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Flavour development during beef stock reduction

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ABSTRACT

In beef stock, made of brisket, water and NaCl, reduction time was found to play a major role in development of volatile compounds and sensory characteristics. Nine stock reductions, made by varying concentration factor and reduction time (controlling power input from stove), were compared using dynamic headspace gas chromatography and a descriptive sensory analysis ($n = 9$). Aroma compounds could be classified into 5–6 groups, based on their concentration–time profiles. The initial flavour was found to be lost for both slow and fast reductions but, for fast reduction, insufficient time was left for development of new flavours. The decrease in volume alone, as often referred to in recipes, is accordingly not sufficient as the sole indication of flavour development. The observed changes in sensory properties, and changes in the underlying concentrations of chemical compounds during reduction, are discussed with regard to theoretical considerations about evaporation of volatile aroma compounds from the boiling two-phase (oil–water) liquid and heat-induced chemical reactions.

1. Introduction

Preparation of a beef stock (also referred to as broth) is a basic procedure in the restaurant kitchen. Stock is used as a base for soups and sauces. Preparation of beef stock involves cooking of meat, bones, vegetable and herbs in water (Larousse, 1997; Peterson, 2008; The Culinary Institute of America, 2006), during which process meat compounds are extracted into the water, adding flavour and mouthfeel to the stock (Cambero, Seuss, & Honikel, 1992; Cambero, Pereira-Lima, Ordonez, & de Fernando, 2000b; Pereira-Lima, Ordonez, de Fernando, & Cambero, 2000; Seuss, Martin, & Honikel, 1990). The non-volatile fractions extracted from meat are important taste compounds in the stock (Cambero et al., 1992; Cambero et al., 2000b; Pereira-Lima et al., 2000; Seuss et al., 1990) and, furthermore, are precursors of volatiles developed during cooking (Hornstein & Wasserman, 1987; Melton, 1999; Mottram, 1998). After separation of meat and stock, the stock is often reduced (boiled down) in order to enhance flavour and change consistency (Montagne, 2001; Peterson, 2008). If greatly reduced, the stock turns into a thick syrupy liquid, a so-called glaze, which is used as a concentrate to fortify soups and sauces (Davidson, 1999; Larousse, 1997; Peterson, 2008).

Meat flavour has been thoroughly studied (Farmer & Patterson, 1991; Gasser & Grosch, 1988; Hornstein & Wasserman, 1987; MacLeod & Ames, 1986; Melton, 1999; Mottram, 1998) and several workers have studied beef stock aroma in particular (Brinkman, Copier, de Leuw, & Tjan, 1972; Guth & Grosch, 1994). Several studies have investigated the effects of different cooking parameters, e.g. time and temperature, when preparing a beef stock (Cambero et al., 1992; Cambero, Pereira-Lima, Ordonez, & de Fernando, 2000a; Cambero et al., 2000b; Pereira-Lima et al., 2000; Seuss et al., 1990). These studies are all concerned with the effect on the non-volatiles, as well as the sensory properties, of the non-reduced stock. No published research has been found on flavour development during the reduction process, which is the topic of this study.

An increase in flavour intensity takes place during reduction, despite the fact that aroma must be expected to be removed, along with water, as evidenced by an intense smell in the kitchen during reduction. The flavour development during reduction of a beef stock, and its physical or chemical background, are not well understood. The aim of the present investigation is accordingly to study the effects of time and concentration factors on the sensory properties and the volatile compounds during the reduction process. We further relate this understanding to the preparation techniques traditionally used by chefs who rely on their experience and intuitive knowledge when cooking. An increased understanding of the reduction process should not only give new tools to the chef when boiling down the stock, but also provide more basic knowledge about flavour development in cooked meat dishes in general, also to be used for large-scale production in industry.

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2. Materials and methods

2.1. Cooking and reduction of stock

The first step was cooking of beef stock for two reduction experiments, T (with focus on reduction time) and P (with focus on power input and reduction rate). Beef brisket from the breed Holstein was obtained from a local retailer. The meat was bought on different days and originated from different farms and used separately for the two kinds of experiments. Visible fat was removed from the meat, which was then cut into pieces of approximately $1 \times 2 \times 2$ cm. The meat was then kept frozen (−18 °C) for approximately 2 weeks prior to stock preparation. The preparation took place after thawing the meat overnight at 5 °C. The meat, bottled water (Aquad'or, Brande, Denmark) and NaCl (pharmaceutical quality, Sanal P, Mariager, Denmark) were brought to the boil on a stove while covered. Bottled water was chosen in order to ensure a consistent and low content of minerals (150 mg/l). For each of the two experiments (T and P), a batch was prepared with 12.5 kg of meat, 25 l of water and 7.5 g of NaCl/l. Immediately after reaching the boiling point, the stock was skimmed free of fat and foam and transferred with the meat to a thermostatic soup cooker (Karma Global, Taichung, Taiwan) set at 80 °C. After simmering at a constant temperature of 80 °C for 60 min, the meat was separated from stock using a colander. The stock was cooled and stored at 5 °C. The following day, the fat layer was removed and the reductions took place.

