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Original Article

Technical Design of a Craft Brewery under Current Regulations for Emerging Agritourism Regions

Diseño técnico de una cervecería artesanal bajo normativa vigente para regiones agroturísticas emergentes

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Spanish version

Abstract

Introduction: This article presents the technical design of a craft brewery located in Puerto Gaitán, Meta, Colombia, focused on producing a Golden Ale enriched with tropical fruits to achieve sensory attributes linked to local identity.
Objectives: To develop a brewery design that integrates high-quality ingredients—malt, malted barley, hops, yeast (Saccharomyces cerevisiae), water, mango (Mangifera indica), and passion fruit (Passiflora edulis)—while ensuring compliance with Colombian sanitary and technical regulations.
Methodology: The plant organization was defined using industrial engineering tools, including the weighted factor method for location analysis, Systematic Layout Planning (SLP) for internal distribution, and the Guarchet method for space determination. The design also incorporated applicable regulations: Resolution 2674 of 2013 (GMP), Decree 162 of 2021, Resolution 2115 of 2007, and Technical Standards NTC 3854:1996 and NTC 4158:1997. Basic sanitation and occupational health and safety plans were proposed.
Results: The design provides a comprehensive proposal including specialized equipment and an efficient operating model aligned with regulatory requirements.
Conclusions: The proposed model demonstrates potential to strengthen the regional craft brewing agroindustry by promoting innovation, added value, and local economic development.

Keywords: beer, quality, food safety, production, Guarchet.

Resumen

Introducción: Este artículo presenta el diseño técnico de una cervecería artesanal ubicada en Puerto Gaitán, Meta, Colombia, enfocada en la producción de una Golden Ale enriquecida con frutas tropicales para lograr atributos sensoriales vinculados a la identidad local.
Objetivos: Desarrollar un diseño de cervecería que integre ingredientes de alta calidad—malta, cebada malteada, lúpulo, levadura (Saccharomyces cerevisiae), agua, mango (Mangifera indica) y maracuyá (Passiflora edulis)—garantizando el cumplimiento de la normativa sanitaria y técnica colombiana.
Metodología: La organización de la planta se definió mediante herramientas de ingeniería industrial, incluyendo el método de factores ponderados para el análisis de localización, el Systematic Layout Planning (SLP) para la distribución interna de áreas y el método de Guarchet para la determinación de espacios. El diseño incorporó la normativa aplicable: Resolución 2674 de 2013 (BPM), Decreto 162 de 2021, Resolución 2115 de 2007 y las Normas Técnicas Colombianas NTC 3854:1996 y NTC 4158:1997. Asimismo, se propusieron planes básicos de saneamiento y de gestión de seguridad y salud en el trabajo.
Resultados: El diseño presenta una propuesta integral que incluye equipos especializados y un modelo operativo eficiente, alineado con los requisitos regulatorios.
Conclusiones: El modelo propuesto muestra potencial para fortalecer la agroindustria cervecera artesanal en la región mediante la promoción de la innovación, el valor agregado y el desarrollo económico local.

