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Isothiocyanates may chemically detoxify mutagenic amines formed in heat processed meat

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ABSTRACT

Meat consumption represents a dietary risk factor increasing the incidence of common cancers, probably due to carcinogenic amines (HAAs) formed upon meat heating. Interestingly, cancers whose incidence is increased by meat consumption, are decreased in populations consuming brassica vegetables regularly. This inverse correlation is attributed to brassica anticarcinogenic components, especially isothiocyanates (ITCs) that stimulate detoxification of food carcinogens. However, ITC reactivity towards amines generating stable thioureas, may also decrease mutagenicity of processed meat. We confirmed here that combining meat with cabbage (fresh or lyophilized), in proportions found in culinary recipes, limited by 17–20% formation of HAAs and significantly lowered mutagenic activity of fried burgers. Moreover, MeIQx mutagenicity was lowered in the presence of ITCs, as well as for synthetic ITC-MeIQx conjugates. This suggests that formation of thioureas could lead to chemical detoxification of food carcinogens, reducing the cancer risk associated with meat consumption.

1. Introduction

Diet is a major risk factor in human cancer and meat is the main dietary ingredient behind this increased incidence of carcinogenesis. This observation was brought to public attention for the first time by the results of classic analysis by Doll and Peto (1981) and has been confirmed by a number of meta-analyses (Genkinger & Koushik, 2007; WCRF/AICR, 2007; Parkin, 2011) and also by recently published results of network case–control studies (Di Maso et al., 2013). Although initially disputable, the growing body of evidence points to the association between the intake of heterocyclic aromatic amines (HAAs) formed upon heat processing of meat and the risk of common cancers, such as colorectal (Fu et al., 2011), bladder (Lin et al., 2012), prostate (Major et al., 2011), breast, colon, pancreatic (Zheng & Lee, 2009) or lung (Lam, Cross et al., 2009; Lam, Gallicchio et al., 2009). These compounds are formed during heat processing in ng per g of meat amounts, but are highly mutagenic, and their carcinogenicity is dozens of times higher than that of other genotoxic food carcinogens, such as aflatoxin B_1 or nitrosoamines, and also much higher than that of benzo[α]pyrene (Püssa, 2013). Interestingly, consumption of brassica vegetables (cabbage, broccoli and cauliflower) decreases the incidence of the same types of cancers – colorectal (Wu et al., 2013), prostate (Kristal & Lampe, 2002), breast (Terry, Wolk, Persson, & Magnusson, 2001), bladder, colon, pancreatic (Bosetti et al., 2012) and lung (Lam, Cross et al., 2009; Lam, Gallicchio et al., 2009).

The most important bioactive phytochemicals produced by brassica plants are glucosinolates, that are degraded by the endogenous enzyme myrosinase and modifier proteins to a number of products, among which isothiocyanates (ITCs) exhibit the strongest anticarcinogenic potential (Dinkova-Kostova & Kostov, 2012). These compounds trigger an array of cytoprotective mechanisms and were shown to affect HAA metabolism (Murray et al., 2001; Walters, 2004) and detoxification (Steck & Hebert, 2009) in humans, that may diminish the carcinogenic effects of processed meats. However, the ability to stimulate human organism's own defense against xenobiotic insult is not the only possible way

Abbreviations: AITC, allyl isothiocyanate; HAA, heterocyclic aromatic amine; ITC, isothiocyanate; MeIQx, 2-amino-3,8-dimethylimidazo[4,5-*f*]quinoxaline; PEITC, phenethyl isothiocyanate; PhIP, 2-amino-1-methyl-6-phenylimidazo[4,5-*b*]pyridine; SFN, sulforaphane.

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