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Selection of Filtration Systems to Improve the Quality of Beverage and Paste Production

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ABSTRACT

This paper presents the critical role of the selection of filtration system to be used in the beverage industry in the small medium scale production enterprises to ensure quality and consumer satisfaction as well as product competitiveness. Previously, in the small medium enterprise, tedious work is done manually to separate leaves and other contaminants for the filtration process. To maintain the quality of the beverage and paste production, the whole process must be controlled, starting with the homogenizer until the filtration process. Mild-heat treatment will be applied in the homogenizer process. The selection process for filtration systems is examined in-depth, considering factors like particle size removal, preservation of flavor and nutritional components, and the prevention of spoilage. The filtration is selected according to the best type of filtration that meets the criteria of improving the quality of the production as well as reducing the manpower and processing time. The filtration will then be placed in the homogenizer unit. Ultimately, the judicious choice of filtration systems which is mesh filtration can significantly enhance the quality and it is selected based on its advantages over the other filtration systems.

Keywords: beverage, filtration system, homogenizer, improve quality, wire mesh filtration

1. INTRODUCTION

In the realm of food and beverage production, quality is an indisputable hallmark of success. When it comes to the production of beverages and pastes, the role of filtration systems in shaping product quality is paramount. The selection and implementation of appropriate filtration technologies represent a pivotal step in the journey toward creating superior beverages and pastes. Filtration is a fundamental process in the manufacturing of beverages and pastes, playing a pivotal role in removing impurities, microorganisms, and undesirable particles that can negatively impact product quality, flavour, and shelf life [1]. The primary objective of filtration in beverage and paste production is to achieve clarity, microbial stability, and sensory attributes while preserving the nutritional content of the final product.

Selecting the appropriate filtration system is crucial to optimize the filtration process and enhance the overall quality of the end products [2]. This technical paper seeks to explore the intricate relationship between filtration systems and the quality of beverages and pastes. It delves into the array of filtration technologies available, scrutinizing their applications and efficacy in diverse production scenarios. Research on various filtration systems, automation, and monitoring, which are essential in achieving optimal filtration outcomes and operational efficiency are highlighted.

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The selection of a suitable filtration system depends on many factors, such as product characteristics, contaminant profiles, and economic considerations. By understanding these parameters, manufacturers can make decisions to implement effective filtration strategies tailored to the specific production requirements.

2. TYPES OF FILTRATION SYSTEMS

The production of high-quality beverages is a paramount concern for the food and beverage industry. Filtration plays a critical role in ensuring that beverages meet stringent quality standards by removing impurities and undesirable particles that may affect taste, appearance, and shelf life [3]. It ensures the removal of undesirable contaminants, particles, and impurities that can compromise product quality, safety, and performance. In many industries, regulatory standards demand strict control over the presence of contaminants, underscoring the significance of robust filtration methods. To achieve these objectives, various types of filtrations are available, each with distinct characteristics and applications. In the context of improving the quality of beverages and pastes, the choice of filtration system plays a pivotal role in achieving desired product attributes. Each filtration system applies different mechanisms to purify beverages, providing a wide range of options to tailor the filtration process according to the specific product requirements [4].

The most used types of filtration systems in the beverage industry will be discussed. The focus is on their mechanisms of operation, applications, advantages, and limitations. By understanding the characteristics of each filtration system, beverage manufacturers can make informed decisions to optimize the production processes and enhance the quality and consistency of the products. Filtration systems discussed in this paper include depth filtration, membrane filtration, crossflow filtration, screw press, and wire mesh filtration. Each system offers unique benefits, and their appropriate selection is crucial for achieving desired beverage characteristics. This study aims to provide valuable insights into the filtration technologies used in the beverage industry, enabling well-informed decisions to optimize the production processes and consistently deliver high-quality beverages to consumers. This topic would focus on different filtration technologies applicable to beverage and paste production, comparing their effectiveness, cost-efficiency, and impact on product quality to help producers make informed choices.

2.1 Depth Filtration

The depth filtration operates on the principle of particle size exclusion through a porous matrix. The filter media typically consists of a depth of fibrous or granular materials, such as cellulose, diatomaceous earth, or activated carbon. As the liquid passes through the filter media, larger particles are trapped within the matrix while smaller particles and clear liquid pass through. The tortuous path within the depth media facilitates the retention of particles, providing high contaminant-holding capacity [6].

