# Analysis of auto-control programs (PAC) in dairy industries in the south region of the Triângulo Mineiro

## Análise dos programas de autocontrole (PAC) em indústrias de leite e derivados da região sul do Triângulo Mineiro

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### ABSTRACT

The implementation of the Self-Control Programs - PAC in seven milk processing industries in the southern region of the Triângulo Mineiro was evaluated. The research methodology was based on the collection of data from in loco inspections carried out by the state agency, microbiological reports and questionnaires applied to those responsible for quality control. To determine the evolution of PACs by industry, the results were tabulated by period: absence of PAC; PAC implementation; PAC consolidation, and post-outage. The overall compliance rates for each industry were satisfactory. The main non-conformities found were related to the physical structure, microbiological analyzes, and hygienic habits. The results of the questionnaire indicated that those responsible carry out their activities based on their experiences, but lack practical and theoretical knowledge about PACs. The interviewees reported support from public agencies and that carry out autonomous studies. The efficiency and evolution of PAC in industries were attested, even with the impact of the pandemic. The importance of inspection agencies for technical support to these industries in the implementation of PACs was highlighted.

**Keywords:** Quality control; Inspection; Dairy products; Legislation.

### RESUMO

Foi avaliada a implementação dos Programas de Autocontrole - PAC em sete indústrias beneficiadoras de leite da região Sul do Triângulo Mineiro. A metodologia da pesquisa baseou-se em coleta de dados de inspeção in loco realizada pelo órgão estadual, laudos microbiológicos e questionários aplicados aos responsáveis pelo controle de qualidade. Para determinar a evolução dos PAC por indústria, foram tabulados os resultados por período: ausência de PAC; implantação de PAC; consolidação de PAC e pós-paralisação. Os índices de conformidade geral de cada indústria foram satisfatórios. As principais não conformidades encontradas foram relacionadas à estrutura física, análises microbiológicas e hábitos higiênicos. Os resultados do questionário indicaram que os responsáveis realizam suas atividades com base em suas experiências, mas falta conhecimento prático e teórico sobre os PAC. Os entrevistados relataram apoio de órgãos públicos e que realizam estudos autônomos. Foram atestadas a eficiência e evolução dos PAC nas indústrias, mesmo com o impacto da pandemia. Evidenciou-se a importância das agências de inspeção para apoio técnico a estas indústrias na implantação dos PAC.

**Palavras-chave:** Controle de qualidade; Fiscalização; Laticínios; Legislação.

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## INTRODUCTION

To make healthy and safe food available to the entire population, strict compliance with the legislation and quality parameters that govern the dairy sector, regardless of the country, is necessary (GONÇALVES et al., 2019). One example of quality management is the Auto-Control Programs (PAC), which are mandatory for the sanitary registration of establishments that produce products of animal origin. In Minas Gerais, Ordinance No. 1659 of September 9, 2016, provides for the mandatory implementation of PAC in establishments of products of animal origin (MINAS GERAIS, 2016a).

The establishments that have the mandatory implementation of PAC are those that handle products of animal origin such as milk, eggs, fish, honey, and meat. PAC are defined as procedures described, developed, implemented, monitored, and verified by the establishment, to ensure the safety, identity, quality, and integrity of its products, which include, but are not limited to, pre-treatment programs. Requirements, Good Manufacturing Practices - GMP, Standard Operating Hygiene Procedures - PPHO and Hazard Analysis and Critical Control Points - HACCP, or equivalent programs recognized by the Ministry of Agriculture, Livestock and Supply (BRASIL, 2017).

As the PAC are relatively recent for establishments, their implementation depends on technical support from inspection bodies and the knowledge of the technical managers of the industries. It is also important to monitor and diagnose the effectiveness of its implementation. The concern of milk and dairy establishments with the effective implementation of quality programs, such as PAC, is relevant since milk and dairy products are often involved in food outbreaks, due to factors such as poor quality of raw feedstock; excessive handling during processing; processing failures (such as in the pasteurization step); cold chain problems.

