Study of the process of transition of milk fat to whey at various stages of cheese production

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Abstract. The article analyzes the factors affecting the fat content in whey in the production of various cheeses and cottage cheese. The dependence of whey fat content on the fat mass con-centration in the dry matter of cheese was obtained. A study of the fat content and fat globules dispersed composition of cheese whey samples taken at different stages of cheese production was carried out.

1 Introduction

The production of protein dairy products, such as cheese and cottage cheese, occupies an important place in the processing of dairy raw materials. A distinctive feature of these processes is the formation of a significant amount of whey (70 ... 75% of the amount of original milk).

The properties of whey, as a heterogeneous system, depend both on the type of whey (curd or cheese whey), the content of solids in it, as well as on the original technology for obtaining a protein product, mainly the fat content of the mixture for the production of cottage cheese or cheese and the technology for subsequent processing of whey, associated primarily with the coagulation of proteins.

The first aspect influences the formation of the fat dispersed phase, the second one effect on characteristics of the protein-dispersed phase, and their combination ultimately makes it possible to obtain disperse systems that are excellent both in composition and in properties.

The production of cheese and fatty cottage cheese is accompanied by destabilization of the fatty phase of milk and its transition to whey with the formation of a dispersed system "milk fat - plasma".

Milk fat occupies only about 5% in the dry matter of whey, but plays a significant role in industrial processing processes, i.e. indirectly through phospholipids, lipoproteins, and even fat-sugar [1].

As a rule, all the resulting whey is directed to defatting. Our studies allow us to conclude that a differentiated approach to this process is expedient.

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2 Materials and methods

The object of the study was cheese whey obtained at different stages of the production of cheese called "Stolovy".

The acid method [2] with special butyrometers with measuring range 0 … 0.5% for low-fat products was used to determine whey fat.

Microscopic studies were carried out according to the generally accepted technique with digital microphotography (scanning) with visual counting of particles by size classes.

Serum samples were placed in a Goryaevs chamber and held for about 30 minutes for the fat globules to float.

The following size classes were used: less than 1 μm; 1 ... 2 μm; 2 ... 3 μm; 3 ... 4 μm; 5 ... 6 μm; more than 6 microns.

To obtain a countable distribution of fat globules in serum, the frequency (empirical probability) of distributions was calculated.

3 Results

Milk fat in whey, on the one hand, can be considered as a natural dispersed phase, since the same dispersed phase is also present in the previous whey product – milk (standardized mixture for manufacturing cheese or cottage cheese).

On the other hand, the results of studies of fat dispersity in whey, given below, clearly indicate that the formation of a light dispersed phase in whey is not only the transfer of a portion of small fat globules from milk (mixture) to whey.

Most likely, it can be assumed that the proportion of such fat globules does not prevail, and some of them are newly formed small fat globules due to the crushing of large ones. Vice versa, it is also quite possible, that larger fat clusters are particles formed by combining small fat globules.

Moreover, the last statement is confirmed by studies on the emulsification of milk fat in whey, buttermilk and skim milk and the analysis of cream settling in these products [2].

The resulting emulsion based on whey used as a dispersion medium is less stable than the emulsion obtained on skimmed milk and especially on buttermilk.

Nevertheless, these experiments confirmed the formation of protein shells on the surface of fat globules directly in whey.

A number of factors influence the transition of fat into whey. One of the most valuable factors, which should be considered, is the fat content of standardized milk intended for the production of cheese or cottage cheese.

We have obtained the dependence of whey fat content on the fat content in the dry matter of cheese which has the form of equation:

$$F_{Whey} = 0.007 F_{Dm} - 0.016 \quad (1)$$

Where F_{Whey} is whey fat content, %; F_{Dm} is fat content in the dry matter of cheese, %.

Dependence (1) is linear and can be applied for prediction the fat content in whey originated from the production of certain cheeses.

Studies [4] confirm that fat content of cheese whey obtained from standardized homogenized milk intended for the production of cheese is reduced in comparison with whey produced from non-homogenized milk.

