# Milk-Clotting Enzymes. 2. Estimating Cheese Yield Losses from Proteolysis During Cheese Making[1]

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## ABSTRACT

Some milk-clotting enzymes are more proteolytic than calf rennet during cheese making. Reductions in cheese yield can be estimated by comparing levels of N (as protein) in wheys produced by calf rennet and those enzymes. A higher level of N in whey means that more casein is hydrolyzed than with the control. This is equivalent to making cheese from milk with less casein. The amount of casein reduction in the milk can be estimated.

Two methods are described for estimating yield losses. One uses a predictive yield formula to estimate yield from the control and casein-reduced milks. The other, preferred, method estimates an "effective", net, or economic reduction in yield. The latter standardizes the two milks to the same casein:fat ratio and accounts for the value of whey fat; the economic reduction must be qualified by the composition of the cheese, whey, and milk; by the name of the variety; and by the relative value of milk fat and cheese. (Key words: milk-clotting enzymes, cheese yield, proteolysis)

## INTRODUCTION

It is difficult to perform meaningful experiments on the effect of milk-clotting enzymes on yield of cheese. Variables during the cheese making process contribute to this difficulty (12), resulting in relatively large experimental errors. These variables include errors in measuring quantities of milk and cheese, errors in analysis of cheese, and variations in the manufacturing process between vats.

The proteolytic nature of milk-clotting enzymes is well-known (7, 8). The variability among enzymes in this property is one of the major causes of differences in yield associated with their use. It is theoretically possible to determine the effect of these enzymes on yield indirectly by measuring differences in levels of protein in whey, since higher levels of protein in whey mean reduced yields. Some work has attempted these determinations (1, 2, 5, 10).

This paper addresses the problem of estimating the effect of enzymes on yield by differences in the levels of nitrogen (protein) in whey during cheese making and gives a procedure for making that estimation.

## MATERIALS AND METHODS

### Cheese Making Trials

An example is taken from a previous study (2) showing different levels of N in whey during making Cheddar cheese using calf rennet (CR) and a preparation from *Endothia parasitica.* Cheese was made in beakers (600 ml of milk) through the cooking and cheddaring processes, collecting whey during cooking (Whey I) and during cheddaring (Whey II). The whey data represent the results of six replicate trials. Differences (CR minus *E. parasitica*) between the enzymes in Wheys I and II [least significant differences (LSD)] were –.0454% (.0123%) and .1048% (.0470%) total N as protein.

### Cheese Yield Formulas

The following four formulas were used where:

Y = yield of cheese (kg/100 kg milk),

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C = casein content of milk (kg/100 kg),
F = fat content of milk (kg/100 kg),
FC = fraction of fat in cheese,
SC = fraction of salt in cheese (.017),
WS = fraction of fat-free, curd-free solids in whey (.065),
M = fraction of moisture in cheese (.37),
MFFC = fraction of moisture in fat-free cheese (.5609),
Msef = moisture in cheese which can act as solvent for whey solids = M − .5(.96C − .022)/Y,
MFFCsef = moisture in fat-free cheese, which can act as solvent for whey solids = MFFC − [.5(.96C − .022)/Y/(1 − FC)].

Van Slyke and Price (VSP) (11):

$$Y = \frac{(.93F + C - .1) \times 1.09}{1 - M}$$

Type A(b) (4):

$$Y = \frac{.93F + 1.01813C}{1 - SC - M - \frac{Msef \times WS}{1 - WS}}$$

Type B(a) (4):

$$Y = \left[ .93F + \frac{1.01813C}{\frac{1 - SC + \frac{Msef \times WS}{1 - WS}}{1 - FC - M}} \right] \left[ \frac{1}{1 - M} \right]$$

Modified Type C(b) (3):

$$Y = .93F + \frac{1.01813C}{1 - \frac{SC}{1 - FC} - MFFC - \frac{MFFCsef \times WS}{1 - WS}}$$

Where FC and Y appear in the formula, a cyclical, iterative calculation was made with an IBM PS50 personal computer using the Lotus 1-2-3 spreadsheet, starting with approximate values of FC and Y.

## RESULTS AND DISCUSSION

### Casein Losses in Whey

To estimate the effect of an enzyme on yield, the additional amount of casein lost in whey must first be estimated. Compared with CR, most other enzymes produce higher levels of protein in whey due to greater hydrolysis of casein (8). The word "additional" is used to refer to casein, because casein is lost in whey with CR or chymosin. Casein content is equivalent, then, to that when making cheese from milk containing that much less casein.

Consideration was given first to using only whey released during cooking. Whey would represent about 90% of the weight of the milk when Cheddar cheese is made. Therefore, the difference in levels of protein in the whey, multiplied by the ratio of whey:milk, 90:100, would represent the additional amount of casein in the milk lost in the whey. The effective level of casein in the milk would then be the original level minus the amount lost in the whey on the basis of 100 kg of milk. This procedure would not be entirely satisfactory, because some enzymes, such as porcine pepsin, have little activity during cheddaring, because it is destroyed during cooking (9). Other more stable enzymes, such as *E. parasitica* (2) and chicken pepsin (10), are relatively more proteolytic during cheddaring (Whey II) than during cooking (Whey I), i.e., levels of N (as protein) in Whey I were higher with those enzymes than with CR, but even higher in Whey II.

All whey released during cheese making was considered and eventually used. Unpublished data showed that Whey I represented 83% of the original milk and starter, Whey II, 6%, and cheddared curd, 11%. Assuming a yield of 10% of cheese, one can extrapolate Whey II to represent 7% of the weight of milk. For the purpose of calculations, yields of Wheys I and II are assumed to be 83 and 7% of the weight of the milk.

Table 1 shows the method of estimating the additional amount of protein lost in the whey and the conversion of the additional loss associ-

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