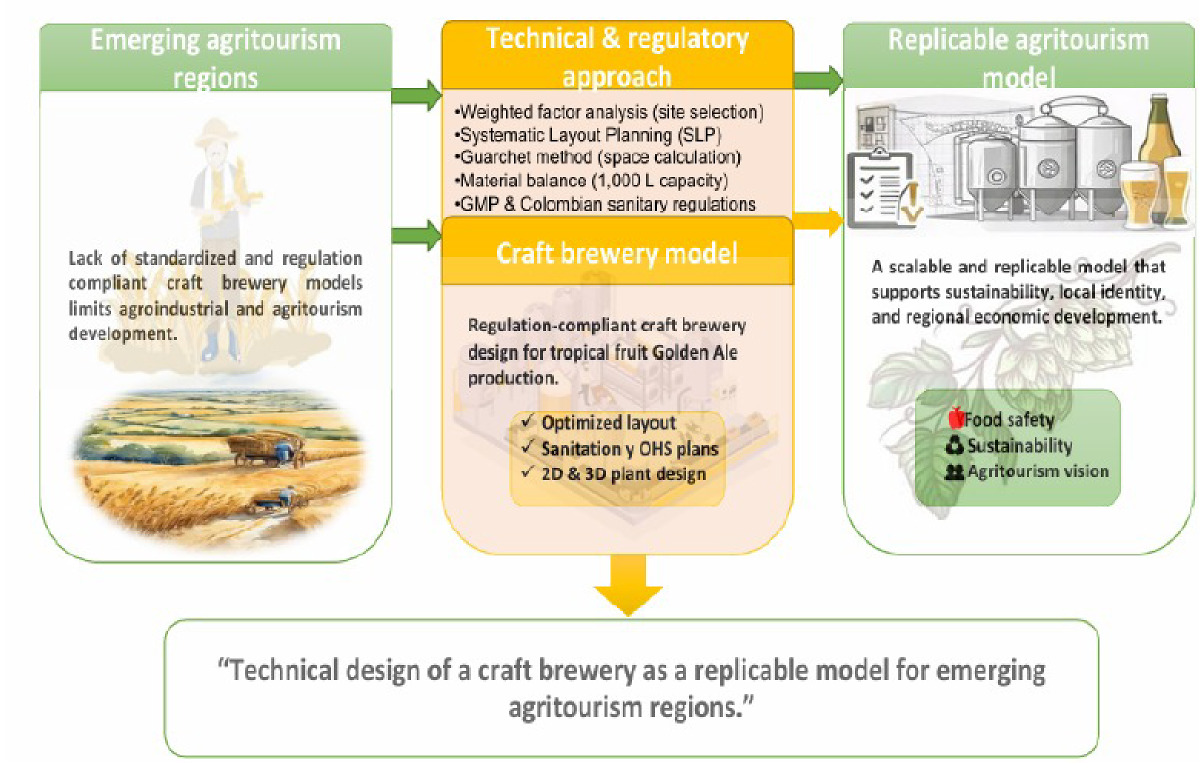
Palabras clave: cerveza, calidad, seguridad alimentaria, producción, Guarchet.

Why was it done?
The study was conducted to demonstrate that it is feasible to design and implement a craft brewery under current regulations in emerging agritourism regions. The main motivation was to provide these regions with a replicable and structured model that combines technical feasibility, regulatory compliance, and a clear long-term vision for local development, innovation, and tourism integration. The research responds to the lack of standardized designs that often limits the establishment of craft breweries outside major urban centers.

What were the most relevant results?
The main results correspond to the formulation of a comprehensive technical–industrial design for a craft brewery focused on the production of Golden Ale beer with the addition of tropical fruits, in accordance with the applicable Colombian regulatory framework. Multicriteria analysis tools were applied for site selection, together with plant layout methodologies such as Systematic Layout Planning (SLP) and the Guarchet method, allowing optimization of production flow, area allocation, and space utilization. In addition, basic sanitation programs, integrated pest management, waste management, potable water supply and distribution, and an occupational health and safety plan were designed, ensuring compliance with Resolution 2674 of 2013, Decree 162 of 2021, Resolution 2115 of 2007, and the relevant Colombian Technical Standards. The proposed model demonstrated high process efficiency, minimal material losses, and a functional layout validated through technical drawings and a three-dimensional digital prototype.

What do they contribute?
This study contributes to the scientific literature by providing a replicable, regulation-based methodological model for the design of small-scale craft breweries. It strengthens the link between industrial engineering tools and regulatory requirements in the food and beverage sector, offering a structured approach adaptable to similar territorial contexts. Furthermore, the findings enhance understanding of how plant design, logistics planning, and food safety systems influence operational efficiency, sustainability, and the viability of agroindustrial ventures in non-traditional regions. The incorporation of local raw materials, such as tropical fruits, reinforces territorial identity and value creation, positioning the model as a technical reference for agritourism-oriented production projects and local economic development.

