The main technical and economic indicators of the introduction of new test equipment for the determination of toxic elements in food in the laboratory center

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Abstract. As a result of the analysis of the main technical and economic indicators of the introduction of new test equipment for the determination of toxic elements in food in the laboratory center, it was found that the replacement of the photoelectric concentration colorimeter "KFK-2MP" with the analyzer "Pan-arsenic" when analyzing samples of food products and food raw materials for the content arsenic will be effective. Replacement of the outdated and decommissioned model of the atomic absorption spectrometer "Kvant-AFA" for the atomic absorption spectrometer "Kvant-2AT" in the analysis of samples of food and food raw materials for lead and cadmium content will be effective. The option of replacing the Kvant-AFA spectrometer with a voltammetric analyzer "TA-4" when analyzing samples of food products and food raw materials for lead and cadmium content will be effective if the performance of the new equipment meets the laboratory's needs in the number of studies, and the purchase of atomic-absorption spectrometer will not be advisable due to the absence of the need for its performance for the implementation of measurements and insufficient solvency of the laboratory. The introduction of the PLP-01M microwave laboratory system introduces a limitation on the number of studies per year, which reduces the capabilities of the measuring device, in cases both for the simultaneously introduced spectrometer "Kvant-2AT" and for the already used "Kvant-AFA". The introduction of the PLP-01M system will be beneficial if the performance of the new equipment meets the laboratory's needs in the number of studies.

1. Introduction

Improving the quality of services provided by updating the laboratory base is considered as one of the most important ways to increase competitiveness, achieve competitive advantages, which, in turn, contributes to increasing the economic efficiency of the testing laboratory center (hereinafter referred to as the TLC).

The relationship between the introduction of new equipment and the economic efficiency of the ILC is shown in figure 1.

Ensuring food safety remains an urgent and priority task [1-7]. Assessment of the quality and safety of the developed food products is a prerequisite [8-18]. In the conditions of market relations at any enterprise, including testing laboratories, the relevance of quality management is determined by its focus on ensuring such a level of quality of services that can fully satisfy all consumer needs. The lack of updating of measuring instruments, test and auxiliary equipment makes it difficult to ensure a stable
quality of services. The processes of updating the laboratory base in modern conditions of the
development of scientific and technological progress are objectively necessary [19-25].

Introduction of new equipment

- Increasing the number of studies being conducted
- Improvement of internal laboratory control indicators
- Reducing the unit cost of one study
- Improving the competitiveness of TLC
- Increasing the economic efficiency of the TLC

Figure 1. The relationship between the introduction of new equipment and the economic efficiency of the TLC.

2. Materials and methods

Equipment:

- atomic absorption spectrometer "Kvant-2AT" (hereinafter referred to as "Kvant-2AT");
- voltammetric analyzer "TA-4" (hereinafter referred to as "TA-4");
- analyzer "Pan-arsenic" (hereinafter referred to as "Pan-arsenic");
- photoelectric concentration colorimeter "KFK-2MP" (hereinafter referred to as "KFK-2MP");
- atomic absorption spectrometer "Kvant-AFA" (hereinafter referred to as "Kvant-AFA");
- microwave laboratory system PLP-01M (hereinafter referred to as PLP-01M).

Profit ($P_r$) from the research were calculated using the formula:

$$P_r = Q \times P_{un},$$

where: $P_{un}$ - price of 1 study according to the price list, rubles; $Q$ is the number of studies per year, nat. units.

Profit from 1 study was calculated using the formula:

$$P = P_r - C_{tot},$$

where: $C_{tot}$ is the total cost of 1 study, rubles.

The profitability of the introduction of new equipment was calculated using the formula:

$$P = \frac{P_r}{C_{tot}} \times 100\%,$$

where $P$ - profitability, $P_r$ - profit from research per year, rubles. $C_{tot}$ - total cost of the study, rubles.

The payback period of capital investments was calculated using the formula:
where $T$ is the payback period of capital investments; $P_{an}$ - annual profit, rubles; $C_{tot}$ - total costs, rub.

The break-even point was calculated using the formula:

$$Tb = T \times P,$$

where $Tb$ is the break-even point; $T$ is the payback period of capital investments; $P$ is the number of studies per year.

3. Results and discussion

We have carried out calculations of the main technical and economic indicators of the introduction of new testing equipment for the determination of toxic elements in food products at the TLC.

1) Number of studies per year:

- Q "Kvant-2AT" = 32,960 studies;
- Q "TA-4" = 9,694 studies;
- Q "Pan-arsenic" = 8,078 studies;
- Q "KFK-2MP" = 6,463 studies;
- Q "Quantum-AFA" = 19,388 studies;
- Q "Kvant-2AT" / "Kvant-AFA" with PLP-01M = 16,055 studies.