As PAC are relatively recent, their implementation depends on technical support from supervisory agencies and on the knowledge of the industrial technicians in charge. This study aimed to evaluate PAC efficiency in seven dairy processing industries in the southern Triângulo Mineiro region through inspection records from the State Inspection Service and microbiological product reports from 2016 to 2021, in addition to knowing the profile and actions of those responsible for the quality control of these industries regarding PAC.

The specific objectives are to evaluate the microbiological quality of food produced by the industries, verify the hygienic and sanitary conditions during the process of implantation and application of the PACs and raise the main challenges of the industries and their technicians about the PACs.

## MATERIALS AND METHODS

It is an applied research of qualitative-quantitative, descriptive, and transversal character. It was carried out in the field with a questionnaire and collection of state inspection data from seven dairy industries located in the southern region of the Triângulo Mineiro. The inspection data used in this research were cordially provided under a term of responsibility and confidentiality.

The seven dairy industries were classified as Processing Plant (UB) pasteurized milk processing (UB); Dairy factories, (L1; L2; L3, and L4) that produce fresh Minas cheese, ricotta cheese, mozzarella and yogurt, Cheese factory (Q) and Dairy Warehouse (E) that handles artisanal Minas cheese.

The inspections were carried out on-site by inspectors from the state of Minas Gerais from January 2017 to May 2021. Due to the pandemic situation in Brazil, there was a stoppage in the in-person inspection activities in March 2020 due to a state decree of public calamity. In February 2021, with the publication of a new state decree and a contingency plan published by the inspection agency, in-person activities returned. After the return of routine activities in February 2021, the monthly in-person inspection was carried out in each of the industries with the completion of an entire cycle (4 months) of verification worksheets to assess the situation of the industries in PAC consolidation and the effects caused by the absence of inspection for eleven months.

In parallel with the inspection activities, product samples from the dairy industries were collected for microbiological analyses by inspectors from the state of Minas Gerais and by those responsible for the Quality Control Sectors during the absence of inspectors from the inspection service. The analyses were carried out in Official Laboratories and/or in those authorized by the Minas Gerais state inspection agency, accredited to the ABNT NBR ISO/IEC 17025:2017 by the CGCRE/INMETRO – General Coordination of Accreditation/National Institute of Metrology, Quality, and Technology (ABNT, 2017). The microbiological reports comprised the period from January 2016 to May 2021.

### PAC inspections by the sanitary inspection service

The frequency with which inspectors inspect the PAC in establishments to fill in the verification worksheets and other assignments is monthly. The records are carried out following the internal protocols described in the Service Instruction of the inspection

agency (MINAS GERAIS, 2016b). Filling out the spreadsheets in Annexes I (Temperature control and control of residual chlorine and pH of the supply water), IV (Document verification); V (PAC Inspection Elements 1, 2, 3, 4, 8, 9, and 10), VI (PAC Inspection Elements 5, 6, 7, 8, 9 and 10) and IX (PAC Inspection Elements 8, 9, 10, 11, 13 and 14) is performed through visual on-site observation, including the visualization of the laboratory analysis records, technical reports and PAC elements recorded by the establishment.

The inspection elements are 1. Industrial Facilities and Equipment, 2. Changing Rooms, Toilets, and Sanitary Barriers, 3. Lighting, 4. Ventilation, 5. Water Supply, 6. Wastewater, 7. Integrated Pest Control, 8. Cleaning and Sanitation, 9. Hygiene, Hygienic Habits, and Worker Health, 10. Sanitary Procedures in Operations, 11. Control of Raw Materials, Ingredients, and Packaging, 13. Laboratory Control and Analysis and 14. Control of Product Formulation.

To complete the document verification worksheet (Annex IV), the inspection service records are evaluated by Annexes I, V, VI, and IX, and the establishment records are completed by the establishment's quality control sector. The evaluation periods were defined to represent the historical evolution of each industry. The period from March 2017 to December 2018 corresponded to the PAC implementation phase. The period from January 2019 to March 2020 was considered the PAC consolidation phase. The period from February 2021 to May 2021 was characterized as post-stoppage when on-site inspection activities were resumed.