Graphical Abstract



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Introduction

The craft beer sector has experienced global growth in recent decades, driven by consumers seeking differentiated, high-quality products with cultural identity. This trend has encouraged innovation in formulations, including the use of tropical fruits such as mango and passion fruit to enhance organoleptic characteristics, which has been shown to positively influence sensory acceptance.

In Colombia, craft beer has become a gastronomic and cultural product linked to agritourism; however, in emerging regions such as Puerto Gaitán, development is constrained by the lack of standardized designs, adequate infrastructure, and replicable models. The absence of clear technical and sanitary criterio especially those related to Resolution 2674 of 2013 has hindered projects that ensure food safety, quality, and tourism experiences, thereby missing the economic and cultural potential of the territory.

Puerto Gaitán, where this design is proposed, offers favorable environmental and logistical conditions for a craft brewery: its sandy-loam soils, water availability, and air quality support the cultivation of inputs such as barley and tropical fruits. Proximity to the airport and main roads strengthens production and commercialization. This project can boost the local economy, tourism, and territorial identity, and aligns with SDGs 9 and 12 by promoting sustainable infrastructure, innovation, and responsible production.

In this context, the integration of location, design, and logistics is important for the competitiveness of craft breweries because it reduces costs and optimizes the value chain (1). Packaging and coordinated distribution affect environmental footprints (2), and production optimization is essential for small and medium-sized companies in the food sector (3). Big data improves decision-making and sustainability (4), and integrated logistics management is critical for industry performance (5)(6). Finally, addressing variability, losses, and costs through operations research strengthens the agroindustrial supply chain (7).

Moreover, studies show that optimization models reduce operating costs and improve food supply chain efficiency, while reinforcing sustainability and competitiveness in an increasingly demanding market (7).

Therefore, implementing a model of this type not only aims to overcome current sector limitations, but also to contribute to job creation, value generation from local resources, and the projection of culturally rooted products into national and international markets.

Accordingly, the purpose of this article is to demonstrate that designing a craft brewery in Puerto Gaitán under current regulations can become a sustainable initiative that integrates economic, social, and environmental dimensions, serving as a benchmark for new agritourism experiences and for the country's productive diversification.

Methodology

The methodology used to design the craft brewery was organized into a series of technical–industrial phases that ensure feasibility, operational efficiency, and regulatory compliance. Each

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phase combines industrial engineering tools, occupational health and safety criteria, and elements that support an agritourism approach. The procedure is summarized below:

Site selection: Location is proposed through a multicriteria analysis using the weighted factor method.

Systematic Layout Planning (SLP): The process is standardized and the mass balance is defined by establishing the product and production volume. The SLP methodology is then applied by developing the relationship matrix (importance of proximity) and the area relationship diagram to optimize a linear flow of materials and personnel.

Space calculation: The Guarchet method is applied to define static surface, gravitational surface, and evolution surface.

Basic sanitation plans: A review of regulatory requirements for the liquor industry in Colombia was conducted, and plans related to the plant's basic sanitation program were proposed. The proposed plans were developed in AutoCAD 2025 at a 1:1 scale, enabling visualization of the plant distribution and design.

Technical drawings: Technical drawings were developed in AutoCAD (2D) and SketchUp (3D) according to Colombian sanitary regulations and Occupational Health and Safety (OHS) guidelines.

Results and Discussion

Site selection

The plant location analysis considered two plots in Las Villas village, Puerto Gaitán, located 1 km from the urban center and with direct access to the main road and the airstrip, improving logistics. Selection was based on technical variables such as raw material availability, transportation, distribution, and proximity to the market, highlighting road quality and access to labor factors that reduce costs and facilitate regional commercialization.

