



THE POTENTIAL OF PCR FOR DETECTING SALMONELLA SPP. IN MEAT AND MEAT PRODUCTS

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Abstract: *This article reviews the potential of the polymerase chain reaction (PCR) for detecting Salmonella spp. in meat and meat products. It examines the importance of selecting Salmonella-specific DNA targets, sample preparation, DNA extraction, and quality controls. Certain components of meat may inhibit the reaction and therefore need to be considered when interpreting results. The review discusses the advantages of PCR for rapid detection while explaining that the detection of DNA does not directly establish the presence of viable bacteria. The literature supports evaluating PCR performance in the context of the entire analytical workflow and the characteristics of the product being tested.*

Keywords: *Salmonella spp., meat, meat products, PCR, real-time PCR, invA, DNA extraction, inhibition, internal control.*

Annotatsiya. *Ushbu maqolada go'sht va go'sht mahsulotlarida Salmonella spp. ni aniqlash uchun polimeraza zanjir reaksiyasining (PZR) imkoniyatlari ko'rib chiqiladi. Salmonella uchun xos DNK nishonlarini tanlash, namunalarni tayyorlash, DNKni ajratib olish va sifat nazoratining ahamiyati tahlil qilinadi. Go'shtning ayrim tarkibiy qismlari reaksiyani ingibitsiya qilishi mumkinligi sababli, natijalarni talqin qilishda bu omil hisobga olinishi lozim. Sharhda PZRning tezkor aniqlashdagi afzalliklari muhokama qilinadi hamda DNKning aniqlanishi o'z-o'zidan yashovchan bakteriyalar mavjudligini tasdiqlamasligi tushuntiriladi. Adabiyotlar tahlili PZR samaradorligini laboratoriya tahlilining barcha bosqichlari va tekshirilayotgan mahsulotning xususiyatlarini hisobga olgan holda baholash zarurligini asoslaydi.*

Kalit so‘zlar: Salmonella spp., go‘sh, go‘sh mahsulotlari, PZR, real vaqt rejimidagi PZR, invA, DNKni ajratib olish, ingibitsiya, ichki nazorat.

Аннотация. В статье рассматриваются возможности полимеразной цепной реакции (ПЦР) для выявления Salmonella spp. в мясе и мясных продуктах. Анализируется значение выбора специфичных для Salmonella ДНК-мишеней, пробоподготовки, выделения ДНК и контроля качества. Некоторые компоненты мяса могут ингибировать реакцию, что необходимо учитывать при интерпретации результатов. В обзоре обсуждаются преимущества ПЦР для быстрого выявления бактерий и поясняется, что обнаружение ДНК само по себе не подтверждает наличие жизнеспособных бактерий. Анализ литературы обосновывает необходимость оценки эффективности ПЦР с учётом всего процесса лабораторного анализа и особенностей исследуемого продукта.

Ключевые слова: Salmonella spp., мясо, мясные продукты, ПЦР, ПЦР в реальном времени, invA, выделение ДНК, ингибирование, внутренний контроль.

Introduction. Reliable detection of *Salmonella* spp. is important for assessing the microbiological safety of meat and meat products. In laboratory testing, both the accuracy of the result and the time required to obtain it have practical significance. Bacteriological methods require successive stages because they involve growing the microorganism on culture media and confirming the recovered isolate. Molecular methods can accomplish some analytical tasks more rapidly by detecting genetic material specific to the microorganism. The polymerase chain reaction (PCR) involves amplifying and detecting a selected segment of DNA. *Salmonella* detection relies on targeting gene sequences specific to the organism. The study by Rahn et al. on the *invA* gene demonstrated the potential of this approach for detecting *Salmonella* [1]. However, meat is a complex sample matrix. Some of its components may affect DNA extraction efficiency or interfere with the PCR reaction.

Consequently, rapid instrumentation and a specific target do not, on their own, ensure a reliable result. This article aims to review the potential of PCR for detecting *Salmonella* in meat and meat products and the main factors affecting the results.

Materials and Methods. The study was conducted as a narrative literature review. Scientific publications addressing *Salmonella*-specific molecular targets, interlaboratory evaluation of PCR assays, and the application of real-time PCR to food samples were selected. Preparation of meat samples for rapid molecular testing was examined using the study by Fachmann et al. [1–4]. The sources were examined through comparative analysis and synthesis of published evidence. The analysis covered target gene selection, sample preparation, enrichment where required, DNA extraction, amplification, and interpretation of results. Conventional and real-time PCR detection formats, the functions of controls, and overall turnaround times were compared. Published findings were evaluated within the respective sample sets and testing conditions. Results obtained using different protocols were not pooled to calculate a single sensitivity estimate for PCR. No new laboratory experiments were conducted.

