frontiers FOR YOUNG MINDS

HUMAN HEALTH
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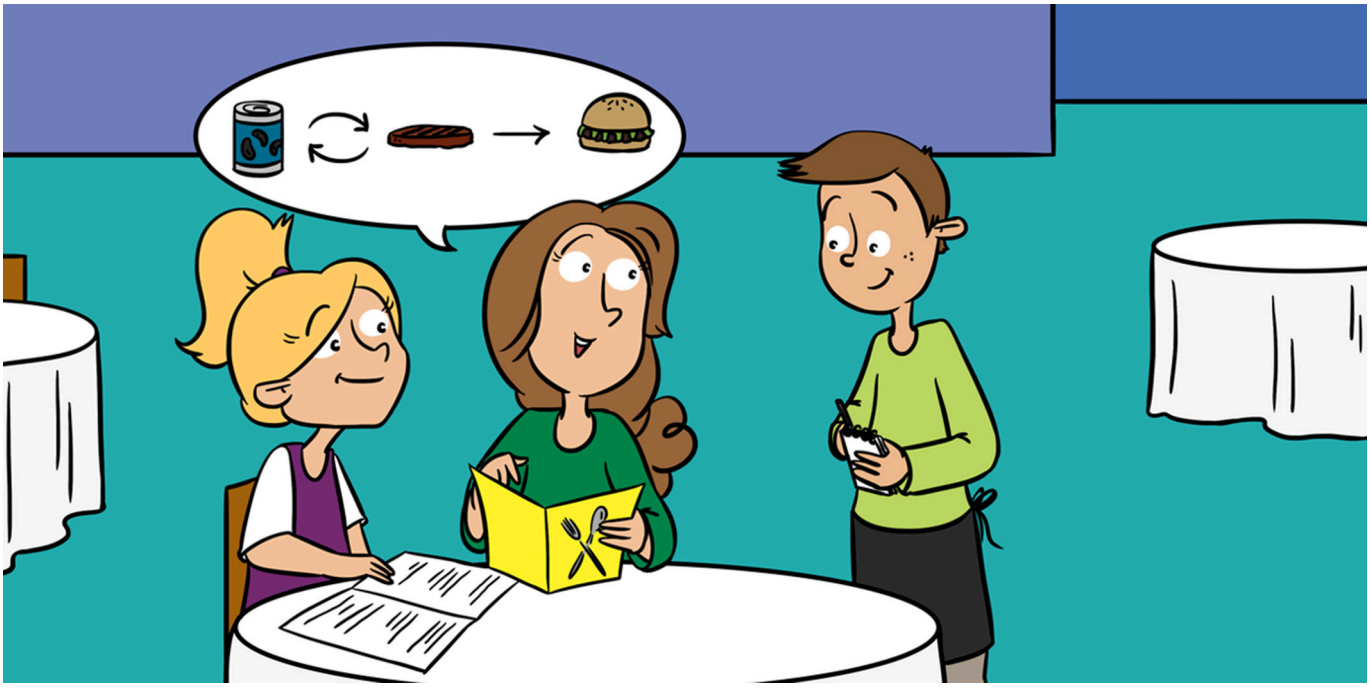


ARE RED AND PROCESSED MEATS BAD FOR OUR HEALTH?

Lieselot Y. Hemeryck[1], Sophie Goethals[2], Lieven Van Meulebroek[1], Thomas Van Hecke[2], Els Vossen[2], John Van Camp[3], Stefaan De Smet[2] and Lynn Vanhaecke[1]*

[1] *Department of Translational Physiology, Infectiology and Public Health, Faculty of Veterinary Medicine, Ghent University, Ghent, Belgium*

[2] *Department of Animal Sciences and Aquatic Ecology, Faculty of Bioscience Engineering, Ghent University, Ghent, Belgium*

[3] *Department of Food technology, Safety and Health, Faculty of Bioscience Engineering, Ghent University, Ghent, Belgium*

YOUNG REVIEWER:

HOLLY

AGE: 14

Metabolites are substances that are formed within our bodies that help us live and grow. Examples include glucose and vitamin D. When changes happen in our bodies, like when we get sick, these metabolites can change. By studying metabolite changes, using a method called metabolomics, we can learn a lot about diseases, what causes them, and how to avoid them. We know that eating foods like fish, fruits, and vegetables is healthy. Eating too much red and processed meat, however, increases our chances of developing certain types of cancer. Unfortunately, we still do not understand why that is. It could be that there are unhealthy, toxic elements or substances in the meat itself or that there are toxic metabolites formed during or after the digestion of red and processed meat. To find out, we must journey into the gut, using metabolomics!

METABOLITES: THE LINK BETWEEN FOOD AND HEALTH?