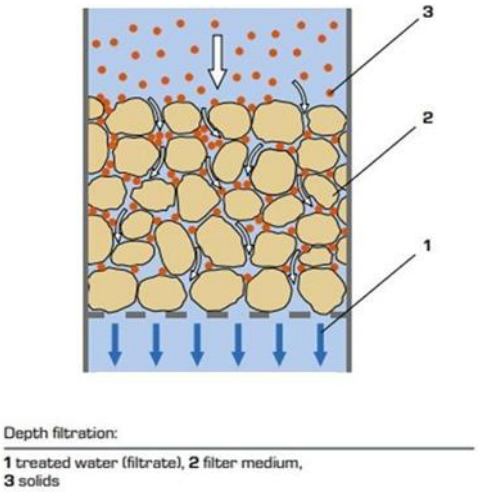

Figure 1. Depth Filtration [5]

In the food and beverage sector, it is commonly employed for clarifying liquids, removing suspended solids, and ensuring product clarity. Additionally, depth filtration is applied in water and wastewater treatment processes to remove impurities and particulate matter. Depth filtration offers several advantages that contribute to its widespread use. It provides effective removal of larger particles and impurities, resulting in a visually clear and aesthetically appealing product. The ability of the depth media is to retain a substantial number of contaminants before requiring replacement or regeneration leads to extended filter life and reduced maintenance frequency. Moreover, depth filtration is well-suited for high-viscosity liquids and processes with variable feed characteristics [7]. Despite its advantages, depth filtration has certain limitations. Fine filtration of submicron-sized particles may not be achievable using this method alone. Additionally, the depth media can become saturated with retained particles over time, leading to increased pressure drop and reduced filtration efficiency. In some cases, depth filtration may not be suitable for applications requiring absolute removal of microorganisms, necessitating supplementary sterilization methods. In summary, depth filtration is a versatile and cost-effective method used to remove a wide range of particles and impurities from liquids in various industries, including food and beverage. While not as precise as membrane filtration, it is an essential tool for achieving clear and high-quality products. Regular maintenance is required to ensure the effectiveness of ilter.

2.2 Membrane Filtration

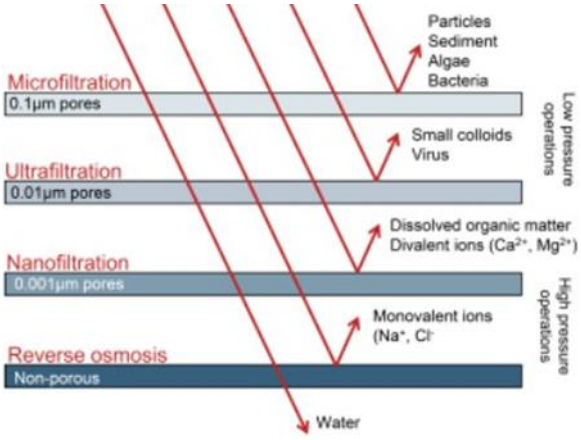

Figure 2. Types of membrane filtration [8]

Membrane filtration operates through semipermeable membranes that act as barriers, allowing only specific particles or solutes to pass through while retaining others. The size and porosity of the membrane determine its filtration characteristics. Microfiltration (MF) membranes have larger pore sizes and are effective in removing suspended solids and bacteria from liquids. Ultrafiltration (UF) membranes have smaller pores and can remove macromolecules, colloids, and proteins. Nanofiltration (NF) and reverse osmosis (RO) membranes have even smaller pores and are suitable for desalination and concentrating solutions [9].

In the food and beverage sector, membrane filtration is used for clarifying juices, concentrating beverages, and removing microorganisms from liquids. In water and wastewater treatment, it is employed for potable water production, wastewater reclamation, and desalination. Additionally, membrane filtration is utilized in the dairy industry for milk and whey processing. Membrane filtration provides high removal efficiency for particles and microorganisms, in clear and sterile products. The ability to control pore size and membrane material allows for precise filtration tailored to specific applications. Moreover, membrane filtration is a gentle process that preserves the nutritional and sensory attributes of the filtrate [10].

Despite its advantages, membrane filtration has certain limitations. Fouling and clogging of membranes can occur due to the accumulation of retained particles, leading to reduced filtration efficiency. Frequent cleaning and maintenance are essential to prevent fouling and extend membrane lifespan. Additionally, membrane filtration may require higher operating pressures and energy consumption compared to other filtration methods [11]. In summary, membrane filtration is a highly precise and versatile filtration method used in industries where product quality and purity are paramount. Its ability to selectively remove particles based on size and molecular weight makes it an essential tool for achieving high-quality and purified products in applications ranging from pharmaceuticals to food and beverage production. However, it does require careful management to prevent fouling and may involve higher initial and maintenance costs.

