Metrological aspects of the safety and quality of meat products

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Abstract. The meat industry is one of the most important sectors of the economy closely related to animal husbandry. In the human diet, meat is the main source of animal protein. Therefore, quality of a final product is extremely important and depends on many factors at all stages of the production. Requirements for parameters of food safety and quality are established in the most countries and are revised permanently depending on the new scientific data.

In the Russian Federation and the Customs Union, the controlled parameters are normalized on the basis of scientific data and approved for use in the relevant Technical Regulations. In order to avoid actions misleading consumers, special requirements for product labeling have been developed. In particular, the labeling of slaughter products and meat products must be conformed in accordance to the Technical Regulation of the Customs Union "Food products in terms of their labeling " - TR CU 022/2011, as well as to the some clauses of the Technical Regulation TR CU 034 / 2013 On the Safety of Meat and Meat Products.

According to the working regulation, the manufacturer s must indicate nutritional parameters (protein, fat, carbohydrates) of meat products on the product label as the parameter true values. At the same time, each standard for analytical methods includes a permissible relative error of the measured value at the confidence level of 0.95, which had not to be exceeded under the conditions described in the standard. In that way target measurement uncertainty is established.

This paper shows the possible risks of false decisions when assessing meat products for its compliance with the labeling, depending on the measurement uncertainty, as well as methods for minimizing these risks.

In the human diet, meat is the main source of protein of animal origin. Therefore the meat industry is one of the most important sectors of the economy, closely related to poultry and animal husbandry. The enterprises of the meat industry carry out the procurement and slaughter of livestock, poultry, rabbits. They are producing meat, canned meat, sausages, semi-finished products (cutlets, dumplings, culinary products). Along that dry animal feed, valuable medicines (insulin, heparin, linocaine, etc.), as well as
glues, gelatin and downy products are produced. At the same time, all stages of production affect the quality of the final product. Thus, each participant in this complex chain from procurement to the receipt of ready-to-eat products is responsible for the safety and quality of meat products. At the same time, consumers at all stages of this chain rely not only on high-quality self-control of manufacturers, but also on reliable and trusty control of the market by regulatory authorities.

Food safety and quality are a broad topic ranging from the presence or acceptable content of heavy metals, toxins and contamination residues, to allergens and bacteria resulting from cross-contact during processing and / or packaging. Moreover, food safety and quality can also extend to authenticity, counterfeiting and falsification, or even potential spoilage.

In order to control food products both at the exit from production (and sometimes at all stages of production) and on the market, appropriate requirements are set for their safety and quality indicators, which are constantly revised depending on new scientific data. The development and standardization of regulatory indicators, their implementation and control is a rather complex mechanism involving many structures (research institutes, manufacturers, metrological structures, regulatory authorities, sellers, consumers, etc.) At the same time, it is very important that both the accuracy and reliability of the measurement results and the established requirements minimize the risks of making false decisions in conformity assessment. "Conformity assessment - activity to determine, whether specified requirements relating to an item are fulfilled" [1]. Obviously, with a high probability of mistakes, either product consumers or manufacturers may suffer. In the first case, it will be considered as a violation of consumer rights or harm to human health, in the second case, it is an infringement of the rights of the producers.

Given the importance and relevance in meat products, in this article we will consider what risks are faced and may be faced when providing the conformity assessment of meat industry products from the point of view of metrology.

Based on the regulated characteristics, the regulatory authorities provide the conformity assessment procedure. That is, the object under consideration is assessed for its compliance with the requirements. It is clear that a significant part of the decisions made in assessing the compliance with the established requirements for meat products are based on the measurement results. Therefore, the less the uncertainty of the measurements, that is, the higher the reliability and precision of measurements, the less the risk of making false decisions. [2-6]. However, as practice shows, this is not enough, and in order to reduce the risks of making false decisions in conformity assessment, there are another important criterion - in the right way and correctly established norms and requirements.

