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Cooking with beer: How much alcohol is left?

Julia Ryapushkina[a], Erik Skovenborg[b], Arne Astrup[c], Jens Risbo[a], Lene Mølskov Bech[d], Morten Georg Jensen[d], Pia Snitkjær[a,*]

[a]Department of Food Science, University of Copenhagen, Rolighedsvej 26, 1958 Frederiksberg, Denmark
[b]Kildegaarden 10 1.th., 8000 Aarhus C, Denmark
[c]Department of Nutrition, Sport and Exercise, University of Copenhagen, Rolighedsvej 26, 1958 Frederiksberg, Denmark
[d]Carlsberg Research Laboratory, Gamle Carlsberg Vej 4, 1799 Copenhagen V, Denmark

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Abstract

When cooking with beer and other alcoholic beverages the loss of ethanol relative to loss of water determines the final concentration of ethanol in the food, but predicting the rate of loss is not simple. Since many people for various reasons (drivers, pregnant women etc.) may strictly want to limit their ethanol intake, it is important to obtain knowledge on this topic. Knowing the final ethanol concentration in prepared foods is also crucial for precisely calculating the energy content of a food. In the current study ethanol was quantified using gas chromatography in ten foods prepared with beer: vinaigrette, pancake, carrot soup, rye bread porridge, steamed fish, spareribs, braised beef, rye bread and wheat bread before, during and after preparation. The estimated amount of ethanol per serving was calculated accordingly. The final concentrations in the foods were in the range from 2.62% (v/v) and 2.48% (w/w) to below detection limit. The highest estimated amount of ethanol per serving was accordingly 1.28 g which would be of little concern to most people. Theoretical concentration values calculated from the recipe were in most cases higher than the measured ones, since these values do not reflect the loss during preparation. Nor do the theoretical concentration values reflect the production of ethanol in yeast fermented foods as demonstrated by the rye bread in which case the measured ethanol concentration was higher than the theoretical. The heat-treated foods generally decreased in ethanol concentration during preparation, implying that a higher proportion of the initial amount of ethanol has been lost than of water. The decrease in ethanol concentration observed during cooking further implies that the cook can control the final ethanol content of a food by adjusting cooking time. The other parameter in control of the cook is the initial concentration as prescribed by the recipe.

Keywords: Cooking; Beer; Alcohol; Ethanol; Food energy calculations

Introduction

Alcoholic beverages are used as an ingredient in a variety of foods across cultures, not least in Denmark where beer traditionally has been used in staple foods like rye bread porridge (Jensen, 1953; Nimb, 1900; Strunge and Strunge, 1924). An extensive cooking literature focuses on traditional as well as innovative food preparations with beer or wine as an ingredient (Botelet, 2008; Ellis, 1975; La France, 1997; Waldo, 1958). The use of alcoholic beverages in cooking has the purpose of adding flavour to the food but it may also change the texture of foods. One very common use is as cooking liquid in meaty dishes or as an ingredient in a sauce.

Relatively few scientific studies have explored the use of wine and beer in cooking. The changes in flavour when cooking with wine have been studied by Rognså (2014) and Snitkjær et al. (2011) which both showed a loss of many

*Corresponding author.
E-mail addresses: jryapushkina@googlemail.com (J. Ryapushkina), eskov@dadlnet.dk (E. Skovenborg), ast@nexs.ku.dk (A. Astrup), jri@foo.ku.dk (J. Risbo), Lene.Bech@carlsberg.com (L.M. Bech), Mortengeorg.jensen@carlsberg.com (M.G. Jensen), piasnitkjaer@food.ku.dk (P. Snitkjær).
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volatile aroma compounds during cooking making the aroma of the wines more alike after cooking.

The health effect of using beer and wine marinades in food preparation has been studied by Gorelik et al. (2008), Melo et al. (2008) and Viegas et al. (2012, 2014) who showed a reduction in the levels of carcinogenic compounds in meat when marinated in wine and beer prior to frying.

One concern when cooking with alcoholic beverages is the concentration of ethanol in the cooked dish. This is important when serving the food to pregnant women, children, drivers and to anyone who wants to control their alcohol intake strictly. The amount of retained ethanol during food preparation is also relevant for energy calculations of a meal since ethanol lost during cooking should not be counted as energy in the final serving. A few studies have been published on the topic (Augustin et al., 1992; Hansen et al., 2012; Helander and Bergström, 2001; Mateus et al., 2011) giving some insight on ethanol loss during cooking. Broader knowledge is however valuable in order to predict and not least control the remaining amount of ethanol relative to water when cooking with beer and other alcoholic beverages.

