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The Cost of Repetition: Why Quality Consumables Matter

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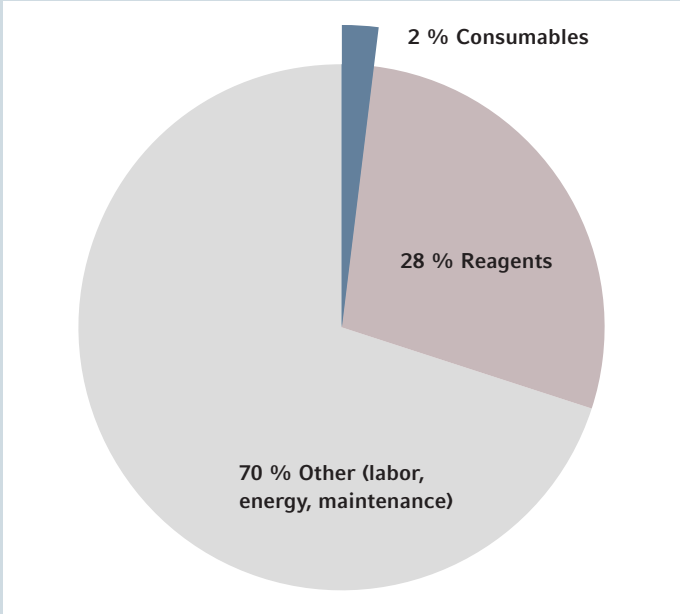
Abstract

Average cost shares for standard experiments

> The costs of an experiment mainly derives from labor, energy and maintenance costs

> Consumables only make up 2 % of all costs for an average experiment

> Repeating an experiment is more expensive than investing in Eppendorf consumables



Cost composition for an experiment, based on four standard assays. The pie chart shows the share for consumables (blue), reagents (brown) and other experimental cost (labor, energy, maintenance; grey) using Eppendorf consumables. Labor costs included in "other" were averaged over the respective costs in the academic or private sector in Europe/BE.

Introduction

Obtaining safe and accurate results and reducing costs are among the most important challenges for laboratories. To achieve the first objective – **obtaining safe and accurate results** – it is crucial to ensure maximum reproducibility and avoid contaminations that can distort the results. Using high-quality, certified consumables from Eppendorf, appears to be a very good solution. However, this brings us to the second objective – **reducing costs**. It can be tempting to opt for lower cost consumables that appear similar or acceptable at first glance compared to Eppendorf consumables.

But are all consumables really equal? What are the real financial impacts of using Eppendorf consumables versus lower cost alternatives? And what risks are incurred? Several Application Notes provide evidence that lower cost consumables can come with a lower quality that negatively impacts assay results through contamination, imprecision and poor reproducibility (see Application Notes 459[1], 396[2], 145[3], 483[4] and 354[5]). External sources corroborate these findings (see Siebels *et al.*, 2023[6] and the LoBind® reference list[7]). Thus, the answer to the first objective is clear: high-quality consumables are essential for obtaining safe and accurate results. Hence, this application note shifts its focus to the second objective – minimizing costs.

Result and Discussion

The exact costs for four distinct and common assays were calculated (see methods for details):

> An enzyme-linked immunosorbent assay (**ELISA**),
> A virus-based reverse transcription, quantitative polymerase chain reaction (**RT-qPCR**),
> An *in-vitro* **RNA production** using a two-dimensional gradient polymerase chain reaction (2D-PCR), and
> A **cell-culture** based protein production using the common expression system of Chinese Hamster Ovary (ExpiCHO) cells.

For each assay, the total costs were divided into three categories: consumables, reagents, and other (labor, maintenance, energy).

