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BEEF FACTS: Nutrition

Red Meat and Cancer – Sorting Out the Data

Dietary factors are estimated to account for approximately one-third of all cancer deaths each year (1). Since these factors, which can be numerous and complex, may yield both positive and negative risk, they are of great interest to the research community and to the public. Reports suggesting that red meat consumption may in some way affect the risk of cancer continue to be the subject of research and media interest.

The scientific literature on this subject is extensive. The popular press coverage is intense and sorting out all the data, interpretations and latest recommendations can be confusing. This overview directs the reader to key reviews and recent publications, and provides perspectives to help evaluate red meat and cancer studies and future media releases.

Over all, results from the epidemiological literature, suggest that the association of meat consumption and cancer risk is not consistent. Examination of the literature yields evidence ranging from "insufficient" to "possible", to "probable". To date, the balance of the data has not provided "convincing" evidence of a consistent, specific link between red meat and cancer. However, this inconsistency has led to division of scientific camps and divided interpretations.

In 1997, there were three significant reviews that summarized much of the existing epidemiological literature on meat and cancer (2,3,4). Additionally, two of the reviews (2,3) focused on studies specific to red meat. As seen in these reviews the interpretation of research findings can vary and be subject to many variables. Qualified scientists do actually interpret the same data differently or put more or less emphasis on co-existing variables.

Epidemiological Studies

In terms of human cancer risk and diet, most discussion and media attention has focused on data from epidemiological studies. *Epidemiology* is the study of disease occurrence in human populations (5). It is important to understand the different types of epidemiological studies. It should be noted that epidemiological associations between dietary components, specific foods (or food groups) and chronic disease rarely are sufficient to establish cause and effect relationships (5,6). The results of epidemiological investigations must be tested through other types of studies (animal studies, metabolic studies, human clinical intervention trials, etc.) before persuasive causal relationships can be established.

Types of epidemiological studies. There are several types of epidemiological studies, each with their own strengths and weaknesses (5,6). In brief:

Ecologic/descriptive studies are the simplest and least persuasive type. They characterize differences between large and diverse populations by simple generalizations and can help formulate hypotheses; however, they cannot control for potential confounding factors.

Case-control studies focus on individuals and provide stronger evidence for an association than ecologic studies. "Recalled" past diet of individuals diagnosed with a disease (cases) is compared to that of individuals without the disease (controls). Many researchers rely on this type of study because of lower cost, smaller sample size and ability to study many potential factors. However, such "retrospective" studies are subject to recall bias and unavailable or incomplete data. There may also be questions regarding the "control" group.

Follow-up (prospective) studies are considered to provide the most definitive information, and are the most persuasive study design. In these studies a cohort (group) of individuals, who do not yet have a disease, are selected and followed over a period of time while collecting specific information regarding diet and other factors related to the development of the disease. "Prospective" studies are more costly and require more time and larger numbers of subjects.

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Following any type of epidemiological study, human, clinical intervention studies are ultimately needed to establish cause and effect.

Findings and Conclusions of Recent Major Reviews

Red Meat and Cancer (NCBA) (2). This review emphasized studies that specified red meat per se. Studies that failed to define meat, referred only to animal foods, or meat components (fat, protein) were excluded. Major cancer sites are discussed; three types of epidemiological studies examined; and results (positive and negative) are discussed. Over all, the evidence is inconsistent in terms of defining red meat and cancer risk. Some studies suggest a relationship, others find no association.

Australian Report - Does Red Meat Cause Cancer? (3). This extensive review, with over 225 references, concludes that the associations of meat consumption and cancer risk are not consistent. It was concluded that any true effect of meat is likely to be small, or even an artifact of a decreased consumption of fruit, vegetables and cereals by high meat consumers.

This review discusses proposed mechanisms by which diet/meat might be associated with increased cancer risk. The two broad areas are: high dietary fat intake, leading to bile acid secretion and conversion to potentially mutagenic compounds, oxidation of fats (especially unsaturated fats) and other unwanted effects exerted by specific dietary fats. A second area of potential concern relates to the production of mutagens (heterocyclic amines (HA) and polyaromatic hydrocarbons (PAH)) in meat by specific cooking methods. These compounds (also found in poultry and fish products) are not unique to red meat, and they can be dramatically controlled by alterations in cooking methods. The actual exposure level in humans is still unclear, as well as the actual risk associated with the exposure.