Plot 1

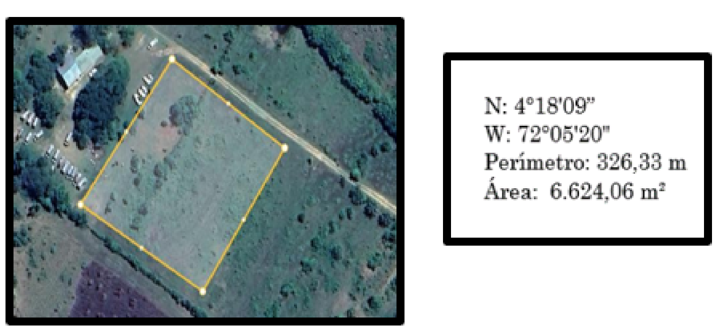

Figure 1. Location of Plot 1 (Google Earth, 2025)

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Figure 1, located in Las Villas village on the airport road, has a strategic position only 1,017 meters from the urban area of Puerto Gaitán. It has excellent access roads and proximity to key points such as a lake (101.78 m), the Manacacías River (1,900 m), the cemetery (1,950 m), and the WWTP (3,160 m). This location supports supply, connectivity, and efficient commercialization of beer.

Plot 2

Figure 2. Location of Plot 2 (Google Earth, 2025)

Figure 2, also located in Las Villas village with direct access to the airport road, is 910 meters from the urban area. It is close to a lake (140 m), the Manacacías River (1,600 m), the cemetery (1,750 m), and the WWTP (2,900 m). This location favors commercialization and ensures quick and convenient access for workers and visitors.

Consistent with the above, this study focuses on the initial phase of a project aimed at selecting the best site for a craft brewery. Key factors affecting production efficiency and the feasibility of an agritourism business model are considered (8). A strategic location is crucial to reduce operating costs associated with supply chain and distribution, and to facilitate access to markets and essential resources (9).

Likewise, selecting the right site requires analysis beyond simple geographic proximity; it must consider raw material availability, transport infrastructure, access to skilled labor, and proximity to the target market. These elements are interconnected with operating costs and commercial strategy (10). Efficient plant layout planning is vital to optimize operations, as it reduces unnecessary material movement and improves workflow, resulting in higher productivity and profitability (11).

This integrated approach to site selection and plant design is essential to ensure long-term sustainability and competitiveness (11). Furthermore, adequate layout planning can also become a differentiating factor that strengthens wine tourism or agritourism, as seen in winery designs that combine aesthetics and production efficiency (12).

Optimizing layout in agroindustrial plants with a tourism focus improves production flow, reduces idle time, and increases operational efficiency (11)(13). Internal distribution and site location are decisive for logistical efficiency and production success (14). In addition, geographic location is key in agritourism projects such as craft breweries (15), as it affects profitability and the relationship with the local environment (16). The use of GIS and multicriteria analysis supports the selection of sites that maximize benefits while minimizing costs and impacts (17).

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Consequently, an optimized layout prevents inefficient flows and reduces operating costs, especially in specialized processes (18)(19).

Weighted factors

Table 1 presents the weighted factor results for two possible plant locations in Puerto Gaitán, Meta, showing each site's ratings and weighted scores to determine the most suitable option.

Table 1. Weighted factor table

Relevant factor	Weight (%)	Plot 1 (Las Villas, airport road) Rating	Plot 1 Weighted	Plot 2 (Las Villas, airport road) Rating	Plot 2 Weighted
Visibility	10	9	0.90	6	0.60
Accessibility	20	8	1.60	6	1.20
Public utilities	10	7	0.70	7	0.70
Proximity to consumers	15	9	1.35	6	0.90
Proximity to raw materials	15	8	1.20	8	1.20
Safety	10	8	0.80	6	0.60
Sector viability	20	9	1.80	7	1.40
Total	**100**		**8.35**		**6.60**

Source: Authors (2025)

Plot 1 scored 8.35 and Plot 2 scored 6.60. Plot 1 is the best option because it received higher ratings in visibility, accessibility, proximity to consumers, safety, and sector viability. The weighted factor methodology, proposed by Koontz and Weihrich (20), is used to evaluate location alternatives by considering key criteria such as accessibility, visibility, availability of public utilities, and proximity to raw materials. This tool assigns weights to each relevant factor and rates each option, facilitating selection of the most appropriate site for installing the craft brewery in Puerto Gaitán.

