



# Marinades Matter: Inhibiting the Formation of Carcinogenic Heterocyclic Aromatic Amines in Foods Through Smarter Cooking Methods

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## Abstract

The purpose of this study was to explore the relationship between cooking methods and carcinogenic Heterocyclic Aromatic Amine (HAA) formation in order to better understand the causes of their formation and, more importantly, to illuminate cooking methods and techniques to implement to best decrease and/or eliminate their levels in food items, thus decreasing their mutagenic effects in the human population.

## Introduction

Heterocyclic aromatic amines, or HAAs, are mutagenic and/or carcinogenic compounds that naturally occur in muscle meats and proteinaceous foods such as beef, chicken, and fish when they are cooked at temperatures over 150 degrees celsius (302 degrees Fahrenheit) and/or for long periods of time, measurable in ng/g levels [1,2]. HAAs have been positively associated with various carcinogen risk and formation, most notably cancers of the gastrointestinal tract, such as colorectal cancer and colorectal adenomas [3]. The amounts of these compounds vary by cooking temperature, technique, time, and type of meat, and thus concentrations of HAAs can vary more than 100-fold. As the formation of HAAs are directly related to cooking methods, it is important to investigate how HAAs formation is affected by different cooking techniques in order to improve and/or modify methods of cooking [2,6]. Mounting evidence and a number of epidemiological studies report that frequent ingestion of well-done cooked meats containing HAAs is positively correlated with an increased risk for colon, prostate, and mammary cancers [3,5]. This correlation is interceded by mutagenic HAAs generated during cooking at high temperatures [3]. Most of the mutagenic activity in fried meat is accounted for by MeIQx, DiMeIQx, and IQ, although there is a notable presence of other HAA, and mutagenic activity of PhIP becomes more momentous the higher the cooking temperature [7].

## Discussion

How you season, marinate, and cook an item of muscle meat or proteinaceous food dramatically impacts the levels of HAAs formed. Which means that, as an informed cook, you have the power to greatly decrease carcinogen formation in your own kitchen with simple, inexpensive interventions. However, It is important to note that cooking technique, marination choice, and seasoning all differ on their impact on the formation of different types of HAAs in different food items, and thus interventions should be individualized to the specific meal being prepared. Based on studies specifically exploring cooking methods and their effects on HAA formation, there is a general overall consensus that cooking foods at higher temperatures and for longer periods of time is highly associated with increased levels of HAA formation, with frying being the cooking method associated with the greatest formation [7].

Though levels of HAA ingested by each individual throughout the day can vary from 1 to greater than 50 mcg per day, this variation is particularly associated with cooking method of choice. For example, barbecuing a beef patty can create as much as 141 ng/g more measurable HAAs that pan-frying it, while cooking meat well-done or making a gravy out of meat scraps can create more than 3 times that amount [5]. Multiple simple, inexpensive interventions are options to significantly decrease carcinogenic formation in foods, such as the addition of edible plant compounds. Significant inhibition is possible with certain common additions to marinades, such a garlic, which when made 20% of a marinade can decrease HAA formation by about 70%. Whole onion, as well, was found to exhibit notable effects [8], while onion powder has been shown to inhibit certain HAA formations by a whopping 94% [9]. Adding plant extracts to foods before cooking is another great intervention. A 1% artichoke extract can cause up to 98% inhibitory effects of total HAAs in over roasted beef and 95% inhibition in chicken breast [10]. Various marinades are superior at inhibiting HAA formation in meats. Red wine, in particular, has been found to decrease HAA formation in cooked meats [12], while beer also exhibits powerful inhibitory effects [13]. Red wine has been found to significantly decrease total HAA formation in fried chicken, reducing PhIP formation by up to 88% [14]. Meanwhile, the addition of black beer to well-done, charcoal grilled pork, a normally high HAA level food, can nearly mitigate the negative impact of it's consumption by decreasing HAA formation by up to 90% [15]. White wine or beer combined with herbs commonly used for meat flavoring, such as garlic, ginger, thyme, rosemary, and red chili pepper has been shown to dramatically improve HAA inhibition, helping to reduce HAA formation by about 90%. White wine or beer combined with herbs commonly used for meat flavoring, such as garlic, ginger, thyme, rosemary, and red chili pepper has been shown to dramatically improve HAA inhibition, helping to reduce HAA formation by about 90% [14].



## Conclusion

Increased levels of mutagenic Heterocyclic Aromatic Amine formation are positively associated with increasing temperature of cooking and/or increased length of cooking, with largest amounts forming when items are fried at high temperatures. The use of various liquid marinades, herbs, and spices can significantly decrease carcinogenic formation. It is important to note that levels of inhibition vary based on type of food item added to and type of HAA targeted, as in some meat types, addition of a marinate caused significant or almost complete inhibition of formation, while in others only modest or no effect occurred. Varying degrees of effect were noted with the addition of red wine, black beer, other beer, garlic, onion, various pepper types, rosemary extract, various asian spices, cinnamon, clove, ginger, thyme, olive extract, apple extract, blueberry juice, blackberry juice, sweet cherry juice, red beet juice, spinach juice, and juices of other various fruits and vegetables, green tea, artichoke extract, with most significant results shown when a liquid marinade of wine or beer was combined with known inhibitory herbs and spices.

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