Meat Products Brassica® exploiting anticarcinogenic potential of cabbage phytochemicals: Polish path to bio-inspired foods

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Major causes of cancer are preventable by changing habits and by adopting healthier dietary preferences.

- Smoking: 25%
- Poor diet: 30%
- Infectious agent: 12%
- Professional environment: 6%
- Industrial products: 2.5%
- Sexual behavior: 7%
- Alcohol: 5%
- Food additives: 2%
- Medical products/treatment: 1.5%
- Geophysical factors: 3%
- Other: 1%
Why meat product?

A Prospective Study of Meat and Meat Mutagens and Prostate Cancer Risk


Abstract

High-temperature cooked meat contained heterocyclic amines, including 2-amino-3-methylimidazo[4,5-f]quinoline (IQ), and polycyclic aromatic hydrocarbons, such benz[a]pyrene (BaP). In rodents, a high intake of BaP induces prostate tumours. We prospectively investigated the association between meat and meat mutagens, specifically, IQ, BaP, and prostate cancer risk in the Prostate, Lung, Colorectal, and Ovarian Cancer Screening Trial. Diet was

Journal of the National Cancer Institute, Vol. 98, No. 15, August 2, 2006

Processed Meat Consumption and Stomach Cancer Risk: A Meta-Analysis

Susanna C. Larsson, Nicola Orsini, Alicja Wolk

Background: The relationship between processed meat consumption and the risk of stomach cancer is controversial. We conducted a meta-analysis to summarize available evidence from cohort and case-control studies on this issue. Methods: We searched Medline, EMBASE, and food science databases to identify studies published from January 1966 to August 2005. Results: Our meta-analysis of 16 studies, which reported 23 comparisons, showed a significant positive association between processed meat consumption and stomach cancer risk (RR 1.36, 95% CI 1.09-1.70). Limitations: Information on environmental and dietary factors was not available. Conclusions: Processed meat is associated with an increased risk of stomach cancer. Future research to identify the specific components responsible for this effect is needed.

Meat consumption and risk of breast cancer in the UK Women's Cohort Study

EF Taylor, VJ Burton, DC Greenwood and JE Cade

We performed a survival analysis to assess the effect of meat consumption on breast cancer risk in the UK Women's Cohort Study. A total of 53,137 women aged 40-70 years were followed for a median of 9.1 years and were classified into quintiles of total meat intake. The relative risk of breast cancer associated with the highest versus lowest quintile of meat intake was 1.20 (95% CI 1.05-1.38). The effect of meat consumption was unaffected by age at menopause, body mass index, alcohol consumption, and other dietary factors. Limitations: Information on smoking and other risk factors was not available. Conclusions: There was no evidence that meat consumption is associated with an increased risk of breast cancer.

Meat, Fish, and Colorectal Cancer Risk: The European Prospective Investigation into Cancer and Nutrition


Background: Current evidence suggests that high red meat intake is associated with increased colorectal cancer risk. High fish intake may be associated with a decreased risk, but the finding that a high intake of red meat but not of chicken or fish might be associated with increased colon cancer risk was first reported in prospective studies by Willett et al. in 1980 (1). In a meta-analysis of 130 colorectal cancer patients in the Nurses Health Study.
Cruciferous vegetables are regarded as particularly rich source of anticarcinogenic phytochemicals


Bioactivity of ITC and indoles

**ITC**

- Inhibition of Phase 1 Enzymes
- Induction of Phase 2 Enzymes
- Epigenetic modulation of gene expression
- Inhibition of H. pylori growth
- Apoptosis
- Inhibition of signal pathways
- Inhibition of inflammation (interference with NFkB)
- Inhibition of invasiveness and angiogenesis
- Cell cycle arrest

**I3C**

- Induction of Phase 1 Enzymes
- Induction of Phase 2 Enzymes
- Epigenetic modulation of gene expression
- Inhibition of HPV infection
- Apoptosis
- Inhibition of signal pathways
- Antiestrogenic activity
- Inhibition of invasiveness and angiogenesis
- Cell cycle arrest
Chemopreventive potential of cruciferous vegetables have not escaped scientists’ notice.

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Why cabbage?

The correlation between colon cancer incidence in women and meat consumption (based on Armstrong & Doll, Int.J.Cancer, 1975)

Pathak D. R., He J. P., Charzewska J.

Joint Association of High Cabbage/Sauerkraut Intake at 12-13 Years of Age and Adulthood with Reduced Breast Cancer Risk in Polish Migrant Women: Results from the US Component of the Polish Women's Health Study (PWHS)

AACR 4th Annual Conference on frontiers in Cancer Prevention Research, Baltimore, Maryland, 2005.
Why cabbage?

HPLC profile of cabbage GLS

Cabbage contains precursors of all 5 most promising natural chemopreventive agents.

