Chapter 4

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ANALYSIS AND QUALITY IMPROVEMENT IN THE DAIRY PRODUCTS MANUFACTURING COMPANY

Abstract: In the chapter the company, operating in the dairy industry and engaged in the production of cottage cheeses, ripened cheese and cream, was presented. The object of the research, Mozzarella cheese, was also presented. In the research part the quality analysis of with use of the Pareto-Lorenz diagram and FMEA method, showing nonconformities in the production process of the Mozzarella cheese, was conducted, with use of the Ishikawa diagram groups of reasons that may contribute to the improvement of the production process of the Mozzarella cheese, were identified.

Key words: dairy products, Ishikawa diagram, Pareto-Lorenz diagram , FMEA method

4.1. Characteristics of subject and object of the research

The production-trade company, which was founded in 1991 and since then has been dealing with the processing of milk, is the research subject. With time, however, it changed the scope of the business. Currently, the company is engaged in production of dairy products such as cottage cheese, ripened cheeses and cream.

The objected of the research is a Mozzarella cheese, which originates from the south of Italy, from the Campania region - the city Aversa. Fresh mozzarella is generally white, but may vary seasonally to slightly yellow depending on the animal's diet. It is a semi-soft cheese. Mozzarella di bufala campana is a type of mozzarella made from the milk of Italian buffalo. Unlike other mozzarellas, 50% of whose production derives from non-Italian and often semi-coagulated milk, it holds the status

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of a protected designation of origin. Fior di latte (written also as one word) designates mozzarella made from cow milk, which greatly lowers its cost. Outside Italy "mozzarella" not clearly labelled as deriving from water buffalo can be presumed to derive from cow milk. Low-moisture part-skim mozzarella has a low galactose content, per some consumers' preference for cheese on pizza to have low or moderate browning. Mozzarella is available fresh or partly dried. Fresh it is usually rolled into a ball of 80 to 100 grams, or about 6 centimetres in diameter, sometimes up to 1 kilogram, or about 12 centimetres diameter, and soaked in salt water (brine) or whey, sometimes with citric acid added. Nutritional information per 100 g: energy 270 kcal, protein 17%, fat 36 - 38%, carbohydrates 0.5%. Higher the fat content of the cheese milk accelerates metabolism, which means that there are not formed fat stores in the body.

The research company for the production of Mozzarella cheese uses pasteurised milk and additives, such as:

- rennet in a liquid or powder,
- sourdough with pure cultures of bacterial strains,
- edible salt.

Raw milk, which is used for production of the mozzarella cheese, comes from farmers. The Mozzarella cheese is produced in the form of blocks in the shape of cuboids, blocks may be uneven, curved and rounded and moulded in the form of round. In Figure 4.1 the Mozzarella cheese is presented.

Fig. 4.1. Mozzarella cheese.

Source: materials from the research company

Mozzarella is produced from the milk. A whey starter is added from the previous batch that contains thermophilic bacteria, and the milk is left to ripen so the bacteria can multiply. Then, rennet is added to coagulate the milk. After coagulation, the curd is cut into large pieces, and left to sit so the curds firm up in a process known as healing.

After the curd heals, it is further cut into large pieces. The curds are stirred and heated to separate the curds from the whey. The whey is then drained from the curds and the curds are placed in a hoop to form a solid mass. The curd mass is left until the pH is at around 5.2-5.5, which is the point when the cheese can be stretched.

Transport packagings for the Mozzarella cheese are containers made of plastic, cartons or other packaging which ensure quality assurance for packing food and having certified by the National Institute of Hygiene.

Mozzarella cheese is stored in the warehouse of finished products at 1-8 ° C. Warehouses must fulfil all the conditions and requirements of sanitary - hygienic storage of dairy products determined by the health authorities.

4.2. Improvement of the manufacturing process of Mozzarella cheese using selected quality management tools

Ishikawa diagrams (also called fishbone diagrams, herringbone diagrams, cause-and-effect diagrams, or Fishikawa) are causal diagrams created by Kaoru Ishikawa (1968) that show the causes of a specific event. Common uses of the Ishikawa diagram (BORKOWSKI S. 2004., BORKOWSKI S. 2012., KONSTANCIAK M., JAGUSIAK-KOCIK M. 2012, HAMROL A. 1998, INGALDI M., ROSAK-SZYROCKA J., JAGUSIAK-KOCIK M. 2012) are product design and quality defect prevention, to identify potential factors causing an overall effect. Each cause or reason for imperfection is a source of variation. Causes are usually grouped into major categories to identify these sources of variation.

In the production process of the Mozzarella cheese both the properties of the raw material and process parameters play an important role.

Improvement of the production process can be carried out by key factors such as employees, their skills and commitment, the parameters of the equipment and machinery used in the process, work organization system, materials and raw materials used for production, methods supporting production process and the measurement of the basic parameters of the production process. The Ishikawa diagram for the improvement of the production process of Mozzarella cheese is shown in Figure 4.2.