**Data collection of microbiological analyses in the industries**

For the PAC diagnosis and monitoring in each of the dairy industries, microbiological reports available at the inspection agency from 2016 to 2021 were analyzed, considering that in 2016 the PAC had not yet been implemented. The number of analyses performed during the study period was 130.

The microbiological standards analyzed were those recommended by the current legislation in place in the state of Minas Gerais, and by the official protocols established in the Normative Instructions of the Ministry of Agriculture, Livestock and Supply - MAPA n° 62/2003 (BRASIL, 2003), n° 30/ 2018 (BRASIL, 2018a) and n° 76/2018 (BRASIL, 2018b).

**Application of questionnaires to those responsible for the industries**

In February 2021, a questionnaire was given to those responsible for the quality control of the industries, consisting of two open questions about professional experience and 10 multiple-choice questions for the diagnosis of the professional's profile and their challenges with PAC. The work was submitted to the Ethics Committee of the Federal University of Triângulo Mineiro (UFTM) and approved according to decision No. 4.284.267.

**Analysis of the results**

Descriptive statistics were adopted for data processing and analysis. The results were presented in Table and Figure format, using Microsoft Office Excel version 365.

**RESULTS AND DISCUSSION**

**Results of inspections carried out in the industries**

There was 100% compliance with residual chlorine and pH in the supply water and temperatures - Annex I in the seven industries investigated in all periods, considering that it is completed in all inspections.

During data collection, industry L3 started its activities in April 2018 and ended its activities at the end of March 2020. Due to this situation, it was not possible to present industry data in the post-stoppage period (Table 1).

**Table 1** - Compliance rates (%) of inspections (Annexes I, IV, V, VI, and IX) and microbiological standards of products in the industries, for PAC evaluation.

| Industry | Period | Annex I and V | Annex I and VI | Annex I and IX | Annex I and IV | Microbiological Standards |
|---|---|---|---|---|---|---|
| L3 | Implementation | 73% | 89% | 87% | - | 95% |
| | Consolidation | 89% | 91% | 97% | 72% | 50% |
| | PAC Absence | | | | | 100% |
| Q | Implementation | 95% | 95% | 96% | 44% | 100% |
| | Consolidation | 87% | 86% | 96% | 97% | 100% |
| | PAC Absence | | | | | 92% |
| E | Implementation | 98% | 100% | 99% | 89% | 84% |
| | Consolidation | 97% | 97% | 98% | - | 100% |
| | Post-stoppage | 95% | 100% | 100% | 76% | 100% |
| | PAC Absence | | | | | 91% |
| L2 | Implementation | 72% | 67% | 79% | 22% | 95% |
| | Consolidation | 92% | 91% | 97% | 29% | 85% |
| | Post-stoppage | 98% | 84% | 95% | 92% | 92% |
| | Implementation | 92% | 94% | 96% | 49% | 76% |
| L4 | Consolidation | 98% | 97% | 100% | 73% | 90% |
| | Post-stoppage | 95% | 100% | 97% | 100% | 100% |
| | PAC Absence | | | | | 100% |
| UB | Implementation | 96% | 98% | 97% | 95% | 56% |
| | Consolidation | 100% | 99% | 97% | 100% | 100% |
| | Post-stoppage | 100% | 94% | 94% | 99% | 100% |
| | PAC Absence | | | | | 100% |
| L1 | Implementation | 79% | 85% | 85% | 42% | 77% |
| | Consolidation | 87% | 86% | 98% | 97% | 100% |
| | Post-stoppage | 79% | 97% | 95% | 82% | 100% |

UB: Milk Processing Unit; L1, L2, L3, and L4 – Dairy Factories; E – Dairy warehouse; Q – Cheese factory. Annex I - Temperature Control and Control of Residual Chlorine and Water Supply pH; Annex IV - Document Verification. Annex V – in loco verification of PAC Inspection Elements 1, 2, 3, 4, 8, 9 and 10; Annex VI – in loco verification of PAC Inspection Elements 5, 6, 7, 8, 9 and 10; Annex IX - in loco verification of PAC Inspection Elements 8, 9, 10, 11, 13 and 14.

Source: Prepared by the author.

