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CHEMICAL PROCESSES APPLIED TO THE PRESERVATION OF ARTISANAL NATURAL JUICES

PROCESSOS QUÍMICOS APLICADOS À CONSERVAÇÃO DE SUCOS NATURAIS ARTESANAIS

PROCESOS QUÍMICOS APLICADOS A LA CONSERVACIÓN DE JUGOS NATURALES ARTESANALES

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ABSTRACT

Chemical preservation processes constitute important tools for microbiological control and for extending the shelf life of artisanal natural juices, especially in production contexts characterized by technological and operational limitations. These methods are based on the application of chemical agents with antimicrobial activity, acting through specific mechanisms such as medium acidification, disruption of cell membranes, inhibition of essential enzymatic systems, and induction of oxidative stress, resulting in microbial inactivation or growth inhibition. Among the main chemical processes employed in juice preservation are the use of organic acids, chemical preservatives authorized by sanitary legislation, sanitizing agents applied during the hygienization of raw materials, surfaces, and equipment, as well as, in specific situations, compounds such as sulfites and oxidizing agents. The effectiveness of these processes depends on multiple factors, including the concentration of the chemical agent, contact time, pH, food matrix composition, and the intrinsic resistance of the microorganisms present. From a technological standpoint, chemical processes present relevant operational advantages, such as ease of application, relatively low cost, and high efficiency against vegetative microorganisms, which explains their widespread adoption in both industrial and artisanal systems. However, their use may be associated with important limitations, including negative impacts on sensory attributes, regulatory restrictions regarding

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maximum usage limits, risks arising from improper application, and increasing consumer rejection of products with added chemical substances. Moreover, chemical processes applied in isolation rarely ensure adequate levels of microbiological safety, particularly against more resistant microorganisms. Thus, the judicious and technically grounded application of chemical processes, integrated with good manufacturing practices and combined preservation strategies based on the hurdle technology concept, constitutes an efficient approach to ensuring the microbiological safety, stability, and quality of artisanal natural juices.

Keywords: Juice Preservation. Chemical Additives. Artisanal Processing.

RESUMO

Os processos químicos de conservação constituem importantes ferramentas no controle microbiológico e na extensão da vida útil de sucos naturais artesanais, sobretudo em contextos produtivos caracterizados por limitações tecnológicas e operacionais. Esses métodos fundamentam-se na aplicação de agentes químicos com capacidade antimicrobiana, atuando por mecanismos específicos, como acidificação do meio, desorganização da membrana celular, inibição de sistemas enzimáticos essenciais e indução de estresse oxidativo, resultando na inativação ou inibição do crescimento microbiano. Entre os principais processos químicos empregados na conservação de sucos destacam-se o uso de ácidos orgânicos, conservantes químicos autorizados pela legislação sanitária, sanitizantes aplicados nas etapas de higienização de matérias-primas, superfícies e equipamentos, bem como, em situações específicas, compostos como sulfitos e agentes oxidantes. A eficácia desses processos depende de múltiplos fatores, incluindo concentração do agente químico, tempo de contato, pH, composição da matriz alimentar e resistência intrínseca dos microrganismos presentes. Do ponto de vista tecnológico, os processos químicos apresentam vantagens operacionais relevantes, como facilidade de aplicação, baixo custo relativo e elevada eficiência frente a microrganismos vegetativos, o que explica sua ampla adoção em sistemas industriais e artesanais. Contudo, sua utilização pode estar associada a limitações importantes, tais como impactos negativos sobre atributos sensoriais, restrições regulatórias quanto a limites máximos de uso, riscos decorrentes de aplicação inadequada e crescente rejeição por parte de consumidores que demandam produtos com menor adição de substâncias químicas. Ademais, processos químicos aplicados de forma isolada raramente asseguram níveis adequados de segurança microbiológica, especialmente frente a microrganismos mais resistentes. Assim, a aplicação criteriosa e tecnicamente fundamentada dos processos químicos, integrada às boas práticas de fabricação e a estratégias combinadas de conservação baseadas no conceito de tecnologia de barreiras, constitui abordagem eficiente para garantir a segurança microbiológica, a estabilidade e a qualidade de sucos naturais artesanais.