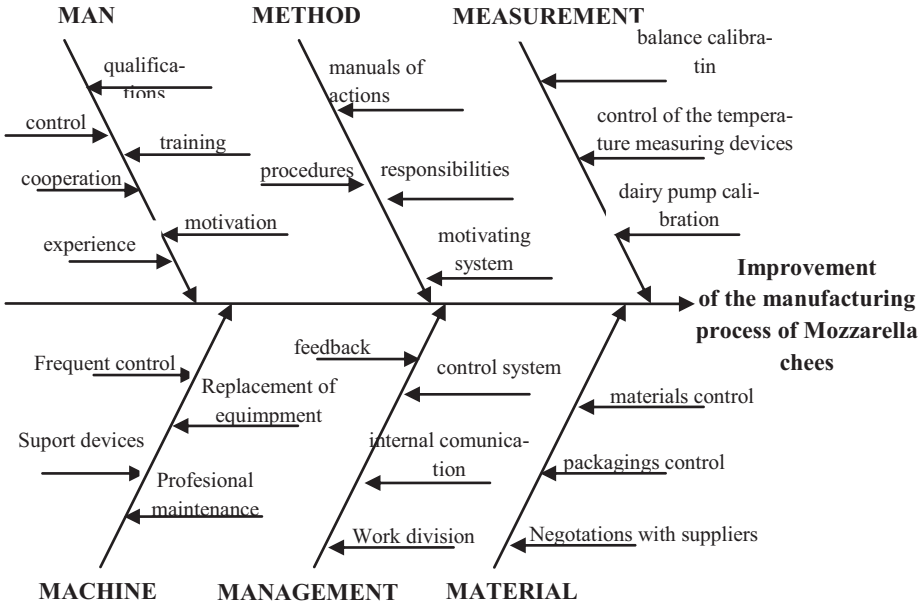

Fig. 4.2. Ishikawa diagram for the improvement of the production process of the Mozzarella cheese.

Source: own study

With the Ishikawa diagram any significant relationships, that exist between the different areas, can be indicated. They lead to the discovery of the source of the failure or malfunction of the process. This greatly

helps in ranking of causes. Use of the diagram allows for graphical analysis and emphasizes the hierarchical ranking of the collected data.

Diagram Pareto-Lorenz (also known as the ABC method, Pareto distribution, Pareto curve, Pareto-Lorenz curve or the 20-80 law) as the traditional management tool is used to improve processes and quality of products and services. It is based on regularities that typically 20-30% of the causes decide about 70-80% of the mistakes, problem. Thanks to this diagram it is possible to identify the most important features (causes, events) that have the most significant impact on the quality and then specify the actions which seek to improve the quality of processes or quality characteristics.

During the production process of the Mozzarella cheese, in the research period (3 months) the following nonconformities were found:

- N_1 - underestimated weight of package,
- N_2 - crookedly glued label,
- N_3 - improper marking labels,
- N_4 - no label,
- N_5 - improper consistency of cheese,
- N_6 - too high or too low salt content,
- N_7 - leaking package,
- N_8 - contamination of cheese,
- N_9 - wrong colour,
- N_{10}- no characteristic taste.

The listed nonconformities and their frequency in the research period are shown in Table 4.1.

Table 4.1. Nonconformity structure causes during production of the Mozzarella cheese in the research period

Denotation of cause	Name of the causes	Frequency of nonconformity (pc)
N_1	underestimated weight of package	142
N_2	crookedly glued label	15
N_3	improper marking labels	44
N_4	no label	21
N_5	improper consistency of cheese	8
N_6	too high or too low salt content	28
N_7	leaking package	158
N_8	contamination of cheese	7
N_9	wrong colour	4
N_{10}	no characteristic taste	1

Source: own study

The causes of nonconformities occurring during the research period in the research period were ranked according to their frequency. Percentage fraction and cumulated percentage of these causes are shown in Table 4.2.

Table 4.2. The ranking of the nonconformity causes occurring during production of the Mozzarella cheese in the research period according to their frequency

Denotation of cause	Name of the causes	Percentage fraction	Cumulated percentage
N_7	leaking package	36.92	36.92
N_1	underestimated weight of package	33.18	70.09
N_3	improper marking labels	10.28	80.37
N_6	too high or too low salt content	6.54	86.92
N_4	no label	4.91	91.82
N_2	crookedly glued label	3.50	95.33
N_5	improper consistency of cheese	1.87	97.20
N_8	contamination of cheese	1.64	98.83
N_9	wrong colour	0.93	99.77
N_{10}	no characteristic taste	0.23	100.00

Source: own study

On the basis of the data presented in Table 4.2 Pareto-Lorenz diagram was created and shown in Figure 4.3.