- Sinigrin (SIN) → AITC
- Glucobrassicin (GBS) → I3C
- Glucoraphanin (GRF) → DIM
- Gluconasturtin (GNC) → SFR
- PEITC

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Isolated substances found in crucifers display activities preventing cancer development at several stages. At Gdańsk University of Technology, it was demonstrated that these activities are also observed for white cabbage juices at dietary relevant doses.
Chemopreventive activities of cabbage juices

- Induction of phase II enzymes
- Induction of DNA repair enzymes
- Protection of cells against oxidative stress
Chemopreventive activities of cabbage juices

- Induction of phase II enzymes
- Induction of DNA repair enzymes
- Protection of cells against oxidative stress
Induction of phase II enzymes in HepG2 cells by cabbage juices (10% v/v)

Fresh cabbage juice
Sauerkraut juice
Chemopreventive activities of cabbage juices

Induction of phase II enzymes

Induction of DNA repair enzymes

Protection of cells against oxidative stress
Chemopreventive activities of cabbage juices

Induction of phase II enzymes

Induction of DNA repair enzymes

Protection of cells against oxidative stress
Induction of DNA repair enzymes in HT29 cells exposed to fresh cabbage juice (10% v/v)

The experiments were carried out by the modified comet assay as explained in the scheme.

The induction of oxidative DNA damage repair in HT29 cells by fresh cabbage juice.
Chemopreventive activities of cabbage juices

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- Induction of DNA repair enzymes
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Chemopreventive activities of cabbage juices

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- Induction of DNA repair enzymes
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Protection of HT29 cells exposed to fresh cabbage juice (10% v/v) together or prior to 0.15 mM H$_2$O$_2$ for 30 min.

Simultaneous incubation

Genotoxic effect of H$_2$O$_2$ applied to HT29 cells for 30 min in combination with fresh cabbage juice (FCJ) at concentrations indicated.

Preincubation

Genotoxic effect of H$_2$O$_2$ applied for 30 min to HT29 cells pretreated for 24 h with fresh cabbage juice (FCJ) at concentrations indicated.

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Technological benefits of cabbage

- Cabbage antioxidative potential increases upon heating
- SH groups of meat protein bind reversibly cabbage volatile ITC
- Cabbage combines smoothly with meat not altering colour or texture and changing the taste as much as can be expected from seasoning
- Release of antioxidants during heating protects other food component (e.g. fat)
- Cabbage phytochemicals prevent conversion of HAA to their mutagenic forms
- Cabbage enriched meat products are as safe microbiologically as their regular counterparts

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Cabbage antioxidative potential increases upon heating

TLC chromatograms of heated cabbage extracts. The numbers at the bottom (0-80) refer to the minutes of heating.

The change of level of total antioxidant activity in cabbage juice during heating process.
Cabbage antioxidant potential increases upon heating

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Cabbage combines smoothly with meat not altering colour or texture and changing the taste as much as can be expected from seasoning.
Cabbage antioxidants (native or rather released upon heating) effectively prevent oxidation of lard by delaying the initiation of oxidative processes and during prolonged heat processing.

**Peroxide value**

**Delay in oxidation**

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2. SH groups of meat protein bind reversibly cabbage volatile ITC.
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The conjugation reaction described for GSH can be expected to occur also between cabbage ITC and Cys present in meat proteins. This should enable reversible capturing of volatile ITC by meat matrix and their release in human organism during digestion processes.
Technological benefits of cabbage

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In Ames test, cabbage phytocomplex exhibits strong antimutagenicity against typical food carcinogens formed in meat products during thermal processing, even at concentration as low as **2.5% v/v** and HAA doses of **100 ng MeIQx** and **5000 ng PhIP**.
Cabbage antioxidative potential increases upon heating

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Innovative meat product

TRADITION
(Central Europe)
Combination of meat meals with cabbage appreciated by the generations of consumers

RESEARCH
(Gdańsk University of Technology)
Scientifically substantiated technological and health benefits of phytochemicals found in cabbage

FOOD PRODUCER
(The Meat Industry Company NOWAK)
Modern and ambitious entrepreneur determined to provide consumers with high quality wholesome products

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Meat products Brassica refer to several recent recommendations of WCRF/AICR:

- **Be as lean as possible within the normal range of body weight** – meat products Brassica® contain lowered fat content than their regular counterparts.

- **Eat mostly foods of plant origin** – despite being meat products, they are enriched in important plant phytochemicals and natural, virtually unprocessed fiber.

- **Limit intake of red meat and avoid processed meat** – cabbage phytochemicals limit the formation (or neutralise) of mutagens and carcinogens during processing, as well as stimulate in human organism protective mechanisms preventing damage induced by such substances.

- **Limit consumption of salt** – thanks to taste enhancing properties of cabbage phytocomplex, it was possible to reduce salt content by 30% without losing palatable properties.

- **Aim to meet nutritional needs through diet alone** - meat products Brassica® are natural composition in which nutritional benefits of both major ingredients are enhanced via carefully designed technology not by supplementation.