We all know that food is essential because it provides us with the energy and building blocks necessary to live and grow. After food is chewed and swallowed, it is digested and broken down into energy and nutrients in the stomach, small and large intestines, followed by absorption. Healthy foods, like whole grains, fish, fruits, and vegetables, provide our bodies with lots of helpful substances. Unfortunately, not all foods are healthy. Certain foods can also contain harmful, toxic substances or can lead to the formation of toxic **metabolites** during or following digestion. Metabolites are the intermediate or end product of **metabolism**, involved in the chemical reactions by which your body converts food into energy. Generally, the amount of harmful metabolites in one meal is too small to instantly make us sick. But, if we eat too much of these unhealthy foods too often, long-term exposure to toxic metabolites may lead to the development certain diseases.

One example of such a disease is **colorectal cancer**. In this form of cancer, dangerous tumors form in the gut, particularly in the **colon** and the **rectum**. The risk of developing colorectal cancer is linked to family history, smoking, and an unhealthy diet and lifestyle, including eating too much red meat (like beef and pork) and processed meat (like ham, meatballs, luncheon meat, sausages, and bacon). It is important to note that eating a lot of white meat, like chicken or turkey, is not linked to colorectal cancer.

METABOLITES

An intermediate or end product of metabolism.

METABOLISM

The chemical reactions by which your body converts what you eat and drink into energy.

COLORECTAL CANCER

A form of cancer in the gut, with formation of dangerous tumors in the colon and/or rectum.

COLON

The longest part of the large intestine, connected to the small intestine at the one end and the rectum at the other.

RECTUM

The last part of the large intestine, connected to the colon at the one end and the anus at the other.

METABOLOMICS

The study of all metabolites in a cell, tissue or organism.

WHY DO RED AND PROCESSED MEATS CAUSE CANCER?

Scientists are convinced that eating too much red and processed red meat leads to the formation of harmful metabolites in the gut. We, however, still do not know which metabolites are formed exactly and how this leads to cancer. That is why we set up a study to investigate which metabolites are formed when we consume meals that contain different types of meat. This was done using **metabolomics**. Metabolomics is a method that allows us to measure the types and amounts of metabolites that are present in for example a stool sample, enabling us to observe which metabolites were formed during food digestion (Figure 1).

The study was performed using pigs. Pigs are good animals to use to study the digestion of food because the pig gut strongly resembles the human gut. In our study, pigs were fed diets with either red and processed meat or white meat (chicken) for 4 weeks in a row. After 4 weeks, samples of the pigs' gut content were collected and analyzed using metabolomics (Figure 2).

Figure 1

By means of a method called metabolomics, we can measure which and exactly how much metabolites are present in for example a stool sample. This allows us to investigate which metabolites were formed during the digestion of food (*figure created with BioRender.com*).