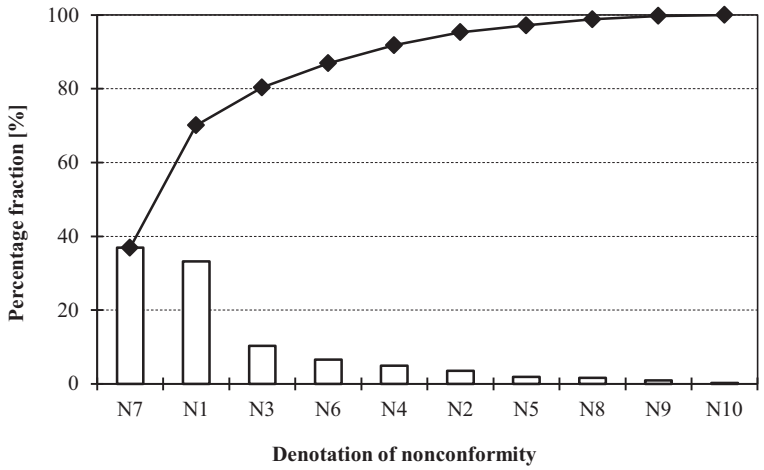

Fig. 4.3. The Pareto-Lorenz diagram for the analysis of the nonconformities occurring during production of the Mozzarella cheese.

Source: own study

Diagram presented in Figure 4.3 and Table 4.2 shows that 20% of causes is responsible for 70.09% results. In addition, it can be concluded that for 70.09% of all nonconformities found in the manufacturing process of cheese Mozzarella 2 causes are responsible: N_7 (leaking package) and N_1 (underestimated weight of package). The remaining seven causes are responsible for the 29.91% of the effects.

4.3. Analysis of the causes and effects of defects - FMEA method

FMEA method is based on the analytical determination of cause-and-effect formation of potential product defects and taking into account the criticality factor analysis (risk). Its aim is to consistently and systemati-

cally identify potential product defects, process, and then to eliminate or minimize the risks associated with them. With the FMEA method the product or process can be continually improved by exposing it to further analyses and on the basis of the results new fixes and solutions can be introduced, effectively eliminating the source of defects and provide new ideas improving the properties of the product. (HAMROL A., MANTURA W. 2002, WOLNIAK R., SKOTNICKA B. 2008, KNOP K., JAGUSIAK M., STASIAK-BETLEJEWSKA R. 2009).

For a description of each of the defects is used so called priority numbers which are in a scale of 1-10:

- P – probability number, showing the probability of nonconformity occurring (1-low, 10-high).
- D – detection number, showing difficulty of nonconformity finding (1-easy, 10-difficult).
- S – severity number, showing how important is the nonconformity for the customer (1-low, 10-significant).
- RPN – risk priority number counted according to the following formula RPN=P*D*S. Respectively the higher RPN is, the more significant nonconformity is, and vice versa.

High values of LPR or priority numbers indicate the need to take specific actions to improve the product / process.

The FMEA sheet for the nonconformities of the Mozzarella cheese is presented in Table 4.3.

Table 4.3. FMEA sheet for the nonconformities of the Mozzarella cheese

Denotation	Nonconformity	Cause of the nonconformity	Effect on the nonconformity	D	P	S	RPN
N_1	Under-estimated weight of package	Uneven pouring slurry, neglect of duties, error of the measuring tool	customer dissatisfaction	4	5	10	200
N_2	crookedly glued label	Improperly set labeler	unaesthetic packaging	2	6	8	96

N_3	improper marking labels	Failure of industrial printers, printing incorrect parameter setting	Poor quality, lack of utility of consumption	6	3	9	162
N_4	no label	Neglect of duties, improperly set labeler	Lack of utility of consumption	2	6	10	120
N_5	improper consistency of cheese	Failure composition, the use of incorrect temperature and time	Poor quality	3	3	10	90
N_6	too high or too low salt content	Failure to comply with the composition of the recipe, incorrect weighing of salt	Poor quality	4	5	8	160
N_7	leaking package	Improper set packing unit, improper packagings, improper handling of the product	No protection from the elements polluting products	5	6	10	300
N_8	Contamination of cheese	Dirty tanks, improper pasteurization,neglect of duties	This product is not suitable for sale	2	4	10	80
N_9	wrong colour	Failure to comply with the composition of the recipe, the use of incorrect temperature and time	The deviation from the colour	2	3	10	60
N_{10}	no characteristic taste	Failure to comply with the composition of the recipe, the use of incorrect temperature and time	Deviation from taste	3	2	10	60

Source: own study

For each nonconformity the preventive actions, which are shown in Table 4.4, were proposed.

Table 4.4. Preventive action for the nonconformities of the Mozarella cheese

Denotation	Nonconformity	Preventive action
N_1	underestimated weight of package	Dosing unit adjustment, control weighting
N_2	crookedly glued label	Adjustment and control of labeler
N_3	improper marking labels	Industrial printer adjustment, regular maintenance
N_4	no label	Labeler adjustment
N_5	improper consistency of cheese	Training of employees
N_6	too high or too low salt content	Training of employees, new procedures for weighing salt
N_7	leaking package	Tightening control of packaging supplier, packing unit adjustment, training of employees
N_8	contamination of cheese	Training of employees in the field of health, tank purity control
N_9	wrong colour	Training of employees, development of new procedures of materials issuance and organization of work
N_{10}	no characteristic taste	Training of employees, development of new procedures of materials issuance and organization of work

Source: own study

Quantification of the causes of nonconformities in the manufacturing process of Mozzarella cheese with use of the FMEA method showed that the highest value of the number of priority risks was related to leaking package (N_7).

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