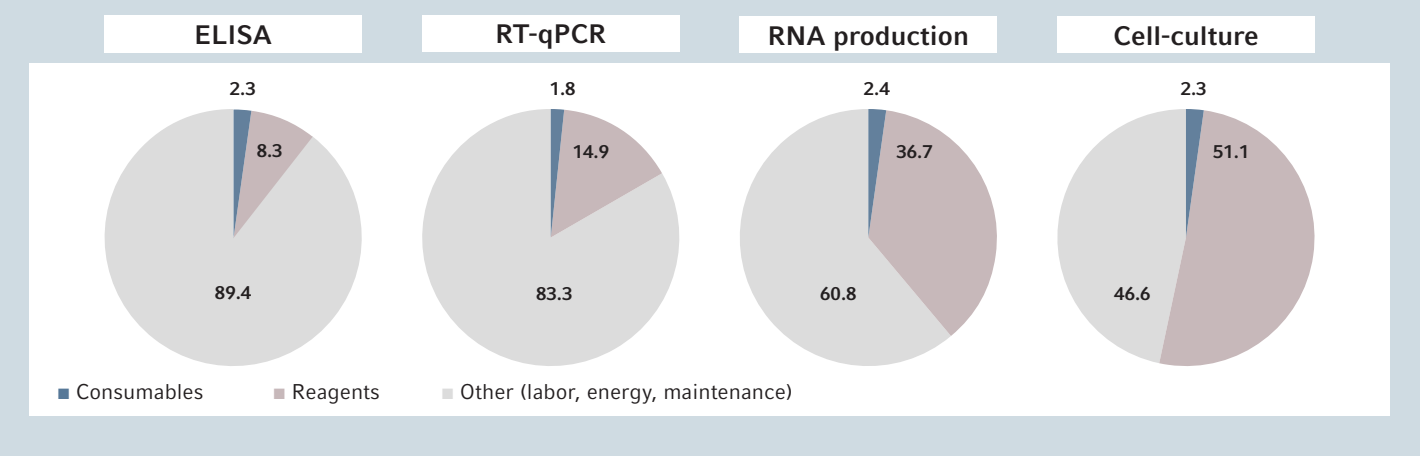


Figure 2: Average proportional costs (in %) for four different assay types using Eppendorf consumables. Other project costs (labor, energy, maintenance; grey) make the biggest proportion, whilst Eppendorf consumables (blue) form the smallest share with less than 3 % over all constellations. Labor costs included in "other" were averaged over the respective costs in the academic or private sector in Europe/BE.

In general, "other" project costs, excluding consumables and reagents, were the highest both in absolute and relative terms for any experiment or setup evaluated, making up at least 46 % of the total costs, and reaching almost 90 % for an ELISA.

The average proportion for reagent costs across all assays was at least 8 % of the total, reaching over 50 % for the cell-culture assay.

For consumables, the total cost share was less than 3 % for each assay and sector evaluated. This allows for the conclusion, that, no matter the assay type, consumables have the least influence on the overall cost for an experiment, even when using higher cost Eppendorf consumables.

On the other hand, consumables influence the results of an assay dramatically, in regards to reproducibility (e.g. inter- and intra-lot consistency, see Application Notes 483[4] and 466[8]), contamination risk (e.g. purities or leaching, see Application Notes 396[2] and 459[1]), or accuracy and precision (e.g. tip-quality, see Application Note 354[5]). Thus, it can be concluded that the overall cost of an experiment increases by (only) 1 % through an investment in Eppendorf consumables. However, this minimal cost increase is worthwhile as it enhances reproducibility and minimizes the risk of contamination, whilst it will hardly be noticeable in the absolute price of the assay.

Additionally, using Eppendorf consumables helps to minimize pre-analytical variances, ensuring more consistent and reliable results (e.g. in NGS, see Application Note 375[15]). It should be mentioned here that a similar, hardly noticeable effect on the overall cost of an experiment will be observed when switching from standard to biobased consumables (1-3 % price difference), which are significantly more sustainable without compromising in quality (see Application Note 469[10], 470[11], 482[12] and 477[13] or White Paper 78[14]).

In contrast to these findings, it is commonly believed that repeating an experiment is quicker and cheaper when results are non-reproducible or erroneous, often overlooking the impact of consumables' impurities, breakage, leaching, or imprecision on these outcomes (see references). To visualize the effect of this practice on the total experiment cost, Figure 3 compares the cost of an assay performed in triplicates using either lower cost or Eppendorf consumables, as well as with the cost of the same assay requiring a fourth repetition using lower cost consumables.