2.3 Crossflow Filtration

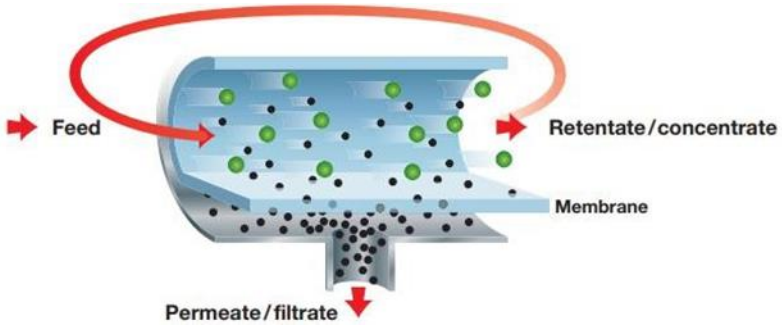

Figure 3. Crossflow principle [12]

Crossflow filtration, also known as tangential flow filtration, is widely used in separation process in various industries, characterized by the tangential flow of the liquid parallel to the filtration membrane. This unique mechanism allows for continuous operation, reducing fouling and extending the life of the filtration system. Crossflow filtration operates by passing the liquid or solution tangentially across the surface of the filtration membrane [13]. The pressure difference across the membrane creates a shear force that continually sweeps away retained particles, preventing clogging and fouling. The unfiltered solution, also known as the retentate, flows parallel to the membrane, while the filtrate passes through the membrane and is collected separately. Crossflow filtration finds numerous applications in various industries which includes the food and beverage sector, where it is used for the clarification and concentration of juices, wines, and beer, as well as the separation of milk and whey components [14].

Several advantages over conventional filtration methods which comprise its continuous operation reduce fouling and allows for higher throughput rates, resulting in improved productivity. The ability to process high-viscosity and shear-sensitive liquids without significant damage makes crossflow filtration suitable for delicate products. Furthermore, the ability to control the size of retained particles allows for selective filtration and the preservation of desired components. Regardless of its advantages, crossflow filtration has certain limitations. The initial investment cost for the equipment can be higher than conventional filtration systems. Proper membrane selection, based on the specific application, is crucial to achieve desired separation efficiency and permeate quality.

Additionally, concentration polarization can occur, leading to reduced flux and increased energy consumption [15]. In summary, crossflow filtration is a highly efficient and continuous separation process used in various industries to effectively remove particles and impurities from liquids. Its ability to reduce fouling and its scalability make it a valuable choice for applications that demand continuous and efficient filtration. While it may require some initial investment and energy usage, its advantages often justify these costs, especially in industries like food and beverage production.

2.4 Screw Filtration

The screw press filtration system operates based on the principle of mechanical pressure applied through a rotating screw. As the beverage passes through the screw press, the rotating screw exerts pressure on the mixture, separating the liquid from the solid particles. The clarified liquid (filtrate) is forced through the screen or perforations, leaving a dewatered cake of solids behind. The filtration process effectively removes impurities, suspended solids, and undesirable particles, resulting in a clarified and visually appealing beverage [16].

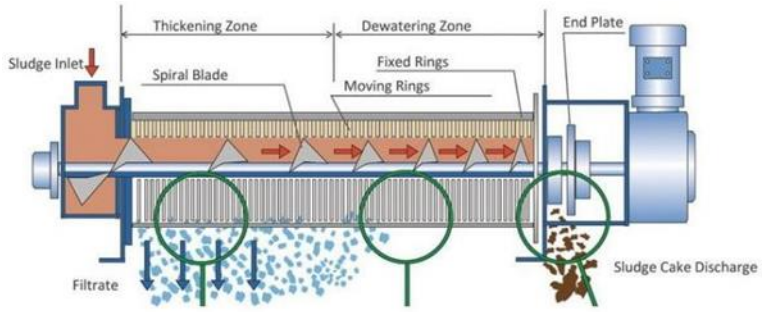

Figure 4. Screw press principle [16]

The screw press filtration system offers several advantages over conventional filtration methods as its continuous operation allows for higher throughput and reduced processing time. The gentle filtration process minimizes the risk of degradation, ensuring better retention of flavor, aroma, and nutrients in the clarified beverage. The compact design and ease of integration make it suitable for both large-scale and small-scale beverage processing plants. Despite its advantages, the screw press filtration system has certain limitations. Variability in feed material characteristics, such as particle size distribution and consistency, can affect filtration efficiency. The initial capital investment and maintenance costs can be relatively high, impacting the economic feasibility for some applications [17]. Additionally, the system may not be suitable for heat-sensitive or shear-sensitive materials due to the mechanical forces involved in the process. In summary, screw filtration is a mechanical dewatering process used for the efficient separation

of solids from liquids. It is known for its continuous operation and ability to reduce the moisture content in the solids, making it particularly valuable in applications such as wastewater treatment and agricultural processes. However, it does require regular maintenance and some energy usage, and there may be an initial investment in the equipment.

