

TESTING THE CAPABILITIES OF GPT-4O FOR ANALYSIS OF MICROBIOLOGICAL QUALITY OF MINCED MEAT AND MEAT SEMI-PRODUCTS

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Abstract: Microbiological examinations of meat included the total number of aerobic mesophilic bacteria, *Salmonella* spp. and *Escherichia coli*. The aim of the research was to examine the microbiological quality of minced meat and meat semi-products and to determine whether the samples meet the microbiological criteria. The results of the microbiological examination of the meat were analyzed using GPT-4O. The authors took care to format the input questions in such a way as to direct GPT-4o to the desired data sources.

Key words: Microbiological quality, minced meat, meat semi-products, GPT-4o, JavaScript, programming language.

1. INTRODUCTION

Meat, due to its high content of water and nutrients, represents an ideal environment for the growth and reproduction of microorganisms [1], [2]. In the Republic of Serbia, according to current legislation, the presence of *Salmonella* in meat is controlled. The basic act in the area of food safety in the Republic of Serbia is Law on Food Safety [3], the second secondary act is the Rulebook on General and Special Conditions for Hygiene of Food and Microbiological Criteria for Food [4].

The aim of this work is to show the microbiological quality of minced meat and meat semi-products (kebabs, fresh sausage). Minced meat is obtained by grinding the cooled meat of domestic ungulates of the first and second category [5]. Fresh sausage is obtained from chopped fresh meat, fatty tissue and additives. Minced meat with additives is an unsalted semi-finished meat product that is marketed as kebabs, hamburgers [5].

1.1 Microbiological safety and hygiene criteria in the production process of minced meat and meat semi-products

The hygiene criterion in the production process is a criterion that should show that the production process is performed correctly. It applies throughout every stage of food production and handling. If the process hygiene criterion is not satisfactory, the applied procedures should be reviewed, corrective measures should be applied, and as a result of these activities, the hygiene of the production process should be improved.

The rulebook on general and special conditions of food hygiene and microbiological criteria for food establishes the microbiological criteria of safety and hygiene in the process of the production of minced meat and meat semi-products (Table 1). The hygiene indicators of the minced meat production process are the total number of bacteria and the number of *Escherichia coli*. *E. coli* is considered the main indicator of fecal contamination. When minced meat and meat semi-products reaches the market, *Salmonella* is considered an indicator of its safety during the shelf life.

E. coli and the total number of bacteria in minced meat and meat semi-products are considered satisfactory if all determined values are $\leq m$, acceptable if the maximum c of n values obtained is between m and M and if the other determined values are $\leq m$, and unsatisfactory if one or multiple determined values $>M$ or if multiple c/n samples are values between m and M .

The aim of this work is to evaluate the microbiological quality parameters of meat using GPT-4O.

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Table 1- Microbiological safety criteria and hygiene criteria in the production process of minced meat and meat semi-products

| | Food category | Microorganisms/ their toxins, metabolites | Sampling plan ⁽¹⁾ | | Limits ⁽²⁾ | | Analytical reference method ⁽³⁾ |
|--------|--|---|------------------------------|---|-------------------------|-------------------------|--|
| | | | n | c | m | M | |
| 1.5. | Minced meat and semi-meat products, except poultry meat, intended for eating after cooking | <i>Salmonella</i> | 5 | 2 | Not present in 10 g | | SRPS EN ISO 6579-1 |
| 2.1.6. | Minced meat | Aerobic colony count ⁽⁷⁾ | 5 | 2 | 5x10 ⁵ cfu/g | 5x10 ⁶ cfu/g | SRPS EN ISO 4833-1 |
| | | <i>E. coli</i> ⁽⁸⁾ | 5 | 2 | 50 cfu/g | 500 cfu/g | SRPS EN ISO 16649-1 or SRPS EN ISO 16649-2 |
| 2.1.8. | Meat semi-products | <i>E. coli</i> ⁽⁸⁾ | 5 | 2 | 500 cfu/g | 5000 cfu/g | SRPS EN ISO 16649-1 or SRPS EN ISO 16649-2 |

⁽¹⁾ n = number of units comprising the sample; c = number of sample units that give values between m and M.