So, in the Russia and on the territory of the Customs Union (CU), as in many other countries, on the basis of scientific data, controlled parameters are normalized, which are then approved in the relevant Technical Regulations. Technical Regulations (TR) of the Customs Union "On the safety of meat and meat products" (TR CU 034/2013) [7], applied to slaughter products and meat products, realised in the Customs Union, as well as to the processes of their production, storage, transportation, sale and disposal was developed. The TR CU 034/2013 has been approved:

- to protect human life and health, the environment, the life and health of animals;
- to prevent actions that mislead consumers of products slaughter and meat products regarding their purpose and safety.

In order to avoid actions that mislead consumers, special requirements for product labeling have been developed. In particular, the labeling of slaughter products and meat products must comply with the requirements of the technical regulations of the Customs Union "Food products in terms of their labeling" (TR CU 022/2011) [8], as well as the requirements established by clauses 107-126 of the technical regulations TR CU 034/2013. [7].

Thus, the assessment (confirmation) of the conformity of slaughter products and meat products and the processes of their production, storage, transportation, sale and disposal should be carried out for compliance with the requirements of the Technical Regulations of the CU: TR CU 021/2011 [9], TR CU 034/2013 [7] and TR CU 022/2011) [8].
At first glance, everything is normalized, everything is established and regulated. What problems do producers and regulatory authorities face in practice?

As a rule, requirements are established with the range of permissible values or with the range of not permissible values of the set parameter.

Possible situations of dividing the range of parameter values into ranges of permissible and not permissible values are given in ISO/IEC 17000:2004 [1]. These values are established on the basis of scientific research, while the error and uncertainty of each standardized parameters must be taken into account.

Let us consider several established parameters for meat products in TR CU 034/2013, chosen in random.

1. **Parameters of industrial sterility for canned of baby food**

   - *Spore-forming mesophilic aerobic and facultative anaerobic microorganisms of the B. Subtilis group* - meet the requirements of industrial sterility in the case of determining the number of these microorganisms, no more than 11 CFU **<** in 1 g (sm3) of the product).

   According to ISO / IEC 17000: 2004 [1], the parameter has been normalized by the way when set the upper limit value. True, at the same time, its metrological characteristics (permissible error and / or measurement uncertainty) or a link to the corresponding document have been not indicated, which make it impossible to unambiguously evaluate this parameter.

   - *Mesophilic clostridium* - do not meet the requirements of industrial sterility when detected in 10 g (cm³) of the product.

   This standardization does not fit any of the situations in ISO / IEC 17000: 2004 [1]. According to the Regulation if detected in 9 g or 11 g the product meets the requirements, if detected in 10 g, it does not comply. It can be assumed that there was a typo. But! This is a valid document, so the producers and regulatory authorities use it in the present.

   Thus, consideration only these two safety parameters for meat products chosen as an example in random showed us that the lack of metrological characteristics in the TR gives a facility for products with not permissible content of the determined component to enter the market.

Let us consider one more example of established nutritional values of meat products in TR CU 034/2013, chosen in random.

2. **Sausages for preschool and school children feeding**

   **Criteria and parameters of nutritional value per 100 g of the product** –

   - **Protein** - not less than 12 g.

   According to ISO / IEC 17000: 2004 [1] this parameter is normalized according to the situation of limiting the lower limit value.

   - **Fat** - no more than 22 g.

   According to ISO / IEC 17000: 2004 [1], this parameter is normalized according to the situation of limiting the upper limit value.

   Although, us we cleared up in the examples, the error and / or uncertainty of measurements have been not specified, it is assumed that they have been taken into account for all parameters in the TR CU 34/2013.