Regarding the calculation, multicriteria analysis is a systematic approach that helps reduce biases that may arise when decisions rely only on experience, although factor weighting may still require expert judgment (21). Even so, combining weighted factors with detailed assessment of each criterion reduces subjectivity and strengthens the final decision, supporting an evidence-based understanding of why one alternative is superior using quantifiable information (22). The importance of accessibility and proximity to consumers, which favored Plot 1, aligns with prior research on site selection for logistics warehouses and other facilities, where these factors strongly influence operational efficiency.

Process standardization

High-quality raw materials are proposed for producing a Golden Ale craft beer with added tropical fruits, including malt, barley, malted barley, hops, yeast (Saccharomyces cerevisiae), water, mango (Mangifera indica), and passion fruit (Passiflora edulis). The production process will comply with Resolution 2115 of 2007, which establishes drinking-water standards, and with NTC 3854:1996 and NTC 4158:1997, which guarantee food safety and quality in craft beer production.

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The plant will include equipment such as a malt mill, mashing and boiling system, stainless steel fermenters, wort chiller, maturation and storage tanks, filtration system, filler and bottling line, labeling machine, and packaging station, ensuring an efficient process aligned with current regulations.

A well-defined facility location strategy can significantly reduce transportation costs and emissions, and help mitigate environmental impact (23). The importance of systematically planning plant layout integrating activity relationships and specific diagrams has been confirmed by improvements observed in small and medium-sized food facilities (24). This planning not only reduces material-handling distances and related costs, but also optimizes the value chain and supports product quality and safety (24).

Material balance diagram

Because beer is a fermented alcoholic beverage, production is governed by Colombian Technical Standard NTC 3854 (1996), which establishes minimum requirements for beers intended for human consumption, including aspects related to processing, composition, labeling, and storage. The diagram describes the process for producing a fruit-based craft beer, from raw material reception and preparation through milling, mashing, boiling, cooling, pulp addition, fermentation, carbonation, packaging, and storage. A material balance for a 1,000 L plant is also presented to calculate inputs and losses at each stage.

Figure 3 shows the material balance for a 1,000 L brewing plant, detailing inputs such as 225 kg of malt, 1,750 g of hops, 5 yeast sachets, 5,200 g of fruit, and 800 g of dextrose. Minimal losses due to evaporation and sediments are reported, yielding 992 L of beer, equivalent to 3,006 bottles of 330 mL. The flowchart and mass balance help optimize the process, control losses, and ensure production efficiency close to 99.2%, consistent with beverage standards and cleaner production principles. This high conversion rate highlights careful process planning and execution to minimize waste and maximize final product yield (25). Such conversion efficiency aligns with best brewing-industry practices, where loss reduction is a key indicator of sustainability and profitability.