Palavras-chave: Conservação de Sucos. Aditivos Químicos. Processo Artesanal.

RESUMEN

Los procesos químicos de conservación constituyen herramientas importantes en el control microbiológico y en la extensión de la vida útil de los jugos naturales artesanales, especialmente en contextos productivos caracterizados por limitaciones tecnológicas y operativas. Estos métodos se basan en la aplicación de agentes químicos con capacidad antimicrobiana, que actúan mediante mecanismos específicos como la acidificación del medio, la desorganización de la membrana celular, la inhibición de sistemas enzimáticos esenciales y la inducción de estrés oxidativo, lo que resulta en la inactivación o inhibición del crecimiento microbiano. Entre los principales procesos químicos empleados en la conservación de jugos se destacan el uso de ácidos orgánicos, conservantes químicos autorizados por la legislación sanitaria, agentes sanitizantes aplicados en las etapas de

higienización de materias primas, superficies y equipos, así como, en situaciones específicas, compuestos como sulfitos y agentes oxidantes. La eficacia de estos procesos depende de múltiples factores, entre ellos la concentración del agente químico, el tiempo de contacto, el pH, la composición de la matriz alimentaria y la resistencia intrínseca de los microorganismos presentes. Desde el punto de vista tecnológico, los procesos químicos presentan ventajas operativas relevantes, como facilidad de aplicación, bajo costo relativo y alta eficiencia frente a microorganismos vegetativos, lo que explica su amplia adopción en sistemas industriales y artesanales. Sin embargo, su utilización puede estar asociada a limitaciones importantes, tales como impactos negativos sobre los atributos sensoriales, restricciones regulatorias en cuanto a los límites máximos de uso, riesgos derivados de una aplicación inadecuada y un rechazo creciente por parte de consumidores que demandan productos con menor adición de sustancias químicas. Además, los procesos químicos aplicados de forma aislada rara vez aseguran niveles adecuados de seguridad microbiológica, especialmente frente a microorganismos más resistentes. Así, la aplicación cuidadosa y técnicamente fundamentada de los procesos químicos, integrada a las buenas prácticas de manufactura y a estrategias combinadas de conservación basadas en el concepto de tecnología de barreras, constituye un enfoque eficiente para garantizar la seguridad microbiológica, la estabilidad y la calidad de los jugos naturales artesanales.

Palabras clave: Conservación de Jugos. Aditivos Químicos. Proceso Artesanal.

1 INTRODUCTION

The use of chemical processes in the conservation of artisanal natural juices is one of the most widespread strategies for microbiological control and the extension of the shelf life of these products, especially in production systems with technological and structural limitations. The high water activity, the availability of nutrients and, in many cases, the less controlled processing conditions make juices highly susceptible to microbiological deterioration, favoring the use of chemical additives as an alternative for rapid implementation and high antimicrobial efficiency (Franco; Landgraf, 2008; Davidson; Taylor, 2007). In this context, chemical preservatives play a central role in ensuring product stability throughout storage and distribution.

From a technological and economic point of view, chemical additives have relevant operational advantages. The application of organic acids, authorized preservatives and other antimicrobial agents makes it possible to significantly extend the shelf life of juices, reducing losses due to spoilage and enabling the expansion of consumer markets. This extension of shelf life directly impacts profitability, by reducing waste and enabling greater logistical flexibility, aspects that are particularly attractive for artisanal producers seeking economic sustainability (Davidson; Taylor, 2007). In addition, the predictability of the antimicrobial effect of these compounds contributes to greater microbiological standardization of the final product.