All reductions were carried out on an electrical stove. The stock was brought to the boil while covered, after which the lid was removed and the water boiled off until a predetermined concentration factor (CF) was reached. Reduction time was measured from onset of boiling. Reduction in experiment T (time varied) was carried out by reducing one large batch (20 l), keeping the temperature at the boiling point throughout the reduction. The samples in experiment T were taken out during reduction, upon reaching the predetermined CF. Reduction in experiment P (power input varied) was carried out by dividing the initial stock into four sub-batches (6 l each), three of which were reduced separately, and the last not reduced. The rate of reduction for the three sub-batches was varied by varying the power input, *P*, at the stove. After reduction, all samples were re-diluted to the original volume with bottled water. The reductions of experiments T and P are illustrated in Fig. 1, which also shows the sample-ID.

The re-diluted samples were stored overnight at 5 °C, and then filtered through a fabric (polyester). The samples were stored frozen at −18 °C in glass bottles (for chemical analyses) and plastic bottles (for sensory analysis). Within one month from sample preparation, the frozen samples were thawed and analysed, as described below.

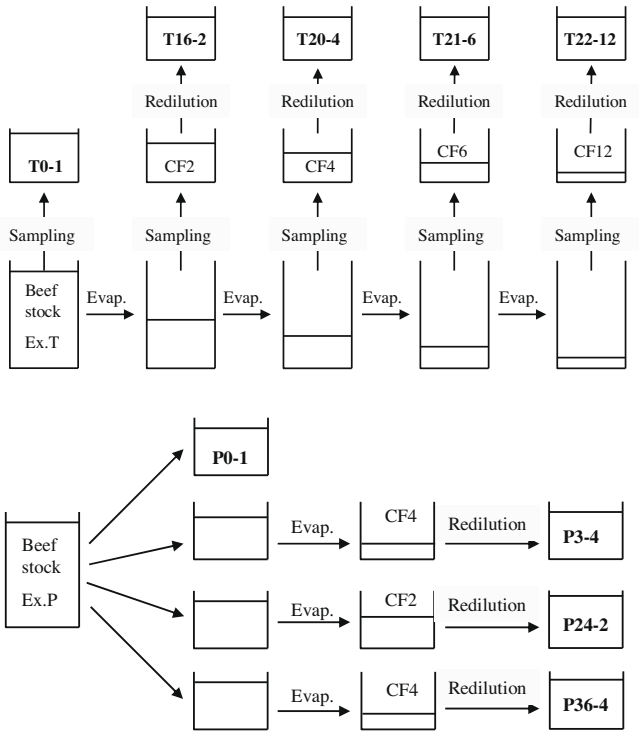

Fig. 1. Preparation of stock reductions in experiment T and P. For each of the two experiments, one batch of stock was prepared, which was reduced (boiled down) on a stove to predetermined concentration factors (CF), as illustrated. The reduced samples were re-diluted to original volume with water. Sample-ID and concentration factors are shown in the figure.

Table 1
Descriptors for the sensory analysis and preparation of reference used in the training sessions. Odour (O), taste (T), and aftertaste (AT).

Descriptor	Preparation of references
Beef (O, T)	Beef brisket boiled in water for 2 h
Chicken (O, T)	Chicken boiled in water for 75 min
Roast crust (O, T)	Beef steak fried 3 min at medium heat
Burned (O, T, AT)	Steak of beef fried 4 min at high heat
Tar (O)	Tar
Nutty (O, T)	Hazel and brazil nuts lightly roasted
Vegetable (T)	Vegetable stock made from stock cube
Astringent (AT)	Strong black tea
Sweet (T)	
Sour (T)	
Bitter (T, AT)	
Salt (T)	

2.2. Sensory descriptive analysis

A panel, consisting of nine external paid panellists (one male and eight female) was used for the evaluation. All panellists had passed screening tests according to ISO standards (ISO-8586-1, 1993), and had previous experience with sensory evaluation. Sensory sessions took place in a sensory laboratory, which complied with international standards for test rooms (ISO-8589, 2007). In three training sessions of approximately 1½ h, panellists were trained on the products, and descriptors were chosen after suggestions from the panel leader, based on consensus among the panellists. In total, 19 descriptors, including odour, taste and aftertaste, were used for the descriptive analysis. These are listed in Table 1, together with descriptions of reference materials. The descriptive analysis took place in three sessions on three different days. During each of the sessions, all nine stock samples were served, once, to each of the panellists in a randomised order. Stock samples of 45 ml were served, one at a time, in a black glass with a lid at 60 °C. The panellists were instructed to swirl the glass and rate the samples with respect to the descriptors by sniffing through the nose (referred to as "odour" descriptors), then taste the stock samples and rate the samples with respect to the descriptors by mouth. The immediate perception in the mouth, as well as the perception lingering in the mouth, were rated referred to as "taste" and "aftertaste", respectively. All descriptors were rated on a horizontal 15 cm continuous line scale, anchored with 'a little' and 'a lot' one cm from left and right end of the scales. Data were collected with data collection software (Fizz, v 1.30 Biosystems, Couternon, France).