There is also discussion of potential *anti*carcinogens found in meat, including anti-oxidants, dipeptides and conjugated linoleic acid (CLA) and the possible role of methionine in gene regulation of cell proliferation.

AICR/WCRF Report (4). This is an extensive report (over 3000 citations) relevant to diet and cancer with the intent to arrive at quantitative recommendations regarding dietary modifications to reduce cancer risk. The report discusses cancer by site and discusses studies/results based on dietary constituents (carbohydrate, fat, protein, etc.) and based on foods (meat, poultry, fish and eggs, fruits, vegetables, etc.).

A strong conclusion from this report is that risk of cancer is strongly influenced by the level of intake of fruits and vegetables. The evidence is perhaps the most convincing for this observation. For meat intake, this report notes that there is no cancer for which the evidence of an association with meat was "convincing".

This report also provides an example of how different interpretations can be given to the same dataset. Compared to the two previously cited reviews, this report concludes a "probable" or "possible" association between red meat and certain cancers when as few as 2 out of 7 cohort studies suggest a significant association. The other reviews consider all the cohort studies (which clearly define red meat) and conclude that the evidence is inconclusive due to the mixed results.

Interpretation of Scientific Studies

To evaluate reviews or research findings, in any area, certain standards need to be applied. In addition, there are always multiple variables that should be considered (See **Appendix**, page 4). The area of meat and cancer research is no exception.

What Do Recent Studies Suggest?

What's in the diet vs. what may be taken out of the diet could be important. The importance of dietary variety and moderation, involving foods from all the food groups continues to be demonstrated. In one study, although an increased risk was suggested with meat intake, the risk was greatly reduced, for red meat, when legumes were added to the diet (7). The idea of glycemic index and insulin sensitivity as a risk factor for colorectal cancer has been put forth (7,8,9). In a case-control study (8), red meat was among several factors not associated with colorectal cancer risk, whereas intake of bread, pasta, and refined sugar was associated with increased risk. In contrast, another case-control study found positive associations with risk of adenomas for animal fat, saturated fat and red meat, and protective effects for vegetables, fruit and grain, among numerous factors examined (10). A conclusion from these studies might be: Is something missing from the diet and is dietary variety and balance needed?

Diet diversity and food group analysis can lead to interpretation questions. At least two studies have attempted to examine eating patterns, diet diversity, etc. related to colon cancer (11,12). While some of the findings suggest an increased risk with meat or red meat, in some subjects, inconsistencies remain. While men showed a trend for increased risk with meat, women showed no relationship. In the second study, where people were categorized by eating patterns, "substituters" (poultry for red meat, whole for refined grains, more fruit, etc.) suggested a reduced risk, however the reduction was not significant. A conclusion was that a "Western-style " diet increased risk. An analysis of

American's eating patterns shows that we have dietary imbalance, creating a "tumbling pyramid" (unbalanced food guide pyramid) (13,14). Meat, on average, is actually consumed at the low end of recommended amounts; fruits, vegetables and grains are underconsumed; whereas fats and sweets are over-consumed.

Heterocyclic amines (HAs) are receiving more attention. With more evidence not supporting meat lipids as a risk factor, there is a tendency to implicate HAs as the factor in red meat that may be a risk for cancers (15). This has generated more attention to HAs despite continued inconsistencies and conclusions. While several recent studies have shown increased risk of certain cancers with potentially high intakes of HAs (16,17,18), other studies suggest that the HA risk is controllable (19). Marinating may reduce the risk of certain HAs but not others (20). In addition, recent reports suggest that human exposure to HAs may span a wide range, with means being much lower than previously expected (21,22). New studies suggest that HA content of beef can vary widely by cooking method, degree of doneness and use of gravy (19,23,24). Epidemiological studies should consider this for accurate assessments of HA risk.

Large, prospective studies in Norway do not suggest a risk. Two separate, prospective studies from Norway do not support an association of dietary fat, (especially animal sources) with risk of prostate cancer (25); or the intake of meat and risk of colon cancer (26).

Results are unclear from colorectal prospective study. A prospective study of diet and female colorectal cancer, found no protective effects of vegetables or dietary fiber, and any relation with red meat or total fat remained unclear (27).