2.5 Wire Mesh Filtration

Wire mesh filtration, often referred to as wire mesh filters or screens, is characterized by its unique construction and operational attributes. It stands out as a robust and adaptable solution that offers exceptional performance in a variety of applications. The key feature of wire mesh filters is their use of woven metal wires or other suitable materials to create a mesh screen.

This mesh structure provides both coarse and fine filtration capabilities, making it applicable in diverse industrial settings. The wire mesh filtration system operates on the principle of mechanical separation. It consists of interwoven wires forming a grid with specific mesh sizes. When the beverage flows through the mesh, solid particles are trapped on the surface or within the openings of the mesh, allowing the liquid to pass through. The size of the mesh determines the filtration fineness and affects the efficiency of the system [18].

Figure 4. Wire Mesh Filtration [19]

Wire mesh filtration systems find widespread applications in the beverage industry, including juice filtration by removing pulp, seeds, and other solid impurities from fruit juices to obtain clear and smooth juice products. Besides that, it plays an important role in water filtration by purifying water and removing particles to meet specific quality standards for water used in beverage production [20]. Wire mesh filtration systems offer several advantages for beverage applications such as efficient particle removal where the wire mesh screens effectively remove solid particles, ensuring a clean and clear beverage. Moreover, it has low maintenance. Cleaning wire mesh filters is relatively simple, requiring minimal downtime during the filtration process. Next, its customizability benefit has different mesh sizes and materials are available, allowing customization based on the specific filtration needs of each beverage type.

Other than that, wire mesh filters reduce waste generation as they are reusable, making them an eco-friendly choice [21]. While wire mesh filtration systems offer several advantages, certain limitations should be considered for instance, the filtration fineness of wire mesh filters may be limited compared to some other filtration methods like membrane filtration. However, to overcome this problem, mesh size should be suitable based on the filtration materials for more effective filtration [22]. In conclusion, wire mesh filtration stands out as a dependable, cost-

effective, and versatile solution for meeting diverse industrial filtration needs. Its ability to endure challenging conditions, adapt to different particle sizes, and minimize environmental impact makes it an essential choice for enhancing the quality and efficiency of various industrial processes.

3. SELECTION OF WIRE MESH FILTRATION

Wire mesh filtration is widely used in the beverage industry. Wire mesh filtration has several advantages over other filter materials, due to the combination of efficient particle removal, low maintenance, customizability, and environmentally friendly. Wire mesh filtration stands out in various industrial applications for several reasons, making it a preferred choice over other filtration methods in many scenarios [23]. It is important to note that the selection of a filtration method should be based on the specific needs and characteristics of the application for beverage and paste production. While wire mesh filtration excels in many areas, other filtration methods may be better suited for specialized applications, such as those requiring extremely fine filtration or unique separation properties.

Small wire-mesh has higher removal efficiency which makes wire mesh filtration the top choice. Its simple design and no complex components or moving parts that can malfunction or require frequent adjustments makes it low-cost maintenance. Other than that, wire mesh filters can be used in various applications, such as air, water, and industrial fluid filtration. Their adaptability and efficiency in different settings make them a popular choice. On top of that, many wire mesh filters are made from sustainable materials such as stainless steel or other non-toxic and recyclable metals. The use of these materials helps reduce the consumption of finite resources and minimizes the environmental footprint [24]. In summary, mesh filter type is suitable for certain beverage and paste production applications, particularly when dealing with larger particles.

4. CONCLUSION

The pursuit of excellence in beverage and paste production is a journey that demands unwavering commitment to quality, meticulous attention to detail, and an acute understanding of the role of filtration systems. As this technical paper has illuminated, the choice of the right filtration technology is a pivotal decision in this endeavour, significantly influencing the sensory, nutritional, and safety aspects of the final product. The objective for the selection of filtration systems to improve quality of the beverage and paste production is achieved. The wire mesh filtration wins over other filtration systems.

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