The same result was obtained in the manufacturing of Roquefort cheese and suluguni cheese with use of non-homogenized milk, while fat content of whey was 0.5% [5], and 0.35% [6] respectively.

Application of separate milk homogenization is also can acts on fat mass concentration in whey. However, the effect of the fat content of whey reducing is observed only when two-stage homogenization of cream is carried out.

Such an effect can be achieved only in a one-stage separation process with a fat content of the resulting cheese cream of no more than 20% [4].

According to a number of researchers, the fat content in cheese whey depends on the duration of clot cutting. In this case, the fat content, according to the data obtained in [7], can be both minimal (0.2% for timely cutting) and maximum (0.5% for cutting unfinished cottage cheese).

It was also established [8] that the smallest transition of fat and protein into whey is observed during the cheese coagulum cutting after a time interval equal to twice the clotting time to the gel point of the rennet clotting process.

A greater amount of fat and solids passes into the whey, if cutting the curd carried out untimely. On the other hand, cutting of overripe coagulum reduces the transition of solids into the whey, but the fat content of the whey increases.

An increased transition of fat into whey also occurs at an elevated temperature of rennet fermentation [9].

The fat content of curd whey is usually minimal in the samples, taken from cheese-making vat, but significantly higher in the whey separated during pressing (self-pressing) [10].

The fat content of milk whey is affected by the heating temperature of the initial milk in the coagulator, for example, in the production of cottage cheese by the so-called method of protein coagulation in the flow [11].

The foregoing makes it possible to judge that the formation of the dispersed composition of milk fat in whey at different stages of the production of cheese or cottage cheese occurs in different ways.

This fact is quite accurately confirmed by the following studies of the transition of milk fat to whey during the production of rennet cheese.

The samples of cheese whey selected at different stages of the technological process of table cheese production were subjected to research.

It was determined that both the content of fat in whey and its dispersity are not constant for the entire course of the technological process.

Since all the whey is usually fed to the separation, it is necessary to clarify the role of the main cheese manufacturing operations in the formation of the fatty dispersed phase.

The results of measuring the content of milk fat in cheese whey samples are presented in the diagram (Figure 1).

For a more complete analysis of the ongoing process, a qualitative assessment of fat globules as a dispersed phase was carried out.

A qualitative assessment of this dispersed phase was carried out by counting of fat globules by size classes in addition to the quantitative determination of whey fat content at different stages of the technological process of cheese manufacturing.

The resulting integral curves of fat globules countable distribution are shown in Figure 2.

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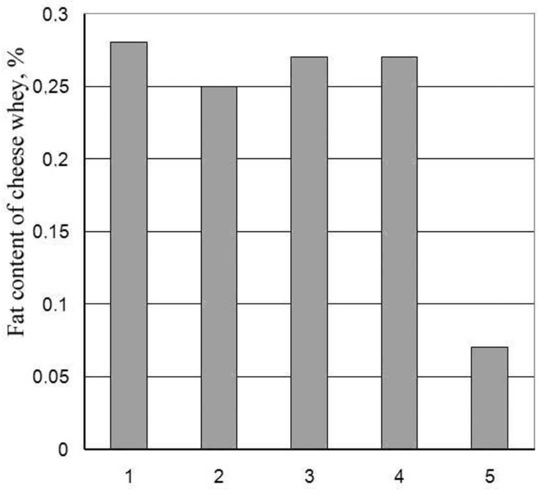

Fig. 1. Diagram of changes in the fat content of cheese whey samples taken at different stages of the technological process: 1 – from the cheese vat after cutting the curd; 2 – from the vat after the cheese grain formation; 3 – from the vat after the curd scalding; 4 – from a horizontal molding machine; 5 – from a vertical press.