However, from a regulatory and legislative perspective, the use of chemical additives in natural juices is strictly conditioned by maximum limits of use and safety criteria established by national and international health agencies. Although these compounds are considered safe when used within legal parameters, improper application, cumulative use of different additives, or lack of strict control of dosages can result in excessive consumer exposure (Jay, 2005). In addition, the growing demand for foods with a lower degree of chemical processing has intensified the regulatory debate about transparency in labeling and the compatibility between the use of preservatives and the designation "natural" or "artisanal".

From the perspective of public health, the use of chemical additives in food has been the subject of critical analysis in the scientific literature. Studies indicate that, although many preservatives have low acute toxicity, frequent and prolonged consumption of foods containing these compounds may be associated with adverse reactions in sensitive populations, such as allergic effects, gastrointestinal disturbances, and possible metabolic impacts (Ordóñez *et al*., 2005). These concerns become particularly relevant in artisanal natural juices, often consumed by individuals looking for healthier and less processed

alternatives, which highlights a contradiction between consumer expectations and technological practice.

Given this scenario, the application of chemical additives in the conservation of artisanal natural juices must be analyzed critically and carefully, considering not only the gains in shelf life and profitability, but also the regulatory limits, the impacts on sensory quality and the potential health risks. Thus, the scientific literature has highlighted that the isolated use of chemical processes rarely constitutes an ideal solution for microbiological safety, and its integration with good manufacturing practices and combined conservation strategies based on the concept of barrier technology is recommended (Leistner; Gould, 2002). This approach allows for a balance between microbiological efficiency, legislative compliance and consumer health protection, aligning artisanal production with contemporary food safety and health responsibility requirements.

2 CHEMICAL PROCESSES FOR THE REDUCTION OF THE MICROBIAL LOAD IN JUICES

2.1 CHEMICAL PRESERVATIVES ALLOWED

The permitted chemical preservatives are a widely used strategy for microbiological control in natural juices, especially when seeking to extend the shelf life of the product while maintaining safe consumption conditions. These compounds act mainly in an inhibitory manner, reducing or delaying the growth of spoilage and pathogenic microorganisms, and are regulated by sanitary legislation that establishes maximum limits of use according to the type of food (Franco; Landgraf, 2008).

Among the chemical preservatives most used in juices are sodium benzoate and potassium sorbate, both of which are especially effective against yeasts and molds, microorganisms often associated with the deterioration of acidic juices. Sodium benzoate has greater antimicrobial activity in media with a pH lower than 4.5, a common condition in fruit juices, while potassium sorbate acts by inhibiting enzyme systems involved in the cellular respiration of microorganisms (Jay, 2005).

The mechanism of action of these preservatives is related to the non-dissociated form of the compound, which crosses the microbial cell membrane and interferes with essential metabolic processes, such as ATP synthesis and oxidative enzyme activity. This interference results in reduced growth rate or complete microbial inhibition, depending on the concentration applied and the sensitivity of the microorganism (Russell, 1992).

The effectiveness of permitted chemical preservatives is influenced by a number of intrinsic and extrinsic factors to the product, including pH, water activity, juice composition,

storage temperature, and initial microbial load. In artisanal juices, in which the variability of the raw material can be high, strict control of these factors is essential to ensure the effectiveness of the preservative and avoid failures in microbiological control (Ordóñez *et al*., 2005).

Despite their proven efficiency, the use of chemical preservatives in artisanal natural juices demands attention regarding sensory acceptance and consumer perception. Excessive concentrations can cause undesirable changes in flavor and aroma, as well as conflicts with the naturalness proposal often associated with artisanal products. Thus, the use of preservatives within legal limits is recommended and, preferably, in association with other conservation methods, such as refrigeration or gentle physical treatments, in line with the concept of barrier technology (Leistner, 2000).