Despite the improvements in the indices achieved by industry L3 industry for structure, hygiene, pest control, and wáter and effluent quality and quality of raw material and product - Annexes V, VI, and IX, there were difficulties in PAC execution (Table 1), as the compliance average reached an overall index of 82.5% when considering the PAC implementation and consolidation. There was no documentary verification during the implementation period, as the recording took place at the end of 2018. There was a reduction in compliance with microbiological standards in the PAC consolidation period, indicative of lower performance in PAC quality control and maintenance.

In the case of industry Q, no data were presented in the post-stoppage period as its inspection model was changed in 2019, and the PAC were no longer required for its operation. Good results were observed in the PAC consolidation period about documentary verification - Annex IV, with an absolute increase of 53% in the compliance rate when considering the PAC implementation and consolidation periods. In contrast, there were reductions in compliance for structure, hygiene, quality of supply wáter and effluents - Annexes V and VI, respectively, of 8% and 9%, which is an indication of the importance of the on-site industry analysis. The compliance average reached an overall index of 90.5% when considering the PAC implementation and consolidation periods (Table 1).

In industry E (Table 1), good results were observed in the PAC consolidation period. In the case of structure and hygiene - Annex V, there was a decrease of 3% in the index when comparing the implementation and post-stoppage periods. The compliance rates, however, remained high. During the implementation period, there was an 8% drop in compliance with microbiological standards, but in the consolidation and post-stoppage periods, there was 100% compliance. Regarding document verification - Annex IV, there was a setback (13% reduction) in compliance when comparing the implementation and post-stoppage periods. There was no documentary verification during the consolidation period, as the state inspection agency did not have the necessary financial resources to carry out its activities for four months.

Industry E already presented quality certification as required by the market before the requirement of PAC, which meant a positive differential for the company. The compliance average reached an overall index of 95% when considering the implementation, consolidation, and post-stoppage periods (Table 1).

In industry L2 (Table 1), there were initial difficulties in its routine recording activities, quality control, and implementation when comparing the compliance rates to other industries. During the consolidation period, there was a significant evolution in compliance for structure, hygiene, pest control and quality of material water and effluents, and quality of raw material and product - Annexes V, VI, and IX. Microbiological standards reached compliance rates close to or above 90%. Analyzing the indices obtained in the post-stoppage period, there was progress in comparison to the indices from the implementation period, especially for documentary verification - Annex IV, with an increase of 70%. The compliance average reached an overall index of 80% when considering the implementation, consolidation, and post-stoppage periods.

Evaluating the results of industry L4 (Table 1), the results indicated good performance and evolution in compliance, with emphasis on documentary verification - Annex IV due to the 51% increase in compliance when comparing the implementation and post-stoppage periods. There were also significant improvements in microbiological standards, which reached 100% compliance in the post-stoppage period. The compliance average reached an overall index of 90.5% in industry L4 when considering the implementation, consolidation, and post-stoppage periods. The compliance results were equal to or greater than 95% in the post-stoppage period, indicating that the industry actually consolidated and efficiently maintained its PAC, even without an on-site inspection. This was also observed in industries Q and E.

The compliance results found in industry L1 (Table 1) were low in the implementation period when compared to other periods, despite 100% compliance with microbiological standards obtained before the PAC implementation and maintained in the consolidation and post-stoppage periods. There was progress in compliance rates in the consolidation period for all items, with emphasis on documentary verification - Annex IV, which increased by 55%. In the post-stoppage period, there was a decrease in compliance for document verification, structure, hygiene, and quality of raw material and product - annexes IV, V, and IX, which represented the need for on-site monitoring. The compliance average reached an overall index of 86.8% when considering the implementation, consolidation, and post-stoppage periods.

Evaluating the results of industry UB (Table 1), it already had satisfactory compliance rates for all items before PAC implementation. However, there was an isolated occurrence of non-compliance in its microbiological standards only in the

implementation phase, which is supposed to be an extraordinary case that is not compatible with all the satisfactory indices obtained by the industry for all periods. The compliance average reached an overall index of 95.4% when considering the implementation, consolidation, and post-stoppage periods. This industry can be considered an example of efficient PAC compliance and maintenance.