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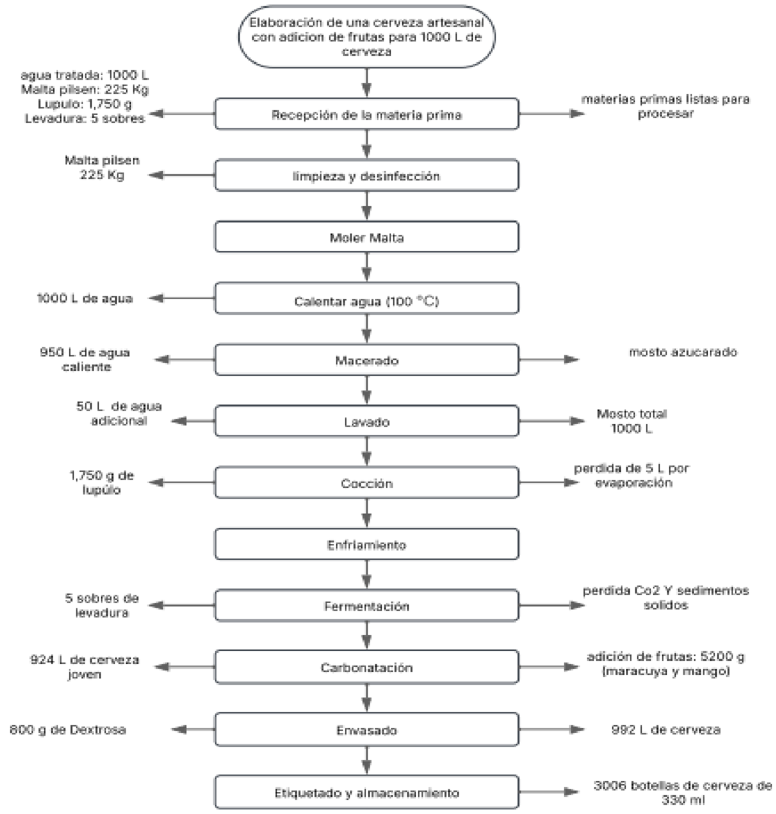

Figure 3. Material balance diagram
Source: Authors (2025)

Relationship matrix

In quality management, the relationship matrix is a key tool within Quality Function Deployment (QFD). This method was developed in Japan in the 1960s.

Figure 4 presents the relationship matrix diagram, where the importance of proximity between areas is indicated through a color system: red for absolutely necessary relationships, yellow for especially important, green for important, blue for ordinary, brown for undesirable, and white for no importance. The analysis shows that proper area distribution in the brewery optimizes process flow, reduces nonproductive time, and ensures quality standards. The relationship matrix supports a logical, hygienic, and safe organization, achieving a functional and efficient design.

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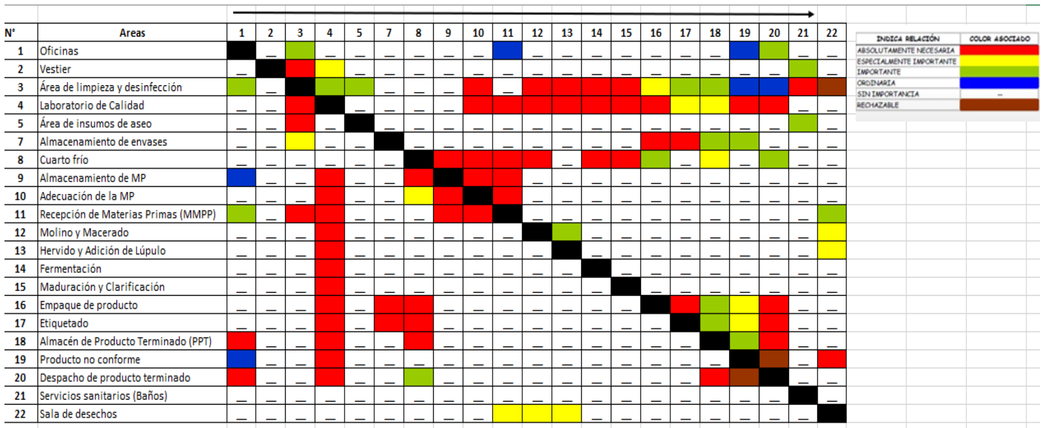

Figure 4. Relationship matrix diagram
Source: Authors (2025)

Consistent with this, optimizing plant design is essential because areas such as raw material receiving, processing units, and bottling zones directly influence production capacity and scalability (26). Methods such as CRAFT can help address layout problems, meeting case-study requirements and enabling continuous improvement despite limitations (27). Likewise, a complete technical study covering both design and logistics is indispensable to reduce waste and satisfy customer needs (14). Finally, choosing a strategic location is key to optimizing logistics and achieving a sustainable competitive advantage (28). In this way, implementing this methodology is fundamental to ensure an optimized flow of materials and processes, minimizing downtime and maximizing productivity critical for operational efficiency in the food and beverage industry (5)(29).

