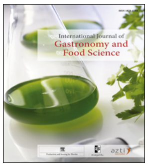

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International Journal of Gastronomy and Food Science 1 (2012) 90–95

International Journal of
Gastronomy and
Food Science

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Scientific Paper

Decoupling the effects of heating and flaming on chemical and sensory changes during flambé cooking

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Received 19 July 2012; accepted 2 April 2013
Available online 25 April 2013

Abstract

Anecdotal and literature accounts on the combustion, or flaming, of high-proof spirits during food preparation (*flambé*) have reported ethanol losses, browning and sensory changes of the final product. In this work, the effects of heating and combustion were decoupled by preparing model flambé (heated-and-ignited) systems alongside similar systems which were heated but not ignited. In a simple flambé systems consisting only of vodka, we observed a 24.7% loss of ethanol in the heated-and-ignited treatments and a 34.7% loss in the heated-not-ignited systems. In a model caramel sauce containing butter, sugar, and vodka, no significant difference in ethanol loss was observed between the ignited (13.2%) and not-ignited (14.1%) treatments. In both systems, the majority of ethanol loss was due to heating rather than combustion. No significant difference was observed in Hunter lightness (L) values between heated-and-ignited and heated-not-ignited treatments for the butter–sugar–vodka system, suggesting that the effect of flambé on browning was minimal. Maximum surface and flame temperatures were then measured in the vodka system by thermocouples. While maximum flame temperatures up to 532 °C were observed during 15 s of flaming, the maximum temperature at 1 cm above the pan surface was 67 °C, below temperatures typically required for significant Maillard or caramelization reactions on this time scale. In triangle tests using the vodka system, panelists were able to discriminate heated-and-ignited from the unheated control and, in one experiment, from the heated-not-ignited sample, even when treated samples were reconstituted with water and ethanol lost. However, for the butter–sugar–vodka system, the majority of panelists could not discriminate between ignited and not-ignited treatments.

Keywords: Culinary science; Flambé; Ethanol retention; Browning reactions

Introduction

Flambé, or the ignition and subsequent flaming of spirits during food preparation, is a cooking method used in several well known recipes such as Bananas Foster and Crêpes Suzette. A typical procedure for flambé involves heating a pan, often containing other ingredients, then adding the spirit and allowing it to heat for a few seconds before igniting the ethanol vapors. The flame is then covered or allowed to burn out on its own. Generally, high proof spirits (40% v/v ethanol or greater) are used in flambé, e.g., rum in Bananas Foster. The chemical and sensory effects of flambé, if any, are of interest to culinary scientists for multiple reasons. First, flambé can be dangerous. Tableside flambé is illegal in several localities, and in cases where it is legal, serious burns can occur if performed improperly. Thus, it may be preferable to avoid flaming a dish if it does not uniquely affect the flavor. Second, consumers who wish to avoid alcohol for health or religious reasons may desire to avoid flambéed foods if a large percentage of ethanol is retained in the final product. However, as subsequently discussed, the amount of ethanol lost during flambé is not resolved.

While the theatricality of flambé is obvious, there is little consensus regarding the sensory or chemical impact of the technique in cookbooks and minimal scientific literature to consult. A common assertion in cookbooks is that flambé results in combustion and rapid loss of ethanol during cooking (Dodge et al., 2002; Schaeli, 1992), and one author reported a 79% loss of ethanol during the flambé preparation of Steak Diane (Olson, 2004). In contrast, an earlier study found that as

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Peer review under responsibility of AZTI-Tecnalia.

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http://dx.doi.org/10.1016/j.ijgfs.2013.04.001

much as 85% of the original alcohol content is retained (Augustin et al., 1992). A second justification cited for performing flambé is that it encourages browning reactions. In support of this assertion, Olson reported that the flame temperature of flambé exceeds 500 °F, well in excess of temperatures needed for caramelization or Maillard reactions (Olson, 2004). However, no chemical data, e.g., a darkening of color, has been reported to justify this claim.

A confounding variable regarding previous observations on flambé, anecdotal or otherwise, is that it is unclear which changes result from heating of the dish and which changes are specifically due to ignition of the spirit. For example, arson science studies have shown that liquid fuels can be lost as a result of both combustion and evaporation (Ma et al., 2004), and evaporative losses of ethanol have been demonstrated for long-simmered dishes (Mateus et al., 2011). Since flambé recipes instruct readers to add the spirit to a hot pan to facilitate ignition (Olson, 2004; Schaeli, 1991), it is unclear what specific role ignition and flaming play in changes that occur during flambé.

