking methods may not represent typical preparation. In an effort to maximize the production of cooking-derived compounds, many experiments are performed under extremes of cooking time or temperature that have little relevance to the cooking methods used by the general population (Alaejos and Afonso, 2011). Also, cultural practice from country to country makes it difficult to generalize data globally.

CONCLUSIONS

Critical research gaps indicate significant shortfalls and barriers to accurately assess exposure to BaP from all foods. There is a need to update existing databases, through an assessment of the current food supply and typical in-home preparation methods, using recent methodology, in order to better evaluate exposure to BaP from red and processed meat, as well as other foods. Significant evidence limitations call into question the relevance of BaP as a possible mechanism associated with cancer risk and red and processed meat intake.

Sincerely,

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Attachments:
Zip file enclosure #1 – Quantitative Reports of BaP in Food; Appendix of Data Summary Tables
Zip file enclosure #2 – Publications Supporting Critical Research Gaps Regarding Measure of BaP in Foods

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