Determination of critical control points of the technological process for the production of whipped frozen fruit and berry dessert from milk whey

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Abstract. The use of whey in the manufacture of food products is among the important areas of using milk as a raw material. Milk whey has a fairly high biological and nutritional value. It contains about 50% of all nutrients that are in milk. When manufacturing any product, it is necessary to take into account all possible hazards that can change the characteristics of the product and, subsequently, harm a person. HACCP is the implementation of a regular approach to ensuring the safety of manufactured products. The purpose of our research is to determine the critical control points of the production process "Frozen whipped fruit and berry dessert from whey". As a result of the research, it was revealed that in the technological process of the production of whipped frozen fruit and berry dessert from whey, there are four critical control points: KKT1 - pasteurization, KKT2 - cooling and temporary storage, KKT3 - adding fruit and berry filler, citric acid, KKT4 - packaging, hardening, packaging.

1. Introduction

The dairy industry is an important branch of the food industry in the Russian Federation. It includes various sub-sectors that specialize in the manufacture of a particular dairy product from milk [1-6]. The latest developments from dairy raw materials are constantly being introduced into production, after the optimization of technological processes [7-12].

The use of whey in the manufacture of food products is among the important areas of using milk as a raw material [13-15]. This direction turned out to be little studied on the territory of our country. At the same time, up to 80% of whey in the Russian Federation is currently not subjected to any processing. It should also be borne in mind that when draining the whey into the sewer network, great harm to the environment is caused. At the same time, it turns out that enterprises, as a result, receive less of their profit, which they could get in the case of the manufacture of a particular product based on whey. Milk whey has a fairly high biological and nutritional value. It contains about 50% of all nutrients that are in
milk. Its energy value is provided largely due to its high lactose content, which is 36% of the level of whole milk. Whey proteins, which are abundant in whey, are well balanced in terms of the composition of amino acids, primarily sulfur-containing ones. Among them, methionine and cysteine should be noted. As a result, there is a real possibility of regenerating liver proteins, improving the amount of hemoglobin in the blood and increasing the level of proteins. Whey contains mineral salts that are almost the same as whole milk salts. They have special "protective" complexes with anti-sclerotic effects. The loss of whey ultimately leads to a decrease in the efficiency of milk processing. Nowadays, various methods of whey processing are known: drying, concentration, obtaining various useful components from it, synthesis of useful substances, etc. As a result, the resulting products can be used in the future to make various food products, create feed and feed additives for farm animals and birds [16-22].

One of the main directions of the dairy industry is the production of ice cream. When manufacturing any product, it is necessary to take into account all possible hazards that can change the characteristics of the product and, subsequently, harm a person [23-29]. Now, based on the currently existing concept of quality management, it is taken into account that the implementation of product quality control should be carried out within the framework of the production process, and not at its completion. This concept is answered by a system based on the principles of HACCP.

HACCP is the implementation of a regular approach to ensuring the safety of manufactured products. At the heart of this is various real possibilities for preventing certain risks that may arise. The abbreviation translated from English means the analysis of the existing risks and the definition of existing critical control points.

The purpose of our research is to determine the critical control points of the production process of whipped frozen fruit and berry dessert from milk whey.

2. Material and methods
Frozen whipped fruit and berry dessert is produced according to the traditional technology of ice cream production.

The difference in production technology lies in the constituent components. First of all, caramel syrup, stabilizer, sugar (at the stage of preparation and mixing of raw materials) are added to the whey. Citric acid and fruit and berry fillers are added after cooling the prepared mixture to the milling stage.

Dessert composition: milk serum, granulated sugar, caramel treacle, fruit and berry filler with pieces of fruit and berries, stabilizer "Palsgaard 811", lemon acid.

3. Results and discussion
A hazard assessment is carried out in relation to the identified product hazard. This allows you to detect the need for the obligation to eliminate the hazard, or to reduce it. In addition, it is ultimately possible to determine the control measures that are required to achieve the appropriate hazard level. Any hazard is assessed taking into account the severity of possible adverse consequences that can be caused to human health. It is envisaged to apply the scoring in accordance with the matrix of the significance of existing hazards.

Hazard severity: Insignificant - nothing more than a mild poisoning that does not lead to illness; Moderate - food contamination leads to mild illness; Critical - food contamination leads to serious illness; Catastrophic - food contamination is fatal.

Probability of danger: Unlikely - very rare; Rarely; Periodically - from time to time; Probably - happens several times; Often - according to historical data, production occurs frequently.