The general compliance index averages for each industry regarding the PAC implementation and consolidation periods were above 80%, which is considered a satisfactory result. It can be considered that the investigated dairy industries went through a period of learning (implementation), accompanied by execution (consolidation) and autonomous execution (post-stoppage), but some industries, such as E and UB, stood out.

Borsato et al. (2016) described in their work "Implementation of auto-control documents in a food sector cooperative" that the implementation of auto-control favors the guarantee of product quality, technological growth, and team growth, with awareness of the importance and need to maintain the safety of processed foods. Thus, in this study, from the non-conformities pointed out by hygiene, pest control, and quality of water supply and effluents - Annex VI, there is a need for this awareness on the part of industries in regards to the sense of organization in all the production process stages.

Benedito Junior et al. (2019) found that dairy industries in Minas Gerais have a great deficiency inadequately demonstrating and documenting PAC items. This reality was also found during the PAC implementation period in the seven dairy industries evaluated in this study. During the consolidation period, however, there was a reduction in non-conformities found in the records, which indicates an improvement in industry records. In the post-stoppage period, there was a setback in quality control, which highlights the need for constant monitoring through inspection for continuous improvements in the industrial production process.

In general, the main non-conformities found in the investigated industries were related to the physical structure, process control (analyses), and, above all, the habits and cleanliness of the handlers. There was also a high turnover of employees in the industries, a situation that requires the industry to continuously offer training courses in hygiene and quality.

Borsato (2016) reported in his study the resistance of part of the employees at the beginning of the implementation of the PAC, as it required a change in routine and the need to record activities that were not carried out before. In the present study, it was also

observed that the process of implementing the PACs in the industries generated discomfort in the routine, and the non-conforming items related to the employees are recurrent, due to the already mentioned employee turnover, which compromises the quality control activities carried out in the industries.

It was possible to assess that all industries now have greater and better control of the production process, making it easier for inspectors and those responsible to identify mistakes and successes during routine operations, which facilitated the traceability of the production chain and compliance with legislation.

**Microbiological results of industrial products**

During PAC absence (2016), four non-compliant microbiological reports were obtained (one due to coliforms at 45°C and three due to molds and yeasts). During the implementation period (2017-2018), 28 non-conformities were obtained (one due to *Listeria monocytogenes*; five due to coagulase-positive staphylococci; eleven due to coliforms at 35°C; five due to coliforms at 45°C and six due to molds and yeasts). During the consolidation period (2019-2020), there were five non-compliant microbiological reports (three due to coliforms at 35°C; one due to coliforms at 45°C, and one due to molds and yeasts). During the post-stoppage period, there were only three non-compliant microbiological reports due to molds and yeasts. No non-compliant analyses were found for Standard Plate Count, *Enterobacteriaceae sp.*, and *Salmonella sp.*

The classification of the 15 dairy industries in Minas Gerais in the study by Benedito Junior et al. (2019) was "very bad" and "bad" according to the degree of compliance with the legislation, reporting deficiencies in the implementation of the programs. In that work, the need for a greater commitment from the industries to meet the legal requirements and guarantee the rights of consumers, as well as the inspection bodies to be more rigorous and enforce the legislation, is highlighted.

Despite the difficulties faced by the industries investigated in this research for the implementation of PACs over the analyzed periods, the results of the microbiological analyzes 40 reflect improvements in their PACs, with the support of the quality control team and other employees of the industries

The non-conformities identified by the microbiological analysis reports when comparing the PAC consolidation and implementation periods showed that the PAC

contributed to the increased microbiological safety of the products sold by the dairy industries.

**Results of the questionnaires given to those responsible for the industries**

Seven people responsible for the Quality Control Sector of the industries were interviewed. The guardians themselves filled in the questionnaires, except for two interviewees, who asked the researcher to fill them in, based on their verbal responses.

During the application of the questionnaires to those responsible for the Quality Control Sector, a median of 13 (thirteen) years of working time exercised by those responsible for quality control in the industries of the study was found; and the median of 25 (twenty-five) years of experience in the food industry. The training of those responsible is very diverse: 43% do not have a degree, 43% have a degree in the area of Human Sciences and 14% have a degree related to the area of food. Of those interviewed, 43% were assisted by extension workers from EMATER-MG and 14.3% by a technical advisory company.