Area relationship diagram (plant work areas)

The following diagram, based on Richard Muther's Systematic Layout Planning (SLP), shows the relationships among the work areas that make up the plant. This scheme facilitates identifying the functional proximity required between zones to optimize material flow, ensure operational safety, and comply with sanitary standards.

Figure 5 shows a logical and efficient distribution of plant areas under the SLP methodology, ensuring a linear flow from receiving and storage of raw materials to milling, fermentation, maturation, packaging, and dispatch. Changing rooms, cleaning, and quality areas are strategically placed to ensure food safety, while the nonconforming product area allows rapid segregation. Support areas do not interfere with the main process, promoting operational efficiency and sanitary compliance.

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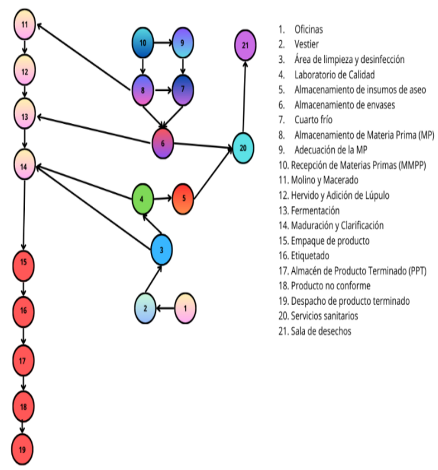

Figure 5. Area relationship diagram (Authors, 2025)

Additionally, adopting an optimized plant layout enables the integration of emerging digital technologies such as IoT and artificial intelligence, improving traceability and transparency across the supply chain (30). Implementing SLP can also improve picking times and reduce errors, directly affecting order-processing efficiency and customer service levels (31). This strategic integration is crucial to meet market demands, adapt quickly to changes, and maintain a competitive advantage (24).

Space and area calculation

Area calculation and distribution in a production plant are fundamental for design and prototyping, as they ensure efficient use of space, operational safety, and compliance with sanitary regulations. The Guarchet method was applied. According to Muther's SLP methodology, space organization must consider not only equipment size and operational requirements, but also material flows, accessibility, occupational safety, necessary clearances for movement, and future expansions.

Table 2 details the area requirements for each process within the craft beer plant, emphasizing the importance of a design that optimizes workflow and minimizes operational risks.

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Table 2. Space and area calculation (Guarchet method)

Area type and total	Main equipment	Width (m)	Length (m)	Height (m)	Operable sides	Static surface (m²)	Gravitational surface (m²)	Evolution surface (m²)	Base area (m²)	Allowance (%)	Final area with allowance
Receiving and raw material storage (13.65 m²)	Shelving, scales	8	3	2.5	2	6	4	0.5	10.5	30	13.7
Production area (55.32 m²)	Malt mill	1	1.5	1.2	1	1.5	1	0.2	2.7	20	3.24
	Mashing & boiling kettle	3	4	3	3	12	8	1.5	21.5	30	28
	Fermentation tanks	2.5	2.5	3.5	3	6.25	4	0.8	11.1	25	13.8
	Maturation tanks	2	2.5	3.5	2	5	3	0.6	8.6	20	10.3
Packaging area (19.18 m²)	Filler, capper, labeling	2.5	3.5	2.5	2	8.75	5	1.0	14.8	30	19.2
Finished product storage (26.5 m²)	Shelving, cold rooms	3	4	3	2	12	8	1.2	21.2	25	26.5
Quality control and lab (10.32 m²)	Analysis tables	2	2.5	2.5	2	5	3	0.6	8.6	20	10.3
Offices and administration (11.4 m²)	Desks, archives	2	3	2.5	1	6	3	0.5	9.5	20	11.4
Services (restrooms & changing rooms) (11.14 m²)	Toilets, sinks	2	3	2.5	1	6	3	0.5	9.5	20	11.4