The current study had two objectives. First, we wished to decouple the effects of flaming from the effects of heating on the loss of ethanol during flambé. Second, we wished to determine if flaming resulted in browning or sensory changes to model food systems.

Materials and methods

Vodka system—sample preparation

100 g of vodka (32 g ethanol, Barton Charcoal Filtered, Sazerac Company, Inc., Metairie, LA) was added to an 17 cm diameter, 1 L aluminum pan (The Vollrath Co., Sheboygan, WI). The pan temperature was initially 120 °C. The vodka was then either allowed to heat for 15 s or immediately ignited by an extended reach lighter (Bic Corporation, Paris, France) and allowed to flame for 15 s. For both treatments, after 15 s the pan was covered to extinguish the flame and prevent further evaporative losses and then removed from heat. The initial and final mass of each sample were measured. Four replicates were performed for each treatment, ignited or not-ignited.

Butter–sugar–vodka system—sample preparation

The ratios of butter, sugar, and spirit were modeled after a typical Bananas Foster recipe (Labensky and Hause, 2007). Fifty grams of unsalted butter (Land O'Lakes, Saint Paul, MN) was melted in aluminum pan followed by the addition of 100 g of sugar (Wegman's granulated, Rochester, NY). The sugar and butter mixture was stirred on a 130 °C hotplate for 2 min. One hundred grams vodka (32 g ethanol) was then added and the mixture allowed to warm for 15 s before it was either ignited and flamed for another 15 s or not ignited and heated without flaming for 15 s, after which the aluminum pan was covered and removed from heat. The initial and final mass of each sample was measured. Four replicates were performed for each treatment, ignited or not-ignited.

Quantification of ethanol and water losses

For the vodka system, each sample was transferred to a graduated cylinder following completion of the heating/flaming steps, plugged with a glass stopper, and cooled to room temperature (21 °C). Initial and final ethanol concentrations were determined by densiometry (Anton Paar DMA 35, Austria). To determine the ethanol concentration in the butter–sugar–vodka system, samples were cooled in an ice bath to allow separation of solids. The mixture was centrifuged and the supernatant of each sample was diluted 1:50 by weight with deionized water. The diluted samples were then sent to the New York State Wine Analytical Lab (Geneva, NY) for quantification of ethanol by GC-FID (Zoecklein, 1995). The amount of ethanol in grams in all samples was then calculated by multiplying the ethanol concentration by the mass, and ethanol lost as a result of a treatment was calculated by subtracting the final ethanol content from the initial ethanol content. Water loss was calculated in both systems by the formula: Water loss = (Initial Mass) − (Final Mass) − (Ethanol Lost), such that any change in mass other than ethanol loss was assumed to be due to water loss.

Characterization of browning in butter–sugar–vodka system by colorimetry

Three ignited samples and three heated butter–sugar–vodka samples were prepared in analytical duplicate as described above. Hunter *L*, *a*, *b* values were measured with a Macbeth Color-Eye spectrophotometer (Model 2020; Kollmorgen Instruments, Corp., Newburgh, NY). Hunter values were computed from the diffuse reflectance of light in the 360–750 nm range at 10 nm intervals based on illuminant A. Measurements were taken at 40 ± 1 °C with a 1 cm path length glass cuvette. Between each sample, the cuvette was rinsed with ~40 °C water, soaked in Decon 90 detergent solution (40% v/v) for ~15 s, rinsed with deionized water, and then dried with Kimwipes (Kimberly-Clark). All values were measured in duplicate.

Temperature measurement during flambé

To measure the temperature at the surface and in the flame of ignited vodka samples, two K-type thermocouple probes (Oakton Instruments—Vernon Hills, Illinois) were set at 1 cm ± 0.5 and 7 cm ± 1 above the base of the pan (see Fig. 1). An additional probe was set in contact with the pan to measure the pan temperature. Samples of 100 g vodka were added to each pan and immediately ignited. Samples were allowed to burn for 15 s before being covered and cooled to room temperature. Maximum surface and flame temperatures were measured using a 4 channel digital thermometer (Sper Scientific Ltd., Scottsdale, Arizona) and recorded using TestLink SE-309—RS232 interface software.

Sensory evaluation—discrimination tests

Prior to evaluation of the vodka system, the treatments (heated-and-ignited, heated-not-ignited) were reconstituted