From a technological and sanitary point of view, the permitted chemical preservatives have advantages such as low cost, ease of application and proven efficacy against spoilage microorganisms. However, its use does not replace the adoption of good manufacturing practices, hygienic control of processing and quality of the raw material, which are determining factors for the microbiological safety of artisanal natural juices (Franco; Landgraf, 2008).

Thus, the permitted chemical preservatives are a relevant tool for reducing the microbiological load in artisanal natural juices, especially when integrated with combined preservation systems, capable of ensuring microbiological stability without significantly compromising the sensory quality of the product.

2.2 ADDITION OF ORGANIC ACIDS

Organic acids are one of the main chemical methods used for microbiological control in foods and beverages, including artisanal natural juices. These compounds have recognized antimicrobial activity, being widely used both naturally, because they are present in the fruits themselves, and by controlled addition during processing. Its efficacy is associated with the ability to reduce the pH of the medium and directly interfere with microbial metabolism (Franco; Landgraf, 2008).

The mechanism of antimicrobial action of organic acids is mainly based on the non-dissociated form of the acid, which can cross the cell membrane of microorganisms. Once inside the cell, the acid dissociates due to the higher cytoplasmic pH, releasing hydrogen ions and anions, which causes acidification of the intracellular medium, destabilization of the proton gradient and inhibition of enzyme systems essential to microbial growth (Russell, 1992).

Among the organic acids most frequently associated with the preservation of natural juices are citric acid, malic acid, lactic acid and acetic acid. Citric acid, naturally present in citrus fruits, is widely used due to its high pH lowering capacity and sensory compatibility with juices. Malic acid, on the other hand, predominant in fruits such as apples and cashews, contributes both to microbiological control and to the maintenance of the sensory profile of the product (Ordóñez *et al*., 2005).

The effectiveness of organic acids depends on several factors, including the type of acid, its concentration, the final pH of the product, the storage temperature, and the sensitivity of the microorganisms present. Pathogenic and spoilage bacteria generally have greater sensitivity to acidic environments, while yeasts and molds demonstrate greater tolerance, especially in juices with a naturally low pH (Jay, 2005).

Studies indicate that the application of organic acids in juices can result in significant reductions in the microbial load, especially when associated with other stressors, such as refrigeration or light physical treatments. This synergy is in line with the concept of barrier technology, in which multiple factors act together to limit microbial growth without excessively compromising food quality (Leistner, 2000).

From the point of view of sensory quality, the use of organic acids requires special attention, since excessive concentrations can result in undesirable changes in flavor, aroma and acceptability of the product. In artisanal juices, in which the perception of naturalness is a decisive factor for the consumer, the use of acids naturally present in the fruit or obtained by fermentation tends to be better accepted (Evangelista, 2008).

In addition, organic acids have advantages in terms of cost, ease of application and compatibility with artisanal production systems. However, as it is a predominantly inhibitory method, its isolated application does not guarantee the complete elimination of pathogenic microorganisms, and its association with good manufacturing practices and other conservation methods along the production chain is recommended (Franco; Landgraf, 2008).

Thus, organic acids are an effective and widely applicable chemical strategy for reducing the microbiological load in artisanal natural juices, especially when integrated with combined conservation approaches, which reconcile microbiological safety, sensory quality and technological feasibility.

2.3 CHEMICAL SANITIZERS

Chemical sanitizers play a fundamental role in the control of microbiological contamination during the processing of handmade natural juices, acting mainly in the cleaning of raw materials, equipment, surfaces and utensils. Unlike preservatives added

directly to food, sanitizers are applied as cleaning and disinfection agents, aiming to reduce the environmental microbial load and prevent cross-contamination along the production chain (Gould, 1995).

Among the chemical sanitizers most used in food processing are chlorinated compounds, peracetic acid, quaternary ammonium compounds and hydrogen peroxide. Chlorinated compounds, such as sodium hypochlorite, are widely used due to their high efficacy against bacteria, viruses, and fungi, as well as their low cost and ease of application. Its antimicrobial action is related to the oxidation of essential cellular components, resulting in irreversible damage to membranes and microbial proteins (Russell; Chopra, 1996).

