Application of statistical methods for quality control of agro-industrial production processes

G N Temasova1, O A Leonov, N Zh Shkaruba, Yu G Vergazova and D I Petrovskiy

Department of Metrology, Standardization and Quality Management, Russian State Agrarian University - Moscow Timiryazev Agricultural Academy, Moscow, Russia

1E-mail: temasova@rgau-msha.ru

Abstract. The article deals with the mechanism of quality control of agro-industrial production processes, namely, quality control of poultry farm processes. It also details the management of nonconforming products using simple quality control and management tools – a checklist and a Pareto chart. It was suggested that a checklist should be used to record nonconformities and their number for each nonconformity. Using this checklist form will allow you to analyze the production process, identify the causes of nonconformities, and quickly intervene in the process to prevent nonconformities from occurring. To analyze the inconsistencies and the causes of their occurrence, it was suggested to use the Pareto diagram, the use of which allows you to pay attention to the most significant problems.

1. Introduction

The quality of products and services in a market economy plays a crucial role in determining the competitiveness of the enterprise as a whole and products and services in particular [1]. Therefore, today much attention is paid to the quality of products and services, fundamentally new requirements are imposed, which is ensured by the development of programs to improve the quality and improve the management system [2]. In this regard, research in the field of improving the management system in the food industry is very relevant.

The quality of products and services directly depends on the quality of management, so the study and implementation of quality improvement programs affects not only the quality of products and services, but also the quality of management itself [3].

Quality is the main factor of competitiveness, which determines the direct relationship between quality and production efficiency [4]. Improving quality always contributes to improving production efficiency, which leads to lower costs and an increase in market share [5, 6]. But not always in the production of products [7, 8], we have the quality that meets the requirements, since in any production there is the possibility of inconsistencies [9]. To work with nonconforming products, the company develops the organization's standard "Nonconforming Product Management", which includes the following processes: Management of nonconforming products identified during the input control process; Management of nonconforming products identified during the production process.
2. Management of nonconforming products identified during the input control process

Management of nonconforming products identified during the input control process consists in the input control of products in accordance with the requirements of the organization's standard for input control.

When identifying nonconforming products, the commission draws up a Protocol in any form. The report indicates the quantity of nonconforming products and their characteristics.

Identification of nonconforming products in the warehouse is carried out by the veterinarian who conducted the entrance control of the products by comparing the product details specified in the act with the labeling and accompanying documents for the products.

Nonconforming products are moved to a designated place in the warehouse or placed on racks marked with paint "nonconforming products".

The warehouse manager is responsible for separating and isolating nonconforming products.

On the basis of the results (examination) by the state laboratory, the assessment of nonconforming products for making a decision on the possibility of its use is carried out by the established commission appointed by the General Director to initiate the withdrawal of products.

All defective products are marked with the label "Defective", which is attached to each package of products from the defective batch or attached to the product in any convenient way in a visible place that allows you to identify the isolated batch of products as defective, and is moved to the waste isolation unit or to a designated place until a decision is made.

Rejected products are subject to reclamation and return to the product supplier.

Copies of the Marriage Certificate and the act of complaint are sent to the accounting department of the Organization (for sending documents to the supplier of rejected products) for the organization of the complaint work, technical accounting of the marriage and evaluation of suppliers in accordance with the procurement regulations. Buyers are notified of dangerous products and withdraw them from sale.

3. Management of nonconforming products identified in the production process

Management of nonconforming products identified in the production process consists in identifying nonconforming products, and their identification is carried out based on the results of production control by comparing the actual values of the controlled product quality indicators with the established requirements. Production control is carried out in the form of technological and laboratory control of the parameters of technological processes and product characteristics in accordance with the requirements of the technological documentation for the manufacture of products.

The objects of control, the controlled parameters and characteristics of the parameters, methods and means of control, the frequency of control, as well as the personnel performing the control, are specified in the production process instructions, control cards and regulations.

Measures for the elimination of correctable defects and the types of defects that lead to the disposal of products are given in the Annex to the standard "Management of non-conforming products".

During the production process, the identified correctable defect is eliminated, and the identified incorrigible defect is sent for disposal.