⁽²⁾ for point 1.5, m=M

⁽³⁾The latest edition of the standard (international or corresponding standard of the Republic of Serbia) is applied.

⁽⁷⁾ This criterion does not apply to minced meat produced at retail with a shelf life of less than 24 hours.

⁽⁸⁾ *E. coli* is used here as an indicator of faecal contamination

2. MATERIAL AND METHODS

2.1. Microbiological tests of minced meat samples and meat semi-products

Microbiological tests of samples of fresh minced pork, minced beef and meat semi-products (kebabs and fresh sausage) were performed according to accredited reference methods in the laboratory of the Scientific Institute of Veterinary Science "Novi Sad" in Novi Sad. For the analysis of the microbiological correctness of the meat, it is necessary to take five units that make up one sample of the product. Microbiological tests were performed according to valid ISO or SRPS ISO methods:

- The total number of aerobic mesophilic bacteria was determined by the SRPS ISO 4833:2008 method [6];
- Presence of *Salmonella* spp. it was determined by the SRPS ISO 6579:2017 method [7];
- The number of *E. coli* was determined by the SRPS ISO 16649-2:2008 method [8].

2.2 GPT-4o

"GPT-4o ("o" for "omni") is our versatile, high-intelligence flagship model. It accepts both text and image inputs, and produces text outputs (including Structured Outputs)" [9]. This model is suitable for our research because it allows for a high degree of automation. The table we send to the input is

converted into an image. Such an image, together with the text question, completes the input to the GPT-4o system. We receive the answer in text format and interpret it and draw conclusions. The authors took care to ensure that the text question was written in such a way as to help the GPT-4o to provide the best possible answer. The author's script was used to ask questions [10]. The script is written in the JavaScript programming language.

3. RESULTS AND DISCUSSION

Table 2 shows the results of the microbiological examination of fresh minced pork meat and minced beef meat. Samples of fresh minced pork, minced beef and meat semi-products (kebab and fresh sausage) were tested for the presence of *Salmonella spp.*, *E. coli* and the total number of bacteria.

Table 2 –Results of microbiological examination of minced pork meat and minced beef meat

| Sample | Microorganism | Unit | Method | Number of samples | Results |
|------------------|------------------------|--------------------|--------------------------|-------------------|--------------|
| Minced pork meat | <i>E. coli</i> | cfu/g | SRPS EN ISO 16649-2:2008 | 5 | 227 |
| | | | | | <10 |
| | | | | | <10 |
| | | | | | 145 |
| | | | | | 15636 |
| Minced pork meat | <i>Salmonella spp.</i> | Not present in 10g | SRPS EN ISO 6579-1:2017 | 5 | Not isolated |
| | | | | | Not isolated |
| | | | | | Not isolated |
| | | | | | Not isolated |
| Minced pork meat | Aerobic colony count | cfu/g | SRPS EN ISO 4833-1:2014 | 5 | 31460 |
| | | | | | 21670 |
| | | | | | 150 |
| | | | | | 368500 |
| | | | | | 17490 |
| Minced beef meat | <i>E.coli</i> | cfu/g | SRPS EN ISO 16649-2:2008 | 5 | <10 |
| | | | | | <10 |
| | | | | | <10 |
| | | | | | <10 |
| Minced beef meat | <i>Salmonella spp.</i> | Not present in 10g | SRPS EN ISO 6579-1:2017 | 5 | Not isolated |
| | | | | | Not isolated |
| | | | | | Not isolated |
| | | | | | Not isolated |
| Minced beef meat | Aerobic colony count | cfu/g | SRPS EN ISO 4833-1:2014 | 5 | 29920 |
| | | | | | 18480 |
| | | | | | 200 |
| | | | | | 368500 |
| | | | | | 17490 |

user: Which samples of minced meat do not satisfy the provisions of the Rulebook on general and special conditions of food hygiene and microbiological criteria for food. The table is given in the picture, for image on <https://i.imgur.com/ASklrMa.png>

assistant: Based on the given results, the minced meat samples that do not meet the provisions of the Rulebook are minced pork meat does not meet the provisions of the Regulations for the *Escherichia coli* parameter:

- One sample has a value of 15636 cfu/g, which exceeds the permitted limits. Results that exceed the specified limits indicate deficiencies in hygiene.