Responses/associations may only occur at high intake levels. Several studies which suggest a possible association between saturated fat intake (28), HA rich foods (29) or red meat (30) and various types of cancers, only report the possible association at the highest intake levels. The idea of a "J" shaped response curve might be considered. At low, or moderate meat intake levels, no association is observed.

Firm evidence is lacking for problems with nitrates and related compounds. Related to cured meats, a recent review (31) could find no firm epidemiological evidence linking stomach, brain, esophageal and nasopharyngeal cancers to dietary intake of nitrate, nitrite and N-nitroso compounds. This is further supported by a study showing opposite trends for cured meat consumption and brain cancer (32).

"Over-interpretation" of study findings can confuse the issue. When reading the literature, the reviewer may find that some authors/researchers tend to "over-interpret" the data to agree with previous publications.

In a prospective study of colorectal cancer, the authors conclude that their findings support previous reports that a high intake of red meat may increase the risk of colon cancer (33). Yet, in the discussion of their results, they acknowledge that the trend was not significant. Another study concluded that meat intake was associated with increased colon cancer risk (34). However, an examination of the data presented shows no association of total meat intake or red meat intake with increased risk of total colon cancer, regardless of site, in either men or women. The discussion in the paper even notes the inconsistent findings relative to other prospective studies.

Reporting on a case-control study in Montreal, the authors concluded that high intake of fat and meat are risk factors for colorectal cancer (35). What is confusing, is that the data presented show an <u>inverse</u> association with total fat and saturated fat, and meat intake data <u>is not even presented.</u>

In one study, the data suggested that the consumption of meats and other concentrated sources of HAs was <u>not</u> associated with increased risk of breast cancer (36). However, the authors suggest a measurement error in HAs and conclude that there must be a relationship with HAs and breast cancer. In a study, which suggests that preference for well-done meat increases the risk of breast cancer, the author's fail to demonstrate any association between actual consumption of foods and relevant exposure to HAs (37).

Different analysis of data can yield different results. A case-control study of dietary fats and lung cancer provides an example of how different data analysis can yield completely different conclusions (38). In this study, risk estimates associated with red meat consumption, were dependent on interview status. An effect was noted only in cases whose dietary information was provided by proxy (a person answering for another).

Responses can differ by sex. A case-control study in Hawaii found a risk for total red meat and colorectal cancer in men, but not in women (39). However, no association was found with fat-trimmed cuts. This study suggested that the ratio of dietary polyunsaturated fat/ saturated fat was the strongest predictor of risk.

The anti-carcinogenic effects of CLA need to be acknowledged. Notably missing from discussions of potential protective dietary components is the emerging research on CLA (conjugated linoleic acid) and its inhibitory effects on various cancers (40). CLA is a naturally occurring fatty acid found in ruminant products such as beef. To date, animal studies provide most of the information on this protective fatty acid. However, in a recent report, the incidence of breast cancer was significantly lower in women with higher tissue levels of CLA (41).

There is a need for well-controlled prospective trials and for better biomarkers of risk. At least two review papers, one related to diet and colorectal cancer (42) and one related to nutrition and prostate cancer (43), stress the need for well-controlled prospective trials and the development and use of better bio-markers of risk.

Conclusions

Although red meat is often linked with increased risk for certain cancers, a review of the epidemiological literature reveals that the associations are not universal between types of cancer and not consistently observed in all studies. This area of research requires continued refinement so that meaningful conclusions can be drawn and existing and new data are not over- or under-interpreted. The consistency of the "inconsistency" suggests that any true effect of meat is likely to be small, or perhaps even a result of an unbalanced consumption of food groups among the higher meat consumers.

There is a need for education and transfer of existing information to consumers. Such a transfer needs to explain risk levels, but also note inconsistencies in the data. For red meat, the importance of recommended cooking/ preparation methods need to be stressed to consumers. And finally, the importance of dietary variety, balance and moderation should be stressed along with the importance of protective factors (including consumption of adequate fruits and vegetables) in the total diet, combined with a physically active lifestyle.