In the production of dairy products, the following types of risks occur: microbiological, chemical and physical.

Possible hazardous factors at all stages of the technological process of dessert production are presented in table 1.
Table 1. Potential hazards at the stages of the technological process.

| Stage of the technological process                                      | Hazard factor                                      |
|-------------------------------------------------------------------------|----------------------------------------------------|
| Acceptance of raw materials, auxiliary equipment and packaging; quality control | Microbiological, physical, chemical |
| Adding and mixing of components                                          | Microbiological, physical, chemical |
| Pasteurization                                                           | Microbiological, physical, chemical |
| Filtration                                                              | Physical, chemical                                 |
| Homogenization                                                           | Physical, chemical                                 |
| Refrigeration, temporary storage                                         | Microbiological, physical, chemical |
| Adding fruit and berry filler, citric acid                               | Microbiological, physical, chemical |
| Milling                                                                  | Physical, chemical                                 |
| Packing, hardening, packaging storage                                    | Microbiological, physical, chemical |
| Storage                                                                  | Physical                                           |

This step is important in practice for the purpose of determining the points as well as the procedures in which the control can be used. In the future, as a result, it is possible to prevent the occurrence of one or another dangerous factor in advance, or eliminate it, if it already exists. A critical control point is any stage directly related to the occurrence of a hazard and the possibility of its prevention. In this case, the total number of critical control points is determined in practice by the variety of products produced, the complexity of the production process carried out, which fall into the scope of the analysis.

The selection of critical control points of the dessert production process is carried out by the "decision tree" method, presented in figure 1.

![Figure 1. Decision tree for production steps.](image_url)
Description of the identification and establishment of critical control points (matrix of significance and analysis of possible risks) is presented in tables 2-11.

**Table 2.** Significance matrix, analysis of possible risks when accepting whey, raw materials.

| Factor                      | Severity | Probability | Significance | Decision tree |
|-----------------------------|----------|-------------|--------------|---------------|
|                             | B1       | B2          | B3           | B4            | №            |
| **1 Chemical:**             |          |             |              |               | KKT           |
| - washing, disinfecting     | 2        | 2           | No           | No            | – a           |
| facilities;                 |          |             |              |               | –             |
| - microtoxins;              | 3        | 1           | Yes          | Yes           | No            |
| - pesticides;               | 3        | 1           | Yes          | Yes           | No            |
| - radionuclides;            | 3        | 1           | Yes          | No            | No            |
| - heavy metals;             | 2        | 1           | No           | –             | –             |
| - allergens.                | 2        | 2           | No           | –             | –             |
| **2 Physical:**             |          |             |              |               |               |
| - staff;                    | 2        | 1           | No           | Yes           | –             |
| - fragments of rubber seals | 2        | 1           | No           | No            | –             |
| - fragments of lavsan bags; | 2        | 2           | No           | No            | –             |
| - pests.                    | 2        | 1           | No           | Yes           | –             |
| **3 Microbiological:**      |          |             |              |               |               |
| - BGKP;                     | 3        | 3           | Yes          | Yes           | No            |
| - yeast, mold;              | 3        | 3           | Yes          | Yes           | No            |
| - staphylococcus;           | 3        | 1           | Yes          | Yes           | No            |
| - salmonella.               | 4        | 1           | Yes          | Yes           | No            |

*a* Skipping a stage.

According to table 2, it can be seen that at the stage of acceptance of whey and raw materials, critical control points are not defined and not established.

**Table 3.** Significance matrix, analysis of possible risks at the stage of introducing and mixing raw materials.

| Factor                      | Severity | Probability | Significance | Decision tree |
|-----------------------------|----------|-------------|--------------|---------------|
|                             | B1       | B2          | B3           | B4            | №            |
| **1 Chemical:**             |          |             |              |               | KKT           |
| - washing, disinfecting     | 2        | 2           | No           | Yes           | –             |
| disinfecting facilities;    |          |             |              |               | –             |
| - allergens.                |          |             |              |               | –             |
| **2 Physical:**             |          |             |              |               |               |
| - plastic;                  | 4        | 2           | Yes          | Yes           | No            |
| - staff;                    | 2        | 1           | No           | –             | –             |
| - paper packaging materials;| 2        | 1           | No           | Yes           | –             |
| - pests.                    |          |             |              |               | –             |
| **3 Microbiological:**      |          |             |              |               |               |
| - BGKP;                     | 3        | 3           | Yes          | Yes           | No            |
| - staphylococcus;           | 3        | 1           | Yes          | Yes           | No            |
| - salmonella.               | 4        | 1           | Yes          | Yes           | No            |

