POWER CONSUMPTION AS A PARAMETER FOR PROCESS CONTROL IN RELATION TO THE MANUFACTURE OF COMMINUTED MEAT PRODUCTS

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INTRODUCTION

SAUSAGE meat batters are characterised by developing binding capacity of water and fat during heating. The relation between the resulting stability and the chopping time has been studied extensively (5). The influence of the chopping temperature is more difficult to explain (1). A maximum stability over a wide temperature range was found and no relationship was established between the rheological properties and the heat stability of the batter (7). However, these properties of batters of varying composition were determined at only one standardized chopping procedure. Several Russian research-workers followed the changes in the rheological behaviour during chopping of sausage batters without finding a relation to the fat and water binding capacity of the batters (2, 6). Hamm (3) extensively investigated the influence of a large number of variables on the rheological properties of the batter. A significant relationship was found between the viscosity and the water binding capacity of fat-free model batters (4). The water binding capacity of the system increased with rising viscosity.

From these results two conclusions can be drawn. First, the rheological properties of a comminuted meat batter are changing during chopping. Second, these properties are related to the binding of water and fat. In this study with regard to the earlier published unit operations approach of the chopping process, a new parameter affecting the rheological properties is introduced (8). The variation of the rheological properties of the batter during chopping was expected to be reflected in a variation of the net power consumed by the bowl chopper. Due to the second conclusion net power consumption and binding of fat and water should also be related. Thus the optimal chopping conditions could be determined by following the net power consumption. Also a way of process control can be developed because the net power consumption can indicate the degree of progress of the chopping process.

MATERIALS AND METHODS

A kiloWatt-hour meter was used to measure the total amount of energy (kWh) consumed by the bowl chopper. The difference in energy consumption between the loaded and the free running bowl chopper is divided by the time interval (hrs) between two measurements to give the actual net power consumption (kW). In this way both net energy and net power consumption were determined at intervals of thirty seconds for 8 kilo material in a 15 l laboratory bowl chopper. The feasability of these measurements depends on some conditions. First, a variable power consumption of a bowl chopper can only be expected if the electro-motor is able to deliver power of the same order of magnitude as needed for chopping. Second, the power consumption of the unloaded bowl chopper should be constant; then only the net value of energy and power consumption can be calculated. Two other factors which influence these measurements are the power needed for the rotation of the loaded bowl and the variation of the speed of rotation of the knives due to changes in the resistance undergone in the batter. The measurements carried out in this way show a good repetability.

The chopping of the batters with compositions given in Table 1 is performed in two stages. In the first stage the raw lean beef is prechopped with water, salt and other ingredients. The aim is an optimal release of salt soluble proteins. In the second stage the batter is chopped to completion after addition of pork trimmings and back fat. In the first experiment only one raw material was taken: lean beef or pork back fat.

RESULTS AND DISCUSSION

The net energy consumption during chopping of pork back fat as a function of time is given in Figure 1. During comminution the rate of increase of the energy consumption declines, resulting in a decreasing power consumption as is shown in Figure 2. This phenomenon is caused by the reducing resistance of the knives when the particle size and the viscosity due to temperature rise are decreasing.

In comparison with back fat the comminution of pure lean beef requires more energy and more power (Figure 1 and 2). An increasing net power consumption occurs in spite of a decreasing particle size and a rising temperature. After addition of water and salt the net power consumption, during chopping, continues to rise, however, to a minor extent. The only possible explanation is an increasing resistance of the knives due to the development of the characteristic visco-elastic properties of the comminuted meat system.

The net power consumption during chopping of batters with different compositions is shown in Figure 3. During the first two minutes of comminution of the complete mixtures I and II the net power consumption is rising. When the maximum value is reached, the net power consumption suddenly decreases. This implies that the chopping process of a comminuted meat batter can be divided into two sharply discernable stages. In the first stage the texture of the batter is developed whilst in the second stage this texture is destroyed. Composition I and II mainly differ in the amount of water added, in order to obtain a lower net power consumption for the batter with the highest water content.

In Figure 4 two batters with a relatively high content of pork back fat are compared. To obtain a marginal heat stability of the batter, polyphosphates were omitted in composition IV. The higher maximum value for the net power consumption of composition IV is followed by a steeper decline. Although no fat and water were separated on heating, it is assumed that the difference in rheological properties between compositions III and IV, is indicative of a lower heat stability of the batter.

CONCLUDING REMARKS

LEAN beef and pork back fat each have a characteristic net power consumption during comminution and mixing in a bowl chopper. The variation of the power consumption with the chopping time is caused mainly by the changes of the rheological properties of the materials. This would imply that a processing value of raw meat materials can be determined.

The net power consumption during the chopping of meat batters is characterised by a sharp maximum value which enables the application of automatic process control. In spite of the chemical composition and the presence of polyphosphates this maximum value always occurs. When upon further chopping this value is exceeded, the texture of the batter will be destroyed. Further investigations are needed to evaluate to what extent the destruction of this texture is affecting the heat stability of the batter.