Peracetic acid has gained prominence in juice processing because it has high antimicrobial activity even in the presence of organic matter, in addition to decomposing into by-products considered environmentally safe. This sanitizer acts through the oxidation of lipids and proteins of the cell membrane, being effective against sporulated bacteria, yeasts and molds, microorganisms often associated with the deterioration of natural juices (Kitis, 2004).

Quaternary ammonium compounds are mainly used in the sanitization of surfaces and equipment, presenting good stability and residual effect. Its mechanism of action involves interaction with the microbial cell membrane, leading to loss of structural integrity and leakage of intracellular constituents. However, its effectiveness can be reduced in the presence of organic residues, which requires adequate prior cleaning procedures (McDonnell; Russell, 1999).

The efficiency of chemical sanitizers in the processing of artisanal natural juices depends on factors such as agent concentration, contact time, temperature, pH and level of soiling of the surfaces. Improper application of these products can result in failures in microbiological control, as well as risks associated with the formation of undesirable chemical residues or corrosion of equipment (Davidson *et al*., 2005).

In artisanal production systems, the use of chemical sanitizers must be integrated with good manufacturing practices, with clear protocols for dilution, application and rinsing, when necessary. Studies highlight that the efficient sanitization of raw materials, such as fruits and vegetables, is a critical step in reducing the initial microbial load, contributing significantly to the microbiological safety of the final juice (Beuchat, 2002).

In addition, the combination of chemical sanitizers with other conservation methods, such as refrigeration or gentle physical treatments, is in line with the concept of barrier technology, in which multiple factors act in a complementary way to limit microbial survival and multiplication (Leistner; Gould, 2002).

Thus, chemical sanitizers are indispensable tools in the processing of artisanal natural juices, acting preventively to reduce microbiological contamination. When applied judiciously and integrated with hygienic-sanitary control systems, these agents contribute significantly to the safety of the product, without directly interfering with the sensory characteristics of the juice.

2.4 SULPHUR DIOXIDE AND SULPHITES

Sulphur dioxide (SO_2) and sulphites are widely used as chemical agents in food and beverage processing due to their high antimicrobial and antioxidant efficacy. In artisanal natural juices, these compounds are used mainly to control yeasts and molds, microorganisms often associated with unwanted fermentation and product deterioration, in addition to contributing to the stability of color and aroma during storage (Sofos, 1993).

The mechanism of action of sulfur dioxide is related to its ability to penetrate the microbial cell in the non-dissociated molecular form, interfering with enzymatic systems essential to cellular metabolism. Studies indicate that SO_2 works by inhibiting enzymes involved in glycolysis and respiration, compromising energy production and leading to inhibition of growth or cell death (Brul; Coote, 1999).

The efficacy of sulfites is strongly influenced by the pH of the medium, since more acidic environments favor the predominance of the active molecular form of sulfur dioxide. This characteristic makes sulfites particularly effective in fruit juices, which have a naturally low pH, allowing a significant antimicrobial action even at relatively low concentrations (Davidson; Taylor, 2007).

In addition to its antimicrobial effect, sulfur dioxide plays an important role in inhibiting enzymatic browning reactions, especially due to its action on polyphenoloxidase. The ability to act as a reducing agent and oxygen sequester contributes to the preservation of the visual appearance and sensory profile of juices, a relevant aspect in minimally processed artisanal products (Fennema, 1996).

However, microbial sensitivity to sulfites varies among different groups of microorganisms. While fermentative yeasts and molds have high susceptibility, some lactic acid bacteria may demonstrate greater tolerance, which reinforces the need to associate this chemical method with other conservation strategies, such as refrigeration or gentle physical treatments, within the barrier technology approach (Hugas; Tsigarida, 2008).