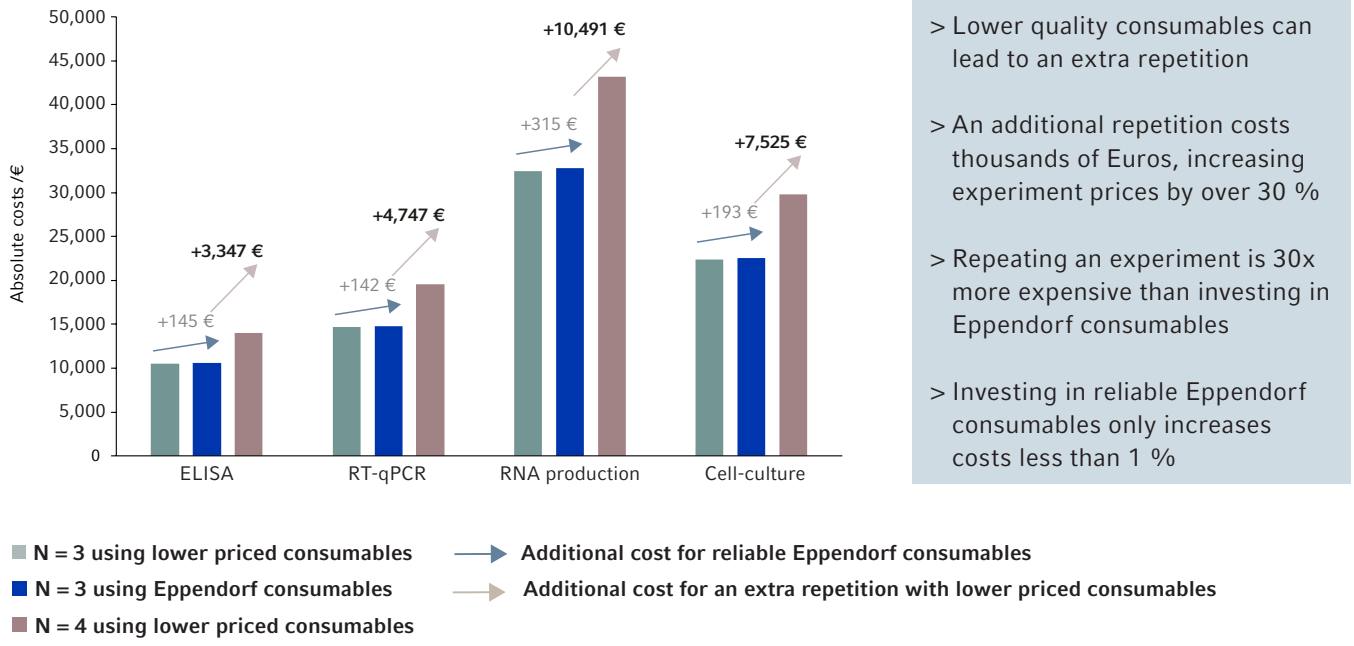


Figure 3: Absolute costs for experiments in a lab working in the private sector when using Eppendorf consumables in triplicates (blue) or lower cost consumables (green) or doing a fourth repetition (red).

It becomes clear that investing in Eppendorf consumables has a negligible impact on the overall cost in absolute terms (only a few hundred euros regardless of the assay type). In contrast, a fourth repetition that might be required or preferred when using lower cost and potentially lower quality consumables is significantly more expensive, as the costs for reagents, maintenance, labor, and energy weigh much more heavily, logically increasing the total costs by nearly one-third (amounting to several thousand euros).

Material and Methods

Cost calculations

Unless otherwise stated, costs were calculated for an experiment with three independent repetitions. All prices are based around experiments that are performed in a lab located in Belgium.

All consumables and their respective quantities required for a single assay were listed (see below). For lower cost consumables, less expansive alternatives were considered. In the cases where Eppendorf does not offer suitable consumables, the same items as from the lower cost group were considered. Prices were adjusted based on the actual number of consumables used. For instance, if a product was sold in units of 100 pieces but only 10 were needed for the assay, the price was proportionally reduced by 90%.

For reagents, the full list price was considered, and the same reagents were considered for every scenario.

For other project costs the following factors were considered: labor, energy consumption, device and lab reparation and maintenance. For energy consumption the prices were based on the average price per kWh and considered equal for both the academic and private sector. If not indicated differently, these other project costs were averaged over the private and academic sector.

For private labs, labor cost was based on the monthly salary for a lab technician as well as a portion of the monthly salary of a lab supervisor (postdoc or senior scientist). Device and lab maintenance was considered as often as recommended by the manufacturer. If not stated otherwise, prices were solely based on private labs.

For academic labs, labor cost was based on the monthly salary of a PhD student. Device and lab maintenance was considered half as frequently compared to private labs.

For statistical analysis, the mean over the cost results for each experiment was calculated with standard deviation. A two-way analysis of variance (ANOVA) and a Bonferroni correction was calculated.

Assays

ELISA

A TNF alpha Human Uncoated ELISA Kit (Invitrogen) was used as a basis for the calculations for an ELISA. Gibco™ Human TNF-alpha recombinant protein was considered as a reagent. One replicate consists of 16 technical replicates. The following consumables were considered in the stated quantity:

Consumables for ELISA	Quantity
1.5 mL microtubes	10
5 mL microtubes	30
2.5 mL positive displacement tips	1
200 µL pipette filter tips	960
Assay plates	None, included in kit.