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Table 1 Batter compositions

batter number	I	II	III	IV
percentages of:				
lean beef	28.7	20.0	28.7	28.9
water	14.4	20.0	14.4	14.5
polyphosphates	0.3	0.3	0.3	-
salts	2.6	2.5	2.6	2.6
pork trimmings	20.0	23.2	10.0	10.0
pork back fat	30.0	30.0	40.0	40.0
starch	4.0	4.0	4.0	4.0
analytical composition				
water	50.0	54.9	48.2	46.7
fat	34.0	30.8	36.5	39.4
protein	11.1	9.1	10.2	9.4

Figure 1 The net energy (kWh) consumed by a bowl chopper as a function of the chopping time for two raw materials

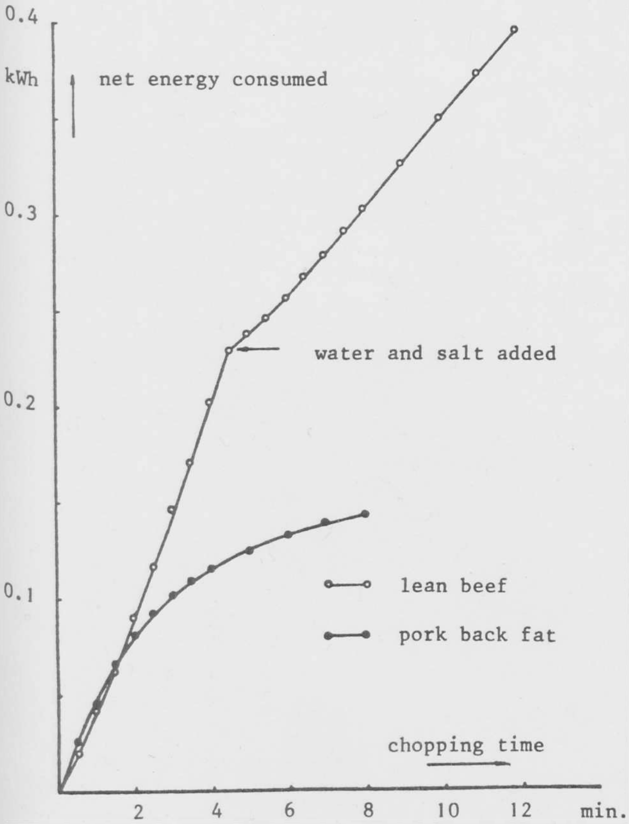


Figure 2 The net power consumption (kW) by a bowl chopper as a function of the chopping time for two raw materials

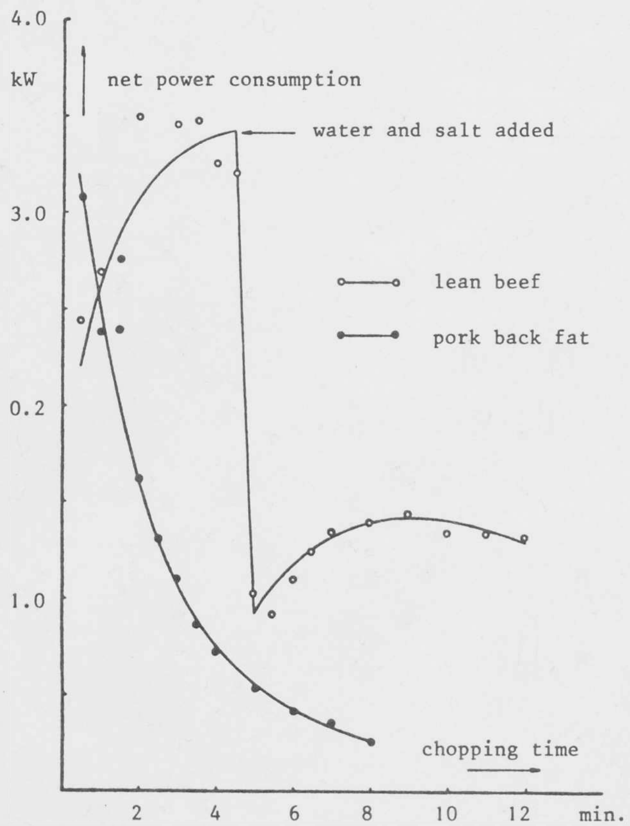
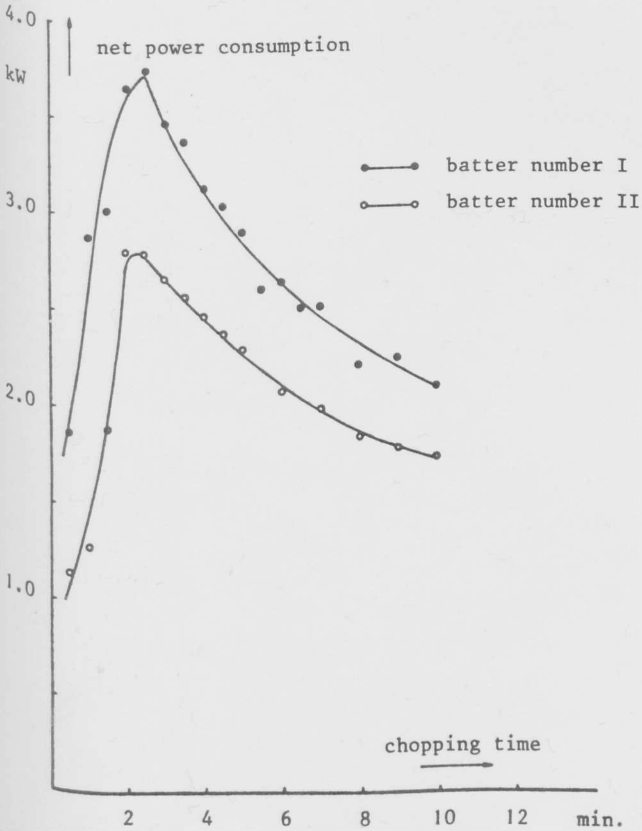