The use of sulfur dioxide and sulfites in artisanal natural juices is limited by toxicological and regulatory aspects, since these compounds can trigger adverse reactions in sensitive individuals. Thus, its application must strictly respect the established legal limits

and be accompanied by appropriate labeling when required, especially in products intended for direct consumption (Sofos; Bhunia, 2010).

In the context of artisanal production, the use of sulfites requires careful evaluation, considering the balance between microbiological safety, consumer acceptance and maintenance of the product's naturalness proposal. Thus, these compounds tend to be used in a complementary and strategic way, integrated with good manufacturing practices and combined conservation methods (Gould, 2000).

Thus, sulfur dioxide and sulfites remain as effective chemical agents for microbiological control and preservation of the quality of natural juices, as long as they are used in a controlled, regulated and integrated manner with technological systems appropriate to the profile of artisanal products.

2.5 OXIDISING AGENTS

Oxidizing agents are an important class of chemical compounds used in food processing to reduce the microbiological load, acting mainly through the oxidation of essential cellular components of microorganisms. In the context of the production of artisanal natural juices, these agents are used mainly in the stages of cleaning raw materials, equipment and surfaces, in addition to specific applications in microbial control, contributing to the safety of the final product (McDonnell; Russell, 1999).

Among the main oxidizing agents used in food processing are hydrogen peroxide, peracetic acid and ozone. These compounds have a broad spectrum of antimicrobial action, being effective against Gram-positive and Gram-negative bacteria, yeasts, molds and, in some cases, bacterial spores. Its action is associated with the generation of reactive oxygen species, capable of causing irreversible damage to lipids, proteins and nucleic acids of microbial cells (Russell, 2003).

Hydrogen peroxide is widely used as a sanitizer due to its high oxidative capacity and decomposition into by-products considered environmentally safe, such as water and oxygen. Its mechanism of action involves the formation of highly reactive free radicals, which promote lipid peroxidation and the denaturation of cellular proteins, leading to the loss of microbial membrane integrity (Davidson *et al.,* 2005).

Peracetic acid has additional advantages over other oxidants, since it maintains high antimicrobial efficacy even in the presence of organic matter and in a wide pH range. Studies report that this agent is particularly efficient in inactivating microorganisms associated with juice spoilage, such as yeasts and molds, as well as aciduric bacteria, and is widely recommended for applications in fruit and beverage processing systems (Kitis, 2004).

Ozone, in turn, stands out as one of the most potent oxidizing agents used in food processing, with a high microbial inactivation capacity in short contact times. Its action occurs through the direct oxidation of components of the cell wall and membrane, in addition to effects on the genetic material of the microorganisms. However, its application requires strict control of operating conditions, due to the instability of the compound and the risks associated with occupational exposure (Guzzo *et al*., 2010).

The effectiveness of oxidizing agents depends on several factors, including applied concentration, contact time, temperature, pH, and the presence of organic matter. In artisanal systems, the variability of these parameters can compromise the efficiency of the treatment, making it essential to standardize procedures and integrate them with good manufacturing practices (Beuchat, 2002).

In addition, oxidizing agents are often used in combination with other conservation methods, such as refrigeration or light physical treatments, in line with the barrier technology approach. This strategy makes it possible to enhance the antimicrobial effect, reduce the intensity of each individual treatment, and preserve the sensory quality of artisanal natural juices (Leistner; Gould, 2002).

Thus, oxidizing agents are effective tools for microbiological control in the processing of artisanal natural juices, acting mainly in a preventive way to reduce environmental and initial contamination. When applied in a controlled manner and integrated into combined conservation systems, these compounds contribute significantly to the microbiological safety of the final product.