Consumables for the RT-qPCR	Quantity
2.5 mL positive displacement tips	1
10 µL pipette filter tips	384
200 µL pipette filter tips	384
1000 µL pipette filter tips	10
PCR sealing film	6
real-time PCR-96-well-plates	6
1.5 mL microtubes	25

RT-qPCR

The quality control of the yellow fever vaccine Stamaril® was used as a basis for the RNA workup including RT-qPCR. It includes the kit-based RNA extraction, purification, and quantification. The reagents that were considered were RealStar® Yellow Fever Virus RT-PCR kit 1.0, QIAamp Viral RNA MINI kit, Qiagen® and Gibco™ DPBS. One replicate consists of three technical replicates. The following consumables were considered in the stated quantity.

RNA production

The basis for the mRNA synthesis assay was the in-vitro transcription of Plasmid DNA in a thermocycler and prior assay optimization of plasmid amplification using a 2D PCR.

Reagents considered were molecular grade water (HyClone HyPure Water), Qubit™ 1X sDNA BR assay kit, Qubit™ 1X RNA BR assay kit (Invitrogen) and the according assay tubes, template DNA (Addgene), master mix (Promega), forward and reverse primers (Eurogentec®), DNA purification kit (Promega Wizard® PCR Preps DNA purification system), Riboprobe® system, SV total RNA isolation system (Promega), RNA screen tape, -ladder and -sample buffer (Agilent) as well as Fluorescent nucleotide for RNA labelling (Jena Bioscience). One replicate consists of three technical replicates. The following consumables were considered in the stated quantity:

Consumables for the RNA production	Quantity
2.5 mL positive displacement tips	1
10 µL pipette filter tips	384
200 µL pipette filter tips	384
1000 µL pipette filter tips	10
1.5 mL microtubes	100
2 mL microtubes	100
PCR tube strips	120
skirted PCR plates	25
PCR sealing film	25

Cell-culture

As an example for a cell-culture assay, the *in-vitro* production of a target protein in ExpiCHO cells was used, including plasmid preparation and bacterial amplification, cell expansion, transfection and extraction, protein purification and characterization. Reagents considered were plasmid (Addgene), LB agar powder and LB broth base (Invitrogen), Glycerol (Honeywell), Ampicillin (Sigma-Aldrich®), QIAprep spin miniprep kit (Qiagen), PCR nucleotide mix (Promega), Promega Go Taq Polymerase, forward and reverse primers (Eurogentec®), ExpiCHO expression system and medium (Gibco®), RNA screentap, -ladder and -sample buffer (Agilent), Superose 6 increase 100/300 GL (Cytiva), NuPAGE: 4-12% Bis-Tris protein gels 1.0 mm, LDS sample buffer (4X), Sample Reducing Agent (10X), antioxidant, MES SDS Running Buffer (20X) from Invitrogen, SeeBlue MagicMark™ XP Western Protein standard (Invitrogen), GelCode™ blue safe protein stain (Thermo Scientific™), 10X buffer R Strep-tactin regeneration buffer with HABA and Strep-tactin superflow 50% suspension (IBA), Amicon Ultra-15 centrifugal filters (Millipore®), D-Desthibiotin, polyprep columns (BioRad). One replicate consists of three technical replicates. The following consumables were considered in the stated quantity:

Consumables for the cell-culture assay	Quantity
2.5 mL positive displacement tips	10
1000 µL pipette filter tips	480
200 µL pipette filter tips	240
5 mL serological pipettes	100
10 mL serological pipettes	40
25 mL serological pipettes	20
50 mL serological pipettes	2
1.5 mL microtubes	20
2 mL microtubes	20
50 mL conical tubes	150
15 mL conical tubes	150
0.22 µm syringe filters	50
U-shaped cell-culture flask	25
125 mL single use Erlenmeyer flask	5

Conclusion

Reproducibility, a reduced risk of contamination and cost efficiency are key for labs. Eppendorf consumables deliver high reproducibility and minimize the risk of contamination – although they may appear expensive at first glance.

However, this study found that investing in Eppendorf consumables, which ensure reproducible results and minimize contamination risks, can be worthwhile. The total cost of an experiment will only increase by about 1 % compared to using lower cost alternatives. In contrast, performing an extra repetition, which might be necessary when using lower cost and every so often lower quality consumables, increases the overall cost by nearly a third. This is because other costs, such as energy consumption, labor, reagents, and maintenance, make up a much larger portion of the total cost of an experiment. Project and reagent expenses stay the main cost drivers, no matter the assay type.

Eppendorf high-quality consumables minimize the risk of an extra repetition due to consumable failure (leaching, stability issues, accuracy and precision, lid-tightness, sample recovery and identification), ensuring maximum reproducibility. This results in economic benefits by saving time and money while maintaining excellent result quality.

Literature

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