Appendix

The International Food Information Council Foundation has addressed the issue of *"How to Understand and Interpret Food and Health-Related Scientific Studies"* (44). They discuss the types of research studies and what journalists, educators and health professionals should look for when critically reviewing scientific studies. For example:

- Could the study be interpreted to say something else?
- Are there any methodological flaws in the study that should be considered when making conclusions?
- Are the study's results generalizable to other groups?
- How does the work fit with the body of research on the subject?
- What are the inherent limitations of this type of study and does the research design fit the stated purpose of the study?
- Has the author omitted important points in the background section which could have a meaningful effect on the study design or interpretation of the results?
- Are there any major design flaws in the study and are the data collection measures appropriate to answer the study questions?
- Were methodological limitations acknowledged and discussed and what influence might these have had on the results?
- What is the real and statistical significance of the results?
- To whom do the results apply and how do the results compare to those of other studies on the subject?
- Are the conclusions supported by the data?
- Are the conclusions of the study related to the stated purpose of the study? If not, do the study design and results support the secondary conclusions?

In addition, FANSA (Food and Nutrition Science Alliance) representing food and nutrition professionals and scientists have issued a list of *"Ten Red Flags of Junk Science"* as a means to help consumers evaluate reports on nutrition and health issues before jumping to premature conclusions (45). Any combination of these signs should send up a red flag of suspicion about the accuracy of the information.

1. Recommendations that promise a quick fix.
2. Dire warnings of danger from a single product or regimen.
3. Claims that sound too good to be true.
4. Simplistic conclusions drawn from a complex study.
5. Recommendations based on a single study.
6. Dramatic statements that are refuted by reputable scientific organizations.
7. Lists of "good" and "bad" foods.
8. Recommendations made to help sell a product.
9. Recommendations based on studies published without peer review.
10. Recommendations from studies that ignore differences among individuals or groups.

While the above issues and "warning flags" apply to any research study or media report, there are examples of variables which are unique or specific to meat and cancer. Two main categories are: Type/site of cancer and Diet-related variables.

Type/Site of Cancer

Colorectal, breast, lung and prostate cancer have the highest incidence rates (1) and have been frequently studied relative to dietary factors. Cancers of other sites, such as: oral, laryngeal, esophageal, stomach, endometrial, cervical and kidney; or other types, such as: non-

Hodgkins lymphoma and childhood, have also been examined. The impact of diet, including meat effects, may vary widely depending upon the cancer type/site and/or the stage of cancer development. Based on experimental animal studies, cancer development is a multistage, multifactorial process. Different factors influence initiation and/or progression (metastasis) (4).

Diet Related Variables

Often interwoven, diet-related variables are both numerous and complex. Consideration of these diet-related variables illustrate why red meat may, or may not, be associated with potential risks/benefits or why results are inconsistent.

- ***Nutrients vs. foods vs. total diet patterns*** - Nutrients are consumed from foods in the context of the total diet.
- ***Levels of intake (of nutrients, of foods)*** - Are levels at, near, or above, recommended levels?
- ***Animal products/foods vs. plant foods*** - Potential differences and interactions of protein and fat sources, dietary fiber, zoochemicals and phytochemicals should be considered.
- ***Fat - source (animal vs. other), type (saturated vs. other), total fat*** - Some cancer studies have used dietary saturated fat as a marker for "meat". Is this appropriate?
- ***Meat - definitions (red meat, white meat, beef, pork, lamb, veal, poultry, seafood, etc., combined or separate)*** - If not clearly defined, the comparison of study results may not be as reliable.
- ***Beef (lean beef, fat trim or amount)*** - Up-to-date nutrient values should be used whenever possible.
- ***Unbalanced diet/"tumbling pyramid" vs. recommended intakes*** - Are we dealing with overconsumption of meat, or underconsumption of other food groups? The intake of adequate protective factors, via a balanced diet, may offset possible negative effects in the diet.
- ***Actual and perceived intakes vs. recommended intakes (of nutrients, of foods)*** - When dealing with food frequency data there are two issues: accuracy of recall, and levels consumed vs. recommended intakes?
- ***Ranges of intakes (quartiles, quintiles, etc.)*** - Where do actual average intakes fall in these groupings? What are the responses (linear, plateau, J-shaped) over a range of intakes? Or, are responses only observed at the highest levels of intake, but not at moderate or recommended levels?
- ***Food/meat preparation/cooking methods*** - How can variations in cooking time and temperature influence heterocyclic amine (HA) and polyaromatic hydrocarbon (PAH) levels? What are actual intake levels of these substances within the total diet? What levels might be harmful in the human diet?
- ***Protective factors in the diet*** - Much has been said regarding the potential protective effects of fruits/vegetables (phytochemicals). Similar protective factors from animal products (zoochemicals), such as CLA, should be acknowledged.

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