All samples meet the specified criteria for *Salmonella* spp. and the total number of bacteria according to the attached results.

Table 3 shows the results of microbiological testing of meat semi-products (kebab and fresh sausage).

Table 3 –Results of microbiological examination of meat semi-products

| Sample | Microorganism | Unit | Method | Number of samples | Results |
|---------------|------------------------|--------------------|--------------------------|-------------------|--------------|
| Fresh sausage | <i>E. coli</i> | cfu/g | SRPS EN ISO 16649-2:2008 | 5 | <10 |
| | | | | | 2673 |
| | | | | | 2673 |
| | | | | | 273 |
| | | | | | 2773 |
| Fresh sausage | <i>Salmonella</i> spp. | Not present in 10g | SRPS EN ISO 6579-1:2017 | 5 | Not isolated |
| | | | | | Not isolated |
| | | | | | Not isolated |
| | | | | | Not isolated |
| | | | | | Not isolated |
| Fresh sausage | Aerobic colony count | cfu/g | SRPS EN ISO 4833-1:2014 | 5 | 199100 |
| | | | | | 193300 |
| | | | | | 150 |
| | | | | | 209000 |
| | | | | | 213400 |
| Kebab meat | <i>E. coli</i> | cfu/g | SRPS EN ISO 16649-2:2008 | 5 | <10 |
| | | | | | 164 |
| | | | | | 164 |
| | | | | | 273 |
| | | | | | 2773 |
| Kebab meat | <i>Salmonella</i> spp. | Not present in 10g | SRPS EN ISO 6579-1:2017 | 5 | Not isolated |
| | | | | | Not isolated |
| | | | | | Not isolated |
| | | | | | Not isolated |
| | | | | | Not isolated |
| Kebab meat | Aerobic colony count | cfu/g | SRPS EN ISO 4833-1:2014 | 5 | 115 |
| | | | | | 88 |
| | | | | | 290 |
| | | | | | 2 |
| | | | | | 152 |

user: Which samples of meat semi-products do not satisfy the provisions of the Rulebook on general and special conditions of food hygiene and microbiological criteria for food. The table is given in the picture, for image on <https://i.imgur.com/OkBDwII.png>

assistant: Based on the given results, the meat semi-products samples that do not meet the provisions of the Rulebook are:

1. Kebab meat for *Escherichia coli* parameter:
 - One sample has a value of 2773 cfu/g, which exceeds the permitted limits.
2. Fresh sausage for *Escherichia coli* parameter:
 - The values include 2673 and 2773 cfu/g, which exceeds the permissible limits.

These results indicate contamination that does not meet hygiene standards for these categories of meat.

According to the obtained results, it can be observed that all samples of minced meat (pork and beef) and meat semi-products (kebab and fresh sausage) meet the safety criteria for *Salmonella* spp. (n=5; c=0; m=M= must not be in 10 g), appendix 1, chapter 1, point 1.5., as well as hygiene criteria in the production process for the total number of bacteria (n=5; c=2 ; m=5×10⁵ cfu/g; M=5×10⁶ cfu/g).

Samples of minced pork meat and meat semi-products (kebab and fresh sausage) do not meet the hygiene criteria in the production process for the number of *Echerichia coli* (n=5; c=2; m=50 cfu/g; M=500 cfu/g) appendix 1, chapter 2, point 2.1.6. and point 2.1.8. according to the Rulebook on general and special conditions of food hygiene and microbiological criteria for food.

4. CONCLUSION

GPT-4o successfully recognized and analyzed microbiological quality parameters of raw minced meat and meat semiproducts.

It is shown that systems based on artificial intelligence like GPT-4o have the ability to successfully deal with the problems in this area. What certainly contributes to their success is the use of good practices from the field of prompt engineering, and the consequences of that are well-formatted inputs, after which better quality output data is obtained. Specifying the correct Rulebook in our case turned out to be good practice, because GPT-4o was informed what its source should be.

5. REFERENCES

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