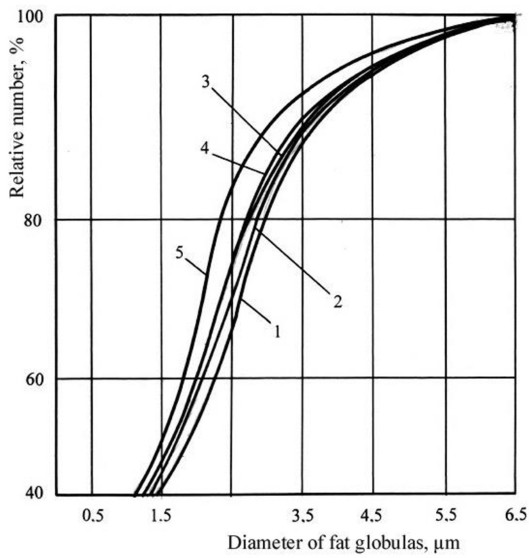

Fig. 2. Integral curves of the countable distribution of fat globules in cheese whey, selected: 1 – from the cheese vat after cutting the curd; 2 – from the vat after the cheese grain formation; 3 – from the vat after the curd scalding; 4 – from a horizontal molding machine; 5 – from a vertical press.

4 Discussion

The average fat content of whey taken from the cheese vat immediately after the curd cutting was equal to 0.28 per cent, but after the cheese grain formation, this value decreased to 0.25 per cent. This fact indicates that the “fat – whey” disperse system is formed already at the initiatory stage of milk separation into coagulum and whey.

The formation of the cheese grain is characterized by the release of whey from the protein particles with a lower fat content.

The scalding gave in some cases a decrease in the fat content of the samples, and in another cases an increase of this parameter values in comparison with the mass concentration of fat in the whey after the grain formation.

The decrease in the fat content of whey during the curd scalding confirms the pattern according to which, during the cheese grain processing the whey released from it contains less and less fat and impoverishes the entire mass of whey.

On the other hand, the increase in whey fat content during the scalding can be explained by increased mechanical stress on the grain, combined with a slow heating rate, the main factors that increase fat loss.

Therefore, opposite results can be obtained during the same technological operation carrying out. In some experiments, the fat content decreased to a level of 0.22 per cent and in other experiments it increased to 0.29 per cent. A similar phenomenon was observed after draining the grain with whey into the molding machine.

A small amount of whey is released from the cheese wheels during their pressing. The study of this whey composition showed that it is characterized by the lowest fat concentration. The average fat content of the samples was equal to 0.07 per cent.

The expediency of such type of whey separating should be determined already taking into account the costs of this process.

Figure 2 shows that the dispersed composition of fat in whey during the technological process of cheese manufacturing changes in the direction of small fat globules content increasing. Fat globules with a diameter of up to 2 μm make up 44.25 per cent immediately after the curd cutting, then after the end of the cheese grain formation (whey sample from the molding machine), their number was already 47.55 per cent.

The whey released during the pressing of the cheese wheels is characterized by noticeably higher dispersity in comparison with other samples. This phenomenon is apparently due to the transition into this whey of small fat globules still remaining in the grain.

When calculating the process of whey skimming, the minimum separable diameter of the fat globule should be taken as 1 μm. In the case of centrifugal separation of fat globules with a diameter of 1 micron or more, the residual amount of fat in the serum will not exceed 0.01%.

In this case, it is not advisable to separate the whey obtained by pressing.

To isolate fat and casein particles from whey, it is most advisable to use special separators of a combined type (separator-clarifier) with centrifugal periodic discharge of sediment.

The conducted research of the whey separation process made it possible to determine the separation parameters, namely the temperature of the initial product depending on the fat content in it: 0.4 % – 30 ºC; 0.5 % – 35 ºC; 0.6 % – 50 ºC [12].

5 Conclusion

The conducted studies allow us to conclude that it is expedient to separate portions of whey obtained at various stages of cheese production, primarily obtained during the pressing process. Whereas the whey obtained at the stages preceding the pressing, it is advisable to degrease.

This will allow, in addition, to correctly choose the rational parameters of the degreasing process, first of all, the productivity of the separator.

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