The current study provides knowledge on ethanol concentrations in ten types of foods and the corresponding amount of ethanol per serving. The study further provides knowledge on the change in ethanol concentration during cooking. The foods chosen comprise a range of different heat treatments and are prepared with different beers. The data provided and the following discussion on the general principles for ethanol loss upon cooking are intended to be used as a guideline for predicting the ethanol concentration in foods prepared with alcoholic beverages. The provided knowledge aims to help control one's alcohol intake and support correct energy calculations in foods prepared with alcoholic beverages.

Materials and methods

Ten foods were prepared according to Table 1. All recipes originate from cookbooks but were in some cases modified slightly in order to fit into the study. Details on sampling times are also given in Table 1. In the case of steamed fish and braised beef samples of the meat/fish and the liquid were taken separately. Samples were frozen at −18 °C prior to ethanol analyses.

Ethanol concentration was determined using static headspace gas chromatography mass spectrometry (HS-GC–MS). Each analysis was performed in duplicate.

For liquid samples, 1 ml of sample was mixed with 9 ml water in a 20 ml headspace vial and 50 µL of internal standard (9.99% methanol) were added. The ethanol concentrations of these foods are given as a volume percentage (also known as ABV).

Solid samples were weighed out for headspace analysis and results given as a weight percentage (also known as ABW). Samples of 15*g* were weighed into a 250 ml centrifuge tube and 135*g* water was added. The mixture was homogenised using a polytron type PT 10–35 homogeniser. Ten ml homogenised samples were weighed into a 20 ml headspace vial and 50 µL internal standard (9.99% methanol) were added.

Quantification of ethanol was done by creating matrix-calibration curves for each food. This was done by spiking the foods prepared without alcoholic beverage (using water instead). In case of the pancakes, rye bread, wheat bread, braised beef and spareribs, separate standard curves were made for the food before and after heat treatment. The bread was a special case because the'blind sample' prepared, substituting beer with water, contained ethanol due to the fermentation process. So for the dough and bread the standard addition method was used, with one non-spiked and 6 spiked levels.

Gas chromatographic analyses were carried out on a Trace GC Ultra gas chromatograph with a split/splitless injection port coupled to a DSQ quadrupole mass spectrometer (Thermo). Headspace sampling was carried out using a CTC CombiPAL sampler (CTC Analytics AG). Headspace sampling was performed after incubation at 60 °C for 10 or 25 min. 250 µL of the headspace was sampled using a 2.5 ml syringe thermostated at 90 °C. Samples were injected in splitless mode (3 min), and injection port temperature was 250 °C.

Separation of compounds (ethanol and methanol) was done using a CP-WAX 52 capillary column (50 m x 0.32 mm internal diameter, 0.45 µm film thickness, Agilent). Helium with a constant flow of 1 ml/min was used as a carrier gas. After injection the column was kept at 40 °C for 10 min, and then raised at 30 °C/min to 240 °C. The temperature of the transfer line connected to the mass spectrometer was set at 260 °C.

Detection was performed using a mass spectrometer in electron-impact (EI) ionisation mode with electron energy of 70 eV. Quantifications were performed in full-scan mode, mass range *m/z* 15–300, with a scan rate of 1.6863 scans/s. Total ion chromatogram (ethanol) and *m/z* 32 (methanol) were used for quantifications.

Results

A variety of foods were prepared with beer according to recipes. The foods were selected to represent a variety of heat treatments and ingredients. The ethanol concentration measured in the prepared foods, presented in Table 2, range from not detectable (ND) to 2.62% (v/v) and 2.48% (w/w). Ethanol concentrations in foods must be evaluated in relation to the amount of the food normally consumed within a meal. Serving sizes are estimated according to Ygil (2013) and the corresponding amount of ethanol per serving is presented in Table 2. The highest value of ‘ethanol per serving’ is 1.28 g, which corresponds to no more than 11% of a lager type beer (330 ml, 4.6% v/v), which contains approximately 12 g ethanol.

In addition to the measured ethanol concentrations, theoretical ethanol concentrations have been calculated based on the recipe, without considering the loss during preparation, see Table 2. These theoretical ethanol concentrations are as expected generally higher than the measured concentrations in the final products. Rye bread and vinaigrette are exceptions.