According to table 3, it can be seen that at the stage of introducing and mixing raw materials, critical control points are not defined and not established.
Table 4. Significance matrix, analysis of possible risks during pasteurization.

| Factor                  | Severity | Probability | Significance | Decision tree | № KKT |
|-------------------------|----------|-------------|--------------|---------------|-------|
|                         |          |             |              | B1  B2  B3  B4 |       |
| 1 Chemical:             |          |             |              |               |       |
| Washing, disinfecting   | 2        | 2           | No           | No            | –\(^a\) – – – |
| facilities.             |          |             |              |               |       |
| 2 Physical:             |          |             |              |               |       |
| Fragments of rubber     | 2        | 1           | No           | No            | – – – –   |
| seals.                  |          |             |              |               |       |
| 3 Microbiological:      |          |             |              |               |       |
| BGKP;                   | 3        | 3           | Yes          | Yes           | Yes Yes No KKT 1.1 |
| KMAFanM                 | 3        | 3           | Yes          | Yes           | Yes Yes No KKT 1.2 |

\(^a\) Skipping a stage.

According to table 4, it can be seen that at the stage of pasteurization of the mixture, the critical control points are determined and set as KKT 1 for the microbiological hazard.

Table 5. Significance matrix, analysis of possible risks at the stage of mixture filtration.

| Factor                  | Severity | Probability | Significance | Decision tree | № KKT |
|-------------------------|----------|-------------|--------------|---------------|-------|
|                         |          |             |              | B1  B2  B3  B4 |       |
| 1 Chemical:             |          |             |              |               |       |
| Washing, disinfecting   | 2        | 2           | No           | No            | –\(^a\) – – – |
| facilities.             |          |             |              |               |       |
| 2 Physical:             |          |             |              |               |       |
| Fragments of rubber     | 2        | 1           | No           | No            | – – – –   |
| seals.                  |          |             |              |               |       |

\(^a\) Skipping a stage.

According to the data in Table 5, it can be seen that at the stage of filtering the mixture, the critical control points are not defined and not established.

Table 6. Significance matrix, analysis of possible risks during homogenization of the mixture.

| Factor                  | Severity | Probability | Significance | Decision tree | № KKT |
|-------------------------|----------|-------------|--------------|---------------|-------|
|                         |          |             |              | B1  B2  B3  B4 |       |
| 1 Chemical:             |          |             |              |               |       |
| Washing, disinfecting   | 2        | 2           | No           | No            | –\(^a\) – – – |
| facilities.             |          |             |              |               |       |
| 2 Physical:             |          |             |              |               |       |
| Fragments of rubber     | 2        | 1           | No           | No            | – – – –   |
| seals.                  |          |             |              |               |       |

\(^a\) Skipping a stage.

According to the data in Table 6, it can be seen that at the stage of homogenization of the mixture, the critical control points are not defined and not established.

Table 7. Significance matrix, analysis of possible risks during cooling and temporary storage of the mixture.

| Factor                  | Severity | Probability | Significance | Decision tree | № KKT |
|-------------------------|----------|-------------|--------------|---------------|-------|
|                         |          |             |              | B1  B2  B3  B4 |       |
| 1 Chemical:             |          |             |              |               |       |
| Washing, disinfecting   | 2        | 2           | No           | No            | –\(^a\) – – – |
| facilities.             |          |             |              |               |       |

\(^a\) Skipping a stage.
2 Physical:

| Factor               | Severity | Probability | Significance | Decision tree | № KKT |
|----------------------|----------|-------------|--------------|---------------|-------|
| fragments of rubber seals; pests. | 2        | 1           | No           | No            | –     |
|                      | 2        | 1           | No           | No            | –     |

3 Microbiological:

| Factor               | Severity | Probability | Significance | Decision tree | № KKT |
|----------------------|----------|-------------|--------------|---------------|-------|
| BGKP; yeast, mold.   | 3        | 3           | Yes          | Yes           | No    |
|                      | 3        | 3           | Yes          | Yes           | No    |

* Skipping a stage.

According to the data in Table 7, it can be seen that at the stage of cooling and temporary storage of the mixture, the critical control points are defined and set as KKT 2.