Figure 3 The net power consumption by a bowl chopper as a function of the chopping time for two batters with different compositions



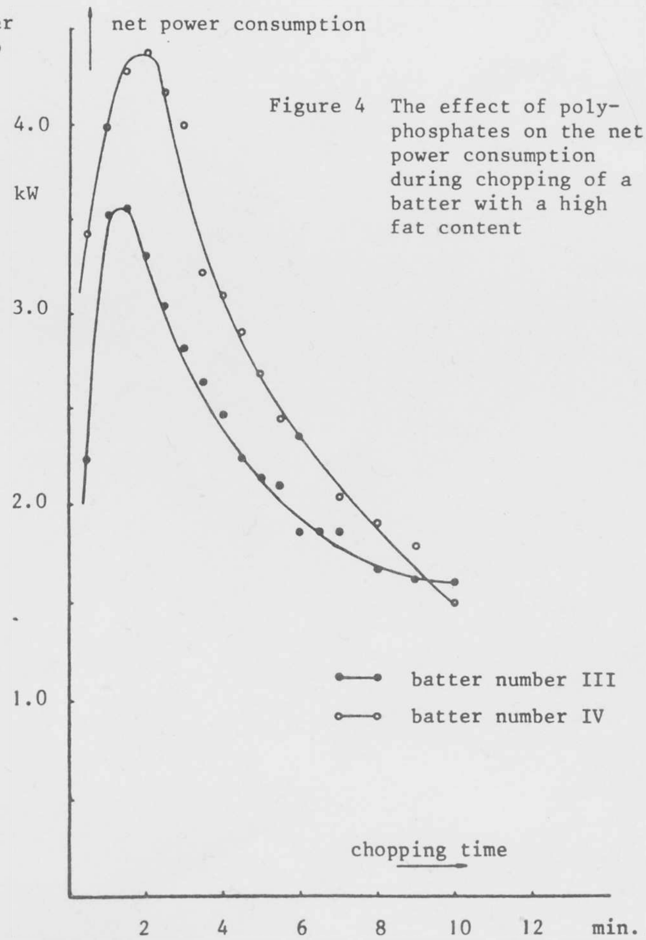


Figure 4 The effect of polyphosphates on the net power consumption during chopping of a batter with a high fat content

Figure 3 Average brine percentages of the slices 1, 2, 3 etc. of the 10 backs (.) and bellies (x) after injection in Factory A

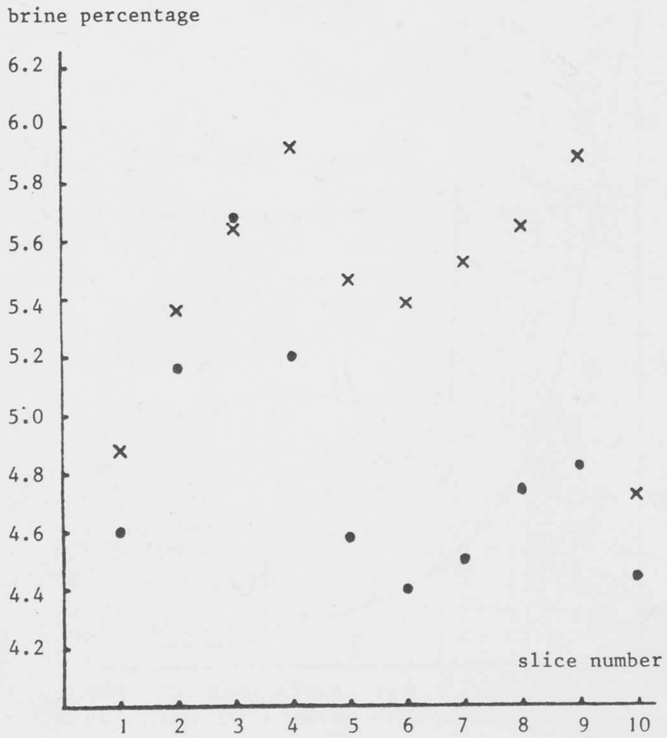


Figure 4 Average brine percentages of the slices 1, 2, 3 etc. of the 5 backs (.) and bellies (x) after injection in Factory B