Results. Selection of *Salmonella*-specific targets. The detection capability of PCR depends on the selected DNA sequence. The *invA* gene is one of the extensively studied targets for *Salmonella* detection. Rahn et al. demonstrated that detecting a segment of this gene could be used to distinguish *Salmonella* [1]. An *invA*-targeted assay was also evaluated by Malorny et al. in 2003. Sixteen laboratories participated in the study using coded DNA samples [2]. This work enabled assessment of the analytical performance of the assay across laboratories. Not all PCR assays for *Salmonella* use the same target. In 2004, Malorny et al. evaluated real-time PCR targeting the *ttr* region in food samples. The assay showed 100% agreement with the culture method in 110 samples, which included chicken rinses and minced meat [3]. This finding applies to the particular assay and sample set and should not be treated as a universal result for all PCR tests. Sample preparation and DNA extraction. An

important stage of molecular testing is preparing material suitable for PCR. The presence of bacteria in a sample and the recovery of their DNA in a form suitable for amplification are separate issues. During DNA extraction, it is important to retain the target material while reducing the effects of substances that interfere with the reaction. Heme compounds, myoglobin, and fats in meat may interfere with PCR. Fachmann et al. focused on reducing these effects during sample preparation. Their method, evaluated in pork, combined a short enrichment step with a specific sample preparation procedure and assessed detection in less than five hours [4]. This finding shows that detection speed depends on sample preparation as well as DNA amplification. Conventional and real-time PCR. In conventional PCR, the amplified product is assessed after the reaction is complete. In real-time PCR, the signal is monitored as the reaction proceeds [2, 3]. In both formats, target specificity, DNA quality, and controls are important. The ability to quantify a real-time PCR signal does not automatically make that signal equivalent to the number of viable bacteria in a product. Importance of quality controls. An internal amplification control helps assess whether the reaction is inhibited or has failed. A positive control is used to verify target detection by the assay, whereas a negative control is used to check for possible contamination with extraneous DNA [2, 3]. When no target signal is observed, the controls must meet the acceptance criteria. If the internal control is invalid, the absence of a signal cannot be interpreted as a reliable negative result. In such cases, technical causes should be investigated and testing repeated according to the instructions for the selected assay.

Discussion. The literature identifies rapid detection of *Salmonella*-specific DNA as the principal practical advantage of PCR. Nevertheless, detection speed cannot be evaluated solely by the duration of the instrument run. Sample preparation, enrichment where required, DNA extraction, and evaluation of controls also contribute to the overall turnaround time. The different turnaround times reported by Malorny et al. and Fachmann et al. reflect differences in the organization of their

analytical workflows [3, 4]. When evaluating the potential of PCR, analytical testing must be distinguished from the complete process of testing a product. An assay that performs well with prepared DNA does not fully characterize the effectiveness of sampling and DNA extraction. Accordingly, results from interlaboratory DNA testing and results obtained from meat samples should be interpreted in relation to their respective purposes [2, 3]. Another important issue is the distinction between DNA detection and bacterial viability. A positive signal from conventional DNA-based PCR does not, by itself, establish that bacteria are viable. Bacteriological testing remains important when a viable culture is needed. PCR results must therefore be interpreted in relation to the purpose of the examination. The type of meat, the processing applied to the product, and its composition may affect sample preparation. High agreement or a short turnaround time achieved in one study cannot be directly extrapolated to another product or assay. The performance of the selected assay in the relevant product should be assessed. In future comparative studies, PCR results should be recorded together with the DNA preparation method, control status, and overall testing time. These data can help identify the conditions under which PCR provides rapid information and the circumstances requiring additional sample preparation or repeat testing.

Conclusion. PCR enables rapid detection of *Salmonella*-specific DNA in meat and meat products. Its reliability depends on target specificity, sample preparation quality, DNA extraction, and reduction of factors that interfere with the reaction. Correct evaluation of controls is particularly important for determining the validity of a negative result. The distinction between DNA detection and recovery of a viable culture should be considered when interpreting PCR results. Published estimates of speed and agreement should be evaluated within the relevant product and protocol. These considerations provide a theoretical basis for future comparison of PCR with bacteriological methods and for improving the analytical workflow.

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