2.6 ADVANTAGES AND DISADVANTAGES OF CHEMICAL METHODS IN REDUCING THE MICROBIOLOGICAL LOAD IN ARTISANAL NATURAL JUICES

The adoption of conservation methods to reduce the microbiological load in artisanal natural juices is essential to ensure the safety of the product and the extension of its shelf life. Among the main strategies employed, chemical methods stand out, which have distinct characteristics in terms of microbiological efficacy, impact on sensory quality, technological feasibility and consumer acceptance (Barbosa Canovas *et al*., 2005).

Chemical methods include the use of organic acids, permitted chemical preservatives, sanitizers, sulfur dioxide, sulfites, and oxidizing agents. The main advantages of these methods are their low cost, ease of application, and high efficacy against certain groups of microorganisms, especially yeasts and molds, which are often responsible for the deterioration of juices (Davidson; Taylor, 2007).

Another relevant advantage of chemical methods is the possibility of application in different stages of processing, including the cleaning of raw materials, equipment and surfaces, as well as the direct preservation of the product. In addition, many chemical agents have a synergistic effect when combined with factors such as acidic pH and refrigeration, enhancing the reduction of the microbiological load (Brul; Coote, 1999).

On the other hand, the use of chemical methods has disadvantages related to consumer acceptance, especially in artisanal products, in which the presence of additives can be perceived negatively. In addition, the inadequate application of these compounds can result in undesirable sensory alterations, toxicological risks or non-compliance with legal limits established by health legislation (Sofos; Bhunia, 2010).

Another critical aspect of chemical methods is that, in general, their action is predominantly inhibitory, not guaranteeing the complete elimination of pathogenic microorganisms when used alone. Thus, its effectiveness strongly depends on the strict control of processing conditions and the simultaneous adoption of good manufacturing practices (Franco; Landgraf, 2008).

In view of these considerations, it is observed that chemical processes have specific advantages and limitations, and are not, in isolation, sufficient to guarantee the microbiological safety and quality of artisanal natural juices. In this context, the adoption of combined conservation strategies, based on the concept of barrier technology, is shown to be the most effective approach, allowing the use of multiple factors at moderate intensities, in order to maximize microbiological safety and minimize negative impacts on product quality (Leistner; Gould, 2002).

Thus, the choice of conservation methods must consider not only microbiological efficacy, but also economic, technological, sensorial and regulatory aspects, in order to enable the production of safe, stable artisanal natural juices in line with the expectations of the consumer market.

3 FINAL CONSIDERATIONS

The analysis of the chemical processes applied to the preservation of artisanal natural juices shows that these strategies play an important role in microbiological control and in extending the shelf life of these products, especially in production contexts marked by technological and operational limitations. The use of chemical additives, organic acids, sanitizers, sulfites, and oxidizing agents offers significant advantages from a technological and economic point of view, such as ease of application, low relative cost, and effectiveness

against spoilage microorganisms, directly contributing to the reduction of losses, the extension of shelf life, and the increase in the profitability of artisanal production systems.

However, such benefits must be critically analyzed, since the indiscriminate or inappropriate use of these compounds can result in negative impacts on sensory quality, risks associated with consumer health, and non-compliance with regulatory and legislative requirements. Although most chemical additives are considered safe within the limits established by health legislation, the frequent and cumulative consumption of products containing these substances, combined with the growing demand for foods with a lower degree of chemical processing, intensifies the debate on their compatibility with the proposal of naturalness attributed to artisanal juices.

In addition, it is observed that the chemical methods present, for the most part, a predominantly inhibitory character, not being able to guarantee, when applied in isolation, adequate levels of microbiological safety, especially against more resistant microorganisms. Thus, the scientific literature converges on the need for a judicious and technically grounded application of these processes, integrated with good manufacturing practices and combined conservation strategies based on the concept of barrier technology. This approach allows for a balance of microbiological efficiency, regulatory compliance, preservation of sensory quality and protection of consumer health, configuring itself as the most consistent and responsible way to produce safe, stable artisanal natural juices in line with contemporary food safety and health responsibility requirements.

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