Registration of product nonconformities is most often carried out with the help of checklists – quality management tools. We analyzed the forms of control sheets for registering nonconformities in the egg assembly shop of poultry farms and came to the conclusion that two forms are currently used: the first-for registering nonconformities, the second-for registering types of nonconformities. This is not very convenient. So we developed a checklist form that combined the two previous ones. Our proposed control sheet of the finished product is shown in table 1.

When different types of inconsistencies are possible when checking objects, it is advisable to use a checklist of this form. But from a cull point of view, it doesn't matter what the reason is for the products being rejected. Therefore, in most cases, poultry farms report only on the units of defective products. However, data on the types of nonconformities is very important for managing production and preventing the risk of repeated defects. Since this information is then used in the analysis of the production process, which allows you to identify the causes of nonconformities and to intervene in the process in time to prevent the occurrence of nonconformities.
**Table 1. Checklist for registering nonconformities.**

| Products       | Chicken egg | Egg assembly shop |
|----------------|-------------|-------------------|
| Collector      | Petrov N I  | Controller Smirnova E P |
| Process control map | Egg assembly shop | March 21, 2021 |

| Type of discrepancy   | Control result | Number of inconsistencies | Percentage of nonconformities |
|-----------------------|----------------|--------------------------|-------------------------------|
| Contaminated shell    |                | 45                       | 35.71                         |
| The presence of spots on the shell |        | 17                       | 13.49                         |
| The presence of spots under the shell |        | 23                       | 18.25                         |
| The color of the shell has signs of staleness | \ | 2                       | 1.59                          |
| Recess with signs of leakage |        | 29                       | 23.02                         |
| Foreign smell         | \           | 3                        | 2.38                          |
| Other                 | \           | 7                        | 5.56                          |
| **Total inconsistencies** | 126          | **100.00**               |                               |
| Total number of rejected products | 37           | -                        |                               |
| Total number of controlled products | 350          | -                        |                               |

In table 1 shows a completed checklist for quality control of the finished product-a chicken egg. The checklist shows that the most common mismatch is a dirty shell, but for further analysis, it is better to build a Pareto diagram (figure 1).

The Pareto diagram will allow you to analyze inconsistencies and understand the reasons for their occurrence [10].

To build a Pareto diagram, you need to create a form based on the data from the checklist (table 2), in which the factors are sorted in descending order of significance (except for the "Other" factor, which is entered last), the accumulated number of defects and the corresponding accumulated percentage are calculated.

The Pareto diagram shows that about 80% of defects are the first three types of nonconformities. It is on the elimination of these inconsistencies that special attention should be paid. The next step may be to analyze the causes of nonconformities using appropriate quality control and management tools.

**Table 2. A form for constructing a Pareto diagram for analyzing the types of inconsistencies.**

| Type of discrepancy              | Quantity | Accumulated quantity | Percentage of nonconformities | Accumulated interest |
|----------------------------------|----------|-----------------------|-------------------------------|----------------------|
| Contaminated shell               | 45       | 45                    | 35.71                         | 35.71                |
| Recess with signs of leakage     | 29       | 74                    | 23.02                         | 58.73                |
| The presence of spots under the shell | 23    | 97                    | 18.25                         | 76.98                |
| The presence of spots on the shell | 17    | 114                   | 13.49                         | 90.48                |
| Foreign smell                    | 3        | 117                   | 2.38                          | 92.86                |
The color of the shell has signs of staleness

| Nonconformity                        | Count | Percentage |
|--------------------------------------|-------|------------|
| The color of the shell has signs of staleness | 2     | 1.59%      |
| Other                                | 7     | 5.56%      |
| Contaminated shell                    | 119   | 94.44%     |
| The presence of spots under the shell | 126   | 100.00%    |
| Foreign smell                        | 30    |            |
| The color of the shell has signs of staleness | 90    |            |

Figure 1. Pareto diagram for nonconformity analysis.

4. Conclusion
Thus, if nonconforming products are detected during the entrance control, the commission draws up an act, the nonconforming products are moved to a specially designated place, subject to appeal and return to the supplier. Management of nonconforming products identified during the production process consists in identifying nonconforming products, and their identification is carried out based on the results of production control by comparing the actual values of the controlled product quality indicators with the established requirements. During the production process, the identified correctable defect is eliminated, and the identified incorrigible defect is sent for disposal. Product nonconformities are recorded using checklists, and nonconformities and their causes are analyzed using a Pareto diagram.

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