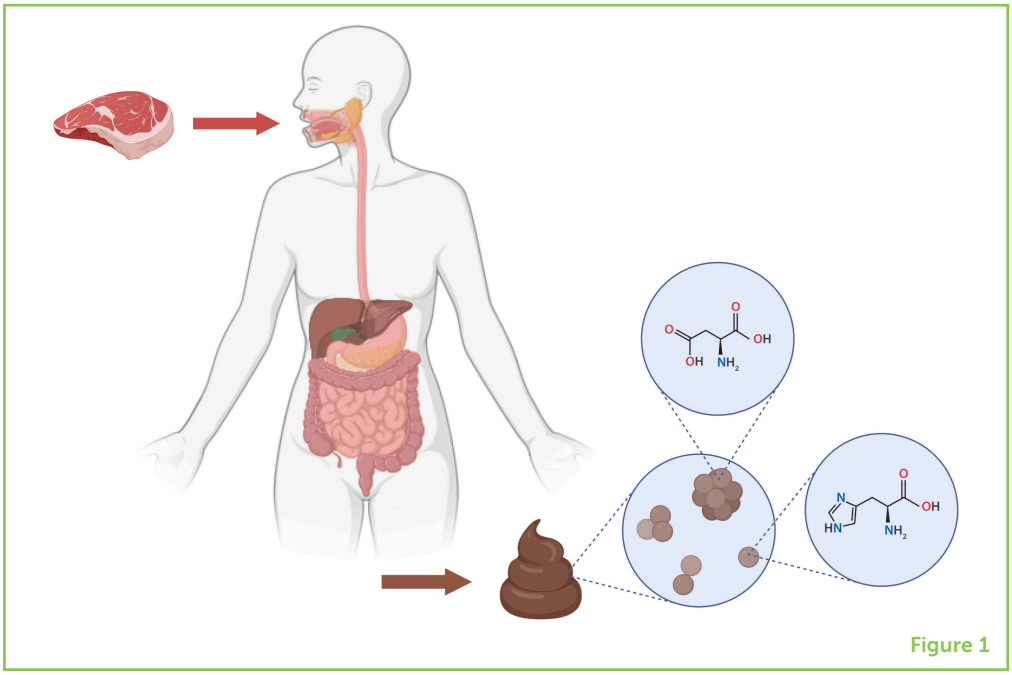
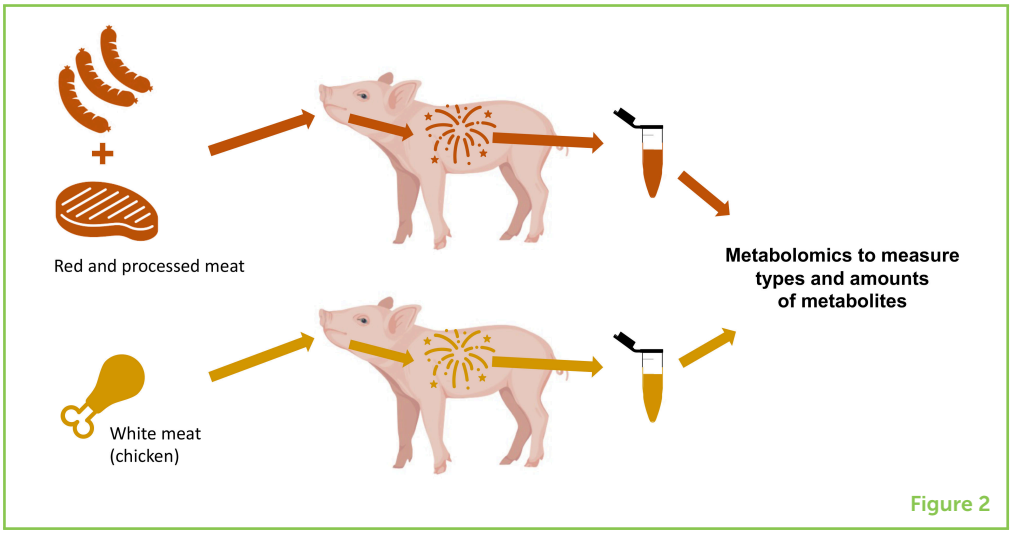


Figure 2

Pigs were used to study differences in the types and amounts of gut metabolites following 4 weeks of a diet with red and processed meats compared to a diet with white meat. Results of this experiment could help us to understand whether eating red/processed meats produces metabolites that contribute to the risk of colorectal cancer (*figure in part created with BioRender.com*).



WHAT DID METABOLOMICS TELL US?

Using metabolomics, our group discovered that the type of meat affects the types and levels of gut metabolites. Different metabolites are formed after eating red and processed meat compared to after eating white meat [1]. Some metabolites were less abundant in the pigs that ate the red and processed meat diet compared to those that ate the white meat diet, and other metabolites were more abundant. The metabolic differences we saw may be linked to differences in the composition of red/processed meat vs. chicken, but those differences may also be explained by changes in the digestive tract caused by these two types of meats, or changes in the helpful microorganisms that live in the digestive tract [2].

CARNITINE

A metabolite that plays an important role in the production of energy in cells.

LYSOPHOSPHATIDYLCHOLINES

Metabolites derived from fats.

The pig study further revealed that a metabolite called **carnitine** as well as several metabolites created from the breakdown of carnitine were higher after the consumption of red and processed meat. We already knew that carnitine levels are higher in red meat than in white meat, so it was not surprising to find higher levels of both carnitine and its breakdown products in the gut following the consumption of red/processed meat. Other gut metabolites that were higher following diets containing red and processed meat were **lysophosphatidylcholines**, which are fat-breakdown products. This makes sense because the processed meats in the red and processed meat diets (ham sausage for example) contained more fat than the lean chicken meat in the white meat diets.

THE END TO THIS QUEST: A LINK WITH COLORECTAL CANCER?

Our quest in the gut, using metabolomics, provided some interesting discoveries. We found that there was a prominent difference in the types of metabolites detected after red and processed meat consumption in comparison to white meat consumption.

It was not possible to determine whether the pigs that ate a red and processed meat diet had a higher risk of developing colorectal cancer later in life because the study only lasted for 4 weeks. However, previous studies demonstrated that elevated levels of certain carnitine breakdown products, as well as lysophoshatidylcholines, are linked to the development of colorectal cancer. Levels of lysophoshatidylcholines are increased in colorectal tumor tissue [3], and elevated levels of carnitine metabolites can be found in the blood of colorectal cancer patients [4]. Could it be that the carnitine metabolites and/or lysophoshatidylcholines are the missing link between red and processed meat consumption and colorectal cancer?