The revenue from research per year, depending on the equipment used, is respectively equal to:

- for Kvant-2AT - RUB 10,382,400.0 rubles;
- for "TA-4" - 3,392,900.0 rubles;
- for "Pan-arsenic" - 2,827,300.0 rubles;
- for "KFK-2MP" - 2,520,570.0 rubles;
- for Kvant-AFA - 6,107,220.0 rubles;
- for "Kvant-2AT" taking into account the use of PLP-01M at a price in the price list of 315 rubles. for research - 5,057,325.0 rubles;
- for "Kvant-AFA" taking into account the use of PLP-01M at a price in the price list of 315 rubles. for research - 5,057,325.0 rubles;
- for "Kvant-2AT" taking into account the use of PLP-01M at a price in the price list of 260 rubles. for the study - 4,174,300 rubles;
- for "Kvant-AFA" taking into account the use of PLP-01M at a price in the price list of 260 rubles. for the study - 4,174,300.0 rubles.

2) The profit from 1 study, depending on the equipment used, will be:

- for Kvant-2AT - RUB 190.28;
- for TA-4 - 125.23 rubles;
- for "Pan-arsenic" - 32.36 rubles;
- for "KFK-2MP" - 12.38 rubles;
- for Kvant-AFA - 167.66 rubles;
- for "Kvant-2AT" taking into account the use of PLP-01M at a price in the price list of 315 rubles. for research - 156.86 rubles;
- for "Kvant-AFA" taking into account the use of PLP-01M at a price in the price list of 315 rubles. for the study - 176.18.95 rubles;
- for "Kvant-2AT" taking into account the use of PLP-01M at a price in the price list of 260 rubles. for the study - 101.86 rubles;
• for "Kvant-AFA" taking into account the use of PLP-01M at a price in the price list of 260 rubles. for research - 121.18 rubles.

The annual profit from research will be:

• for Kvant-2AT - 6,271,805.49 rubles;
• for "TA-4" - 1,214,858.76 rubles;
• for "Pan-arsenic" - 261,374.95 rubles;
• for "KFK-2MP" - 80,036.98 rubles;
• for Kvant-AFA - RUB 3,250,622.02;
• for "Kvant-2AT" taking into account the use of PLP-01M at a price in the price list of 315 rubles. for research - 2,518,401.47 rubles;
• for "Kvant-AFA" taking into account the use of PLP-01M at a price in the price list of 315 rubles. for the study - 2,828,529.64 rubles;
• for "Kvant-2AT" taking into account the use of PLP-01M at a price in the price list of 260 rubles. for research - 1,635,376.47 rubles;
• for "Kvant-AFA" taking into account the use of PLP-01M at a price in the price list of 260 rubles. for research - 1,945,504.64 rubles.

3) The profitability of the introduction of new equipment is reflected in the formation of the research price set by the ILC accounting department and is 25%.

4) Net profit:

The annual net profit from research will be:

• for Kvant-2AT - 3,633,390.60 rubles;
• for TA-4 - 701,476.86 rubles;
• for "Pan-arsenic" - 146,727.00 rubles;
• for KFK-2MP - 42,137.46 rubles;
• for Kvant-AFA - 1,881,541.04 rubles.

The annual net profit from research will be:

• for "Kvant-2AT" taking into account the use of PLP-01M at a price in the price list of 315 rubles. for research - 1,456,989.56 rubles;
• for "Kvant-AFA" taking into account the use of PLP-01M at a price in the price list of 315 rubles. for research - 1,637,794.28 rubles;
• for "Kvant-2AT" taking into account the use of PLP-01M at a price in the price list of 260 rubles. for research - 942,185.98 rubles;
• for "Kvant-AFA" taking into account the use of PLP-01M at a price in the price list of 260 rubles. for research - 1,122,990.70 rubles.

5) Capital investments for the introduction of new equipment are:

• for "Kvant-2AT" - 1,421,500 rubles;
• for TA-4 - 162,100 rubles;
• for Pan-arsenic - 108,900 rubles;
• for Kvant-2AT taking into account the use of PLP-01M (Kvant-2AT and PLP-01M are being introduced at the same time) - 1,917,790 rubles;
• for "Kvant-AFA" taking into account the use of PLP-01M (PLP-01M is being introduced) - 496,290 rubles.
The total costs of research, taking into account the capital costs of introducing new equipment, will be:

- for Kvant-2AT - RUB 5,532,094.51;
- for TA-4 - 2,340,141.24 rubles;
- for Pan-arsenic - 2 674 825.05 rubles;
- for Kvant-2AT, taking into account the use of PLP-01M (Kvant-2AT and PLP-01M are being introduced at the same time) - 4,456,713.53 rubles;
- for Kvant-AFA, taking into account the use of PLP-01M (PLP-01M is being introduced) - 2,725,085.36 rubles.