   In addition, in order to avoid actions that mislead consumers, both the protein content and the fat content should be indicated in the product labeling, in accordance with the new requirements of the Technical Regulations [7-9]. So, according to TR CU 22/2011, producers must indicate the actual or
average values of the parameters of the nutritional value of products. That is, if earlier the labeling indicated: in 100 g of the product: protein - not less than 13 g, fats - not more than 20 g; now they must indicate: in 100 g of the product: protein - 13 g, fats - 20 g. At the same time, it is important to note that, the features of meat as a product with a heterogeneous structure, as well as the features of technological processes production of meat products were not taken into account in the developed TR CU 022/2011. As a result of that, there are the inevitably different content of protein and fat in different parts of the product. This is clearly seen in Tables 1 and 2, as well as in Figures 1 - 3.

| Trimmed beef | Protein/100 g of product, error - 20% |
|--------------|--------------------------------------|
| Tg (A)       | 21,7                                 |
| Tg (B)       | 21                                   |
| Tg (C)       | 23,1                                 |
| 1st g (a)    | 20,1                                 |
| 1st g (b)    | 18,8                                 |
| 1st g (c)    | 20,9                                 |

| Pork trimmed | Protein/100 g of product, error - 20% |
|--------------|--------------------------------------|
| Lean pork (a)| 21,4                                 |
| Lean pork (b)| 19,3                                 |
| Lean pork (c)| 18,8                                 |
| Lean pork (d)| 19,8                                 |
| Demi fat Pork (a)| 15,5                                 |
| Demi fat Pork (b)| 15,1                                 |
| Demi fat Pork (c)| 15,8                                 |
| Demi fat Pork (d)| 16,3                                 |
| Fat Pork (a)  | 10,8                                 |
| Fat Pork (b)  | 8,7                                  |
| Fat Pork (c)  | 8,9                                  |
| Fat Pork (d)  | 14,6                                 |
| Pork for Sausage (a)| 16                                  |
| Pork for Sausage (b)| 15,4                                |
| Pork for Sausage (c)| 18,5                                |

Thus, the described facts show that the indication parameters of nutritional value in the labeling of meat and meat products without normalised limitations make the labeling impossible for unambiguous understanding [11]. Moreover, according to the valid measurement methods, the measurement error for protein is \( \pm 20\% \) [12], and for fat - \( \pm 18\% \) [13].
Thus, today, the lack of the necessary metrological characteristics of specific meat product parameters in the Technical Regulations and a clear instructions of the required approach when assessing the conformity of products has led to the fact that:
- market participants are not able to unambiguously interpret the requirements;
state control/supervision bodies apply the requirements of TR CU 022/2011 in accordance with own understanding, which leads to unreasonable administrative fines;

despite the fact that TR CU 022/2011 allows for the nutritional value of food products labeling with the inscription: "Average value", nevertheless, when monitoring the market on the issue of compliance with the requirements of TR CU 022/2011, as well as in judicial practice, permissible deviations of the average value are not taken into account.

Why is it so important to indicate the metrological characteristics of the standardized parameters?

In the ISO 10576-1: 2003 [13] is described and shown possible situations of measurement results in relation to a established limit. The ISO 10576-1: 2003 clearly demonstrates the need to take into account measurement uncertainty in conformity assessment. Otherwise, if we are analysing parameters of the safety of meat products, in the three situations out of described five there are high risks of letting meat products hazardous to the health of consumers enter the market. About that was said above. At the same time, in the four out of five situations, a product with an insufficient amount of nutritional value may enter the market or, the other, quality products may be withdrawn from sale. In the latter cases, of course, characteristics are not dangerous for human health, but it can violate the rights of a the consumers or the producer. It is, in general, is also not desirable and not permissible. Taking into account the measurement uncertainty, the laboratory can calculate and reduce its risks of making erroneous decisions [4] in 3 out of 5 situations described in the ISO 10576-1: 2003.

Thus, based on the above, we may make the conclusions:

- in normative and regulated documents, the metrological requirements for the parameters have not clearly formulated, which leads to ambiguity of interpretation by the users;
- there is no clear consistency between the regulations due to the lack of metrological characteristics of the established parameters, which in turn brings an ambiguity in the interpretation of the requirements;
- during the development of TR CU 022/2011, the measurement uncertainties, associated with the peculiarity of meat as a product with a heterogeneous (inhomogeneous) structure and with the peculiarity of technological processes for the meat product production, were not taken into account;
- the need to develop decision-making rules for conformity assessment of products to established requirements is obvious (of course, taking into account the above).

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