Ongoing and future scientific studies should focus on how carnitine metabolites and lysophoshatidylcholines might increase the risk of developing colorectal cancer. It could be that these metabolites attack the healthy cells in the gut, or maybe they provide nutrients for tumor cells.

SHOULD WE EAT LESS RED AND PROCESSED MEAT?

How should we apply this knowledge in our everyday lives? Based on what is known today about the health effects of red and processed meat consumption, recommendations [5] are to consume very little, if any, processed meat and to limit the consumption of red meat to no more than about three portions per week (equivalent to about 350–500 g cooked weight). This does not mean that you should

completely avoid eating meat, since meat can be a valuable source of nutrients, including high-quality protein, iron, zinc, and vitamin B12. The results of future research may further finetune these guidelines, as scientists discover exactly how the metabolites generated from red/processed meats affect our bodies. We do not know the answers yet, so there are many more quests to come!

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWER

HOLLY, AGE: 14

I am an aspiring biomedical student and love all things related to the human body. I enjoy watching crime shows that use science to solve the mystery. I have been surrounded by medical science and research my entire life. When I am not studying, I am a dancer and artist.

AUTHORS

LIESELOT Y. HEMERYCK

Lieselot Y. Hemeryck is a researcher at the Lab of Integrative Metabolomics (Ghent University, Belgium). She holds a Master in Veterinary Medicine (2012), but decided to pursue a career in science. Her Ph.D. research (2017) focused on the potential harmful effects of red meat consumption. Currently, Lieselot is investigating the potential adverse health effects of a wide range of environmental exposures in relation to e.g., obesity, food allergy and cancer by means of metabolomics and DNA adductomics. In her free time, Lieselot likes to travel, read, dance and watch Netflix series. *lieseloty.hemeryck@ugent.be

SOPHIE GOETHALS

Sophie Goethals is a researcher at the Flanders Research Institute for Agriculture, Fisheries and Food in Belgium. She has been fascinated by nature and by how our bodies work for as long as she remembers. During her Ph.D., she learned that humans and pigs share many physiological similarities and used pigs as a model for humans, to study what happens in our bodies when we eat meat. Currently, Sophie's work focusses on efficient pig production. Besides taking care of piglets, Sophie also really enjoys hiking and playing the tenor horn.

LIEVEN VAN MEULEBROEK

Lieven Van Meulebroek is a researcher from Ghent University (Belgium) who is currently employed at the pre-clinical CRO company ProDigest. Both during his academic career as well as at ProDigest, Lieven is very much interested in the measurement of small molecules. The biggest challenge? Picking the right strategy to achieve the most reliable measurements and go for the scientific win. This is something he also enjoys when playing board games, a hobby where creative strategies are often key.

THOMAS VAN HECKE

Thomas Van Hecke is a post-doctoral researcher at Ghent University in Belgium. Following his graduation as a veterinarian, he started his research intrigued with the question how our health is influenced by what we eat. More specifically, he is interested in what happens in the body after we eat meat. Is this affected by meat processing techniques? Do other foods or beverages influence the effects of meat consumption on health? Besides his research, he loves to travel, discover new places, and play with his 2 daughters.

ELS VOSSEN

Els Vossen is a lab coordinator at Ghent University in Belgium. Els studied Bioscience engineering specialized in agriculture as she is fascinated by food production and the science behind it. She is especially interested in meat science. After work and during the weekend, she enjoys playing with her children, going out with friends, reading a book or having a nice meal.

JOHN VAN CAMP

John Van Camp is a bio engineer (1989) with a special interest for nutrition and health. He obtained a Ph.D. (1997) at the Faculty of Bio-Science Engineering (FBE) at Ghent University, Belgium, where he became nutritionist in the research group Food Chemistry and Human Nutrition at FBE-UGent. His research unit develops advanced models with animal cells to study the metabolism of bioactive components in our foods. John has a passion for science and teaching. He also likes traveling and exploring the diversity of our planet.

STEFAAN DE SMET

Stefaan De Smet is a professor in Animal Sciences at Ghent University, Belgium. He grew up on a livestock farm, which triggered his interest in understanding the role animals can play at the benefit of humans. In his research, he focuses on the qualities of foods of animal origin (meat, milk and eggs), and how these foods contribute to adequate nutrition and affect human health. In his spare time, he loves breeding and riding horses.

LYNN VANHAECKE

Lynn Vanhaecke holds an M.Sc. (2004) and Ph.D. in Bioscience Engineering (2008) and is at present Full Professor and head of the Lab of Integrative Metabolomics at Ghent University with a 20% appointment at the Institute of Global Food Security at Queen's University Belfast. The holistic analyses of small molecules through metabolomics using advanced mass spectrometry, in relation to the diet—microbiome—health axis, belong to her major research objectives. A healthy diet is a healthy life and thus a healthy metabolome!