The extension workers are a team of two EMATER-MG servants, who help in the elaboration and implementation of PACs, and who have training in veterinary medicine and domestic economics, respectively (Table 2).

There was a great diversity of training for the elaboration of PACs, but all of them have considerable professional experience in the food sector. It is worth mentioning the relevant role of technical support provided by EMATER-MG to industries L3, L4, and Q, which are classified as family agro-industries and cheese dairy. In no industry, the interviewees responsible for the Quality Control Sector are qualified to be technically responsible for the industry, because there is a requirement for training in Veterinary Medicine. However, industries L3, L4, and Q are classified in the state registry as cheese dairy or the denomination of family agroindustry, which allows them to not have the requirement that the technician in charge has training as a Veterinary Doctor. These industries, in particular, receive technical assistance from the Minas Gerais Technical Assistance and Rural Extension Company EMATER-MG, and the owners are responsible for the entire food production process. All respondents stated that they sought guidance in the preparation of PACs, 50% from public agencies, 33% from self-employed studies, 8% from a private consulting firm, and 9% from professional colleagues.

**Table 2**. Academic background of those responsible for the elaboration of PACs in the milk and dairy industries located in the southern region of the Triângulo Mineiro.

| Responsible for preparing | Industry |
|---|---|
| Food engineer | L1 |
| Management | L2 |
| Extensionist and High school | L3 |
| Extensionist and Agribusiness manager | L4 |
| Extensionist and Management | Q |
| Consulting company | E |
| Letrologist and Agricultural engineer | UB |

UB: Milk Processing Unit; L1, L2, L3, and L4 – Dairy Factories; E – Dairy warehouse; Q – Cheese factory

Source: Prepared by the author.

For the implementation of PACs, a percentage of 14% of respondents said they had not received guidance from the inspection body. Of those interviewed who received guidance (86%), support came from the following sources: public agencies, independent studies, professional colleagues, and a private consulting firm.

During the elaboration and implementation of PACs, the difficulties encountered were 25% in theoretical knowledge about PACs, 34% in practical knowledge about PACs, 8% lack of commitment from management, 8% lack of commitment from employees, 8% lack of training and 17% due to financial difficulties. Silva, Batista, and Bainy (2019) report that the company must be aligned with the concepts of quality, a fact that will interfere with the actions of the management identified as the main responsible for the difficulties in implementing and maintaining quality programs. Thus, it was observed that those responsible for the Quality Control Sector of the industries are the main ones responsible for the elaboration and implementation of the self-control programs

In view of the results obtained in the applied questionnaires, it was found that those responsible for quality control carry out their activities based on their experiences, but that there is still a lack of practical and theoretical knowledge about PACs, which may be related to the lack of qualification and training. In the area of hygiene and food quality control. Despite the unfavorable situation, those responsible find support in public agencies and are committed to carrying out autonomous studies.

Borsato (2016) applied questionnaires to the quality control team in dairies in Minas Gerais and the results indicated that the implementation of self-control favors the technological growth of the industry and the team, even with resistance from employees at the beginning of the implementation because of the change in routine and the need to record activities that were not performed before. From the analysis of these reports, it was found that the new is always difficult, but generates good results, taking everyone out of the routine and instigating the search for knowledge, and improving the quality of the food production process.

## FINAL CONSIDERATIONS

The efficiency of the PAC in the investigated industries was attested to as they progressed, even with the impact of the pandemic, with compliance rates above 80%, which was also reflected in the microbiological reports of the products. The importance of the inspection agency in the inspection and technical support to the industries was verified.

According to the responses to the questionnaires given to those responsible for the industries, it was noted that most of them do not have academic and/or professional training. However, they do have experience in the food area and seek to improve the PAC implementation processes through theoretical references and consultations with other sources or support agencies, such as EMATER. For future work, it is suggested to expand the research on PAC to other regions and research the application of the program in other activities, such as refrigeration, fish industries, and egg production.

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