The annual profit from the research, depending on the equipment used.

\[
T_{\text{Kvant-2AT}} = \frac{5532094.51}{6271805.49} \approx 0.88
\]

\[
T_{\text{TA-4}} = \frac{2340141.24}{1214858.76} \approx 1.93
\]

\[
T_{\text{Pan-arsenic}} = \frac{2674825.05}{261374.95} \approx 10.23
\]

\[
T_{\text{Kvant-2AT at PLP-01M, Cun.} = 315 \text{ RUB}} = \frac{4456713.53}{2518401.47} \approx 1.77
\]

\[
T_{\text{Kvant-AFA at PLP-01M, Cun.} = 315 \text{ RUB}} = \frac{2725085.36}{2828529.64} \approx 0.96
\]

\[
T_{\text{Kvant-2AT at PLP-01M, Cun.} = 260 \text{ RUB}} = \frac{4456713.53}{1635376.47} \approx 2.73
\]

\[
T_{\text{Kvant-AFA at PLP-01M, Cun.} = 260 \text{ RUB}} = \frac{2725085.36}{1945504.64} \approx 1.40
\]

- T "Kvant-2AT" = 0.88 years = 0.87 × 12 = 10.56 months = 10 months and 16 days.
- T “TA-4” = 1.93 years = 1 + 0.93 × 12 = 1 year 11 months and 4 days.
- T "Pan-arsenic" = 10.23 years = 10 + 0.23 × 12 = 10 years 2 months and 22 days.
- T "Kvant-2AT" at PLP-01M, Cun. = 315 RUB = 1.77 years = 1 + 0.77 × 12 = 1 year 9 months and 7 days.
- T "Kvant-AFA" at PLP-01M, Cun. = 315 RUB = 0.96 years = 0.96 × 12 = 11 months and 15 days.
- T "Kvant-2AT" at PLP-01M, Cun. = 260 RUB = 2.73 years = 2 + 0.73 × 12 = 2 years 8 months and 22 days.
- T "Kvant-AFA" at PLP-01M, Cun. = 260 RUB = 1.40 years = 1 + 0.40 × 12 = 1 year 4 months and 24 days.

The payback period for capital investments will be:

- for "Kvant-2AT" - 10 months and 16 days;
- for "TA-4" - 1 year 11 months and 4 days;
- for "Pan-arsenic" - 10 years, 2 months and 22 days;
- for "Kvant-2AT" with PLP-01M, Tsed. = RUB 315 - 1 year 9 months and 7 days;
- for "Kvant-AFA" at PLP-01M, Tsed. = RUB 315 - 11 months and 15 days;
- for "Kvant-2AT" with PLP-01M, Tsed. = 260 rubles. - 2 years 8 months and 22 days;
- for "Kvant-AFA" at PLP-01M, Tsed. = 260 rubles. - 1 year 4 months and 24 days.
Break-even points for test equipment:

- \( Tb = 0.88 \times 32960 = 29.073 \) studies;
- \( Tb = 1.93 \times 9694 = 18.673 \) studies;
- \( Tb = 10.23 \times 8078 = 82.668 \) studies;
- \( Tb = 1.77 \times 16055 = 28.412 \) studies;
- \( Tb = 0.96 \times 16055 = 15.468 \) studies;
- \( Tb = 2.73 \times 16055 = 43.753 \) studies;
- \( Tb = 1.40 \times 16055 = 22.488 \) studies.

To cover the capital costs for the introduction of new ILC equipment, it is necessary to carry out:

- for "Kvant-2AT" – 29.073 studies;
- for "TA-4" – 18.673 studies;
- for "Pan-arsenic" – 82.668 studies;
- for "Kvant-2AT" with PLP-01M, Tsed. = RUB 315 – 28.412 studies;
- for "Kvant-AFA" at PLP-01M, Tsed. = RUB 315 - 15 468 studies;
- for "Kvant-2AT" with PLP-01M, Tsed. = 260 rubles. – 43.753 studies;
- for "Kvant-AFA" at PLP-01M, Tsed. = 260 rubles. – 22.488 studies.

4. Conclusion
As a result of the analysis of the main technical and economic indicators of the introduction of new testing equipment for the determination of toxic elements in food products, the TLC established:

- replacement of the photoelectric concentration colorimeter "KFK-2MP" with the analyzer "Pan-arsenic" in the analysis of samples of food products and food raw materials for arsenic content will be effective.
- replacement of the outdated and subject to write-off model of the atomic absorption spectrometer "Kvant-AFA" for the atomic absorption spectrometer "Kvant-2AT" in the analysis of samples of food and food raw materials for lead and cadmium content will be effective.
- the option of replacing the atomic absorption spectrometer "Kvant-AFA" with a voltammetric analyzer “TA-4” in the analysis of samples of food products and food raw materials for lead and cadmium content will be effective if the performance of the new equipment meets the needs of the laboratory; theory in the number of studies, and the acquisition of an atomic absorption spectrometer will not be advisable due to the absence of the need for its performance in carrying out measurements and the insufficient solvency of the laboratory.
- the introduction of the PLP-01M microwave laboratory system introduces a limitation on the number of studies per year, which reduces the capabilities of the measuring device, in cases both for the simultaneously introduced atomic absorption spectrometer "Kvant-2AT" and for the already used spectrometer "Kvant-AFA ". The introduction of the PLP-01M system will be beneficial if the performance of the new equipment meets the laboratory's needs in the number of studies.

The use of the PLP-01M microwave laboratory system will make it possible to implement one of two options for the price policy of the laboratory management: when the estimated price per unit of research is established, the competitiveness in the market for the services provided significantly increases; rub. additional income.
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