Design of a process for the manufacture of Beef Stock

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Michael Edward Parker

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Abstract

This work deals with the development of a process for the production of commercial stock from beef bones using a formal food process engineering analysis instead of random experimental trials of potential processes. The major difference between a food and a traditional chemical process engineering analysis is the inclusion of the food functional, textural and/or sensory properties besides the yield and efficiency in the optimal design. These properties often interact with the process and equipment design.

The bones were extracted with hot water and the kinetics of extraction determined by following the changes in soluble solids over time. Extraction curves measured at several temperatures between 80 and 120°C could be modelled using first order rise to an equilibrium concentration and the effect of extraction temperature could be measured using the Arrhenius law.

Despite the presence of gelatine in the aqueous stock extracts, which is known to produce strongly time-dependent non-Newtonian solutions, they were found to be Newtonian for temperatures above 20°C. Thus the Newtonian viscosity of the aqueous extracts was measured as an indicator of stock texture. Textural changes due to exposure to high temperatures over time were determined for temperatures between 60 and 120°C and found to follow first order kinetics. The effect of temperature followed the Arrhenius law.

An equilibrium curve for bone extraction in hot water at 120°C and a maximum yield of extractable solids non-fat were also determined.

A mathematical model was constructed on an Excel platform using the kinetics of extraction and textural changes as well as the equilibrium data. It is based on a novel method of analysis of multi-stage solid-liquid extraction called “stage wise iterative analysis” and gave a profile of soluble solids concentration and viscosity during the extraction and concentration phases of the manufacturing process that fell within less than 10% of experimental measurements. Simulations showed that soluble solids concentration, viscosity, yield and processing time all impacted on the optimum design.

These analyses highlighted the significant importance of reducing the run time from the current 6 days to 5 hours as it has the potential to increase the production rate and therefore revenue ten-fold with a minimum change in equipment. The higher extraction rate can be achieved by increasing the extraction temperature from the current 92°C to 120°C. While the rate of losses of viscosity and therefore texture is increased with the higher process

temperature, the model showed that the great reduction in processing time more than compensates for the temperature effect and the viscosity of the final stock extract is greater than that found in the current industrial operation. It was also found that the yield of extracts from the bones could be improved significantly by conducting a multi-stage semi-counter current extraction instead of a single stage extraction for the same overall extraction time. Preliminary considerations were given to the use of secondary product streams, high quality tallow and calcium phosphate to improve further the financial returns of the process. Finally a process modification was considered to improve the consistency of the flavour properties of the stock. It was proposed that separating the meat from the bones and roasting it in a smaller oven to allow quick and separate extraction of the flavour components found in the commercial stock. These can be added back to the bone extracts in standardised quantities to produce a product of consistent flavour.

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