Table 8. Significance matrix, analysis of possible risks at the stage of adding fruit and berry filler and citric acid.

| Factor               | Severity | Probability | Significance | Decision tree | № KKT |
|----------------------|----------|-------------|--------------|---------------|-------|
| 1 Chemical: washing, disinfecting facilities; Allergens. | 2        | 2           | No           | No            | –     |
|                      | 2        | 1           | No           | No            | –     |

2 Physical:

| Factor               | Severity | Probability | Significance | Decision tree | № KKT |
|----------------------|----------|-------------|--------------|---------------|-------|
| Plastic; Staff; Paper packaging materials; Pests. | 4        | 2           | Yes          | Yes           | Yes   |
|                      | 2        | 1           | No           | No            | –     |

3 Microbiological:

| Factor               | Severity | Probability | Significance | Decision tree | № KKT |
|----------------------|----------|-------------|--------------|---------------|-------|
| BGKP; Staphylococcus; Salmonella. | 3        | 3           | Yes          | Yes           | No    |
|                      | 3        | 1           | Yes          | Yes           | No    |
|                      | 4        | 1           | Yes          | Yes           | No    |

* Skipping a stage.

According to table 8, it can be seen that at the stage of adding fruit and berry filler and citric acid, the critical control points are determined and set as KKT 3.

Table 9. Significance matrix, analysis of possible risks at the milling stage (* Skipping a stage).

| Factor               | Severity | Probability | Significance | Decision tree | № KKT |
|----------------------|----------|-------------|--------------|---------------|-------|
| 1 Chemical: washing, disinfecting facilities. | 2        | 2           | No           | No            | –     |

2 Physical:

| Factor               | Severity | Probability | Significance | Decision tree | № KKT |
|----------------------|----------|-------------|--------------|---------------|-------|
| fragments of rubber seals. | 2        | 1           | No           | No            | –     |

According to the data in table 9, it can be seen that at the stage of milling the mixture, the critical control points are not defined and not established.
Table 10. Significance matrix, analysis of possible risks at the stage of filling, hardening and packaging.

| Factor                      | Severity | Probability | Significance | Decision tree | № KKT |
|-----------------------------|----------|-------------|--------------|---------------|-------|
|                             |          |             |              | B1  | B2  | B3  | B4  |
| 1 Chemical:                 |          |             |              |                |      |
| washing, disinfecting       | 2        | 2           | No           | No            | –    | –   | –   | –   |
| facilities                 |          |             |              |                |      |
| 2 Physical:                 |          |             |              |                |      |
| plastic;                   | 4        | 2           | Yes          | Yes           | Yes  | –   | –   | –   |
| staff;                     | 2        | 1           | No           | No            | –    | –   | –   | –   |
| paper packaging materials; | 2        | 1           | No           | No            | –    | –   | –   | –   |
| pests;                     | 2        | 1           | No           | No            | –    | –   | –   | –   |
| bones, branches from fillers. | 3      | 2           | Yes          | No            | No   | –   | –   | –   |
| 3 Microbiological:          |          |             |              |                |      |
| BGKP;                      | 3        | 3           | Yes          | Yes           | No   | Yes | No  | No  |
| staphylococcus;            | 3        | 1           | Yes          | Yes           | No   | Yes | No  | No  |
| salmonella;                | 4        | 1           | Yes          | Yes           | No   | Yes | No  | No  |
| yeast, mold.               | 3        | 3           | Yes          | Yes           | No   | Yes | No  | No  |

* Skipping a stage

According to table 10, it can be seen that at the stage of filling, hardening and packaging, critical control points are defined and set as KKT 4.

Table 11. Significance matrix, analysis of possible risks when storing dessert.

| Factor                | Severity | Probability | Significance | Decision tree | № KKT |
|-----------------------|----------|-------------|--------------|---------------|-------|
|                       |          |             |              | B1  | B2  | B3  | B4  |
| Physical:             |          |             |              |                |      |
| Pests                 | 2        | 1           | No           | Yes           | –    | –   | –   | –   |

According to the data in Table 11, it can be seen that at the stage of storing the dessert, critical control points are not defined and not established.

4. Conclusion

Thus, in the technological process of the production of whipped frozen fruit and berry dessert from whey, we have identified four critical control points: KKT1 - pasteurization, KKT2 - cooling and temporary storage, KKT3 - adding fruit and berry filler, citric acid, KKT4 - packing, hardening packing.

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