Source: Authors (2025)

Plot 1, selected in Las Villas village, Puerto Gaitán, has a total area of 6,624.06 m². The analysis indicates that productive activities according to the conceptual design including production, storage, distribution, administrative, and service stages require approximately 148 m². This significant difference between available area and required area indicates a large land surplus; therefore, the lack of a well-structured method to plan distribution can limit flexibility and competitiveness in small and medium-sized enterprises (24). In practice, implementing a Lean Service Model that includes SLP can reduce order cancellations and expired inputs while improving customer satisfaction in the food sector (32).

Furthermore, Muther's systematic approach differs from traditional methods by offering a scientific, data-driven perspective focused on optimizing efficiency and adaptability in manufacturing facilities (33). This method integrates all required areas according to a process flow that meets sanitary regulations and reduces operational risks (33).

Basic sanitation program

The initial plan identifies 26 areas of interest, including administrative offices, changing rooms and lockers, entrance corridor, sanitary filter, nonconforming product area, laboratory, packaging

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storage, raw material dispatch to processing, cold room, raw material storage and preparation, processing area, packaging and labeling, finished product storage, dispatch, social area, restrooms, waste area, elevated tank with stair access, and a wastewater treatment plant, among others.

The layout shown in Figure 6 is based on a design that optimizes a linear process flow, ensuring product traceability from raw material reception to final dispatch. The strategic placement of support and control spaces such as the sanitary filter, nonconforming product area, and quality laboratory creates safety barriers that reduce contamination risk and ensure food safety. Sustainable infrastructures, such as the elevated tank and wastewater treatment plant, demonstrate responsible water-resource management and effluent treatment, consolidating a modern, safe, and environmentally sustainable design.

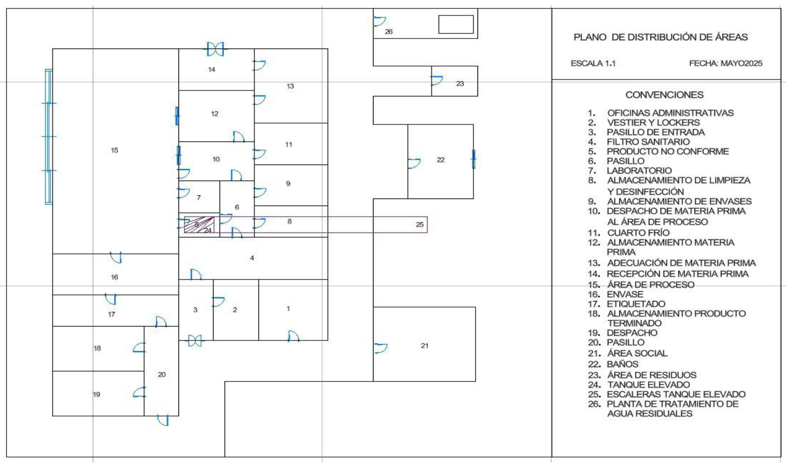

Figure 6. Initial plan—areas of interest according to sanitary regulations
Source: Authors (2025)

It is also essential to integrate hygiene and safety regulations into layout design to ensure compliance and prevent operational risks, which optimizes process efficiency and reduces production interruptions. This proactive approach helps minimize physical, chemical, and biological hazards, ensuring final product safety and protecting personnel (34).

Physical barriers plan for pest control

Pest control is a fundamental requirement in production plant design, as it ensures food safety, security, and compliance with current sanitary regulations, as established by Resolution 2674 of 2013 in Colombia. Therefore, the physical barriers plan represents the strategic placement of preventive elements to minimize the risk of insect and rodent entry and proliferation within the facilities.

Figure 7 shows the strategic distribution of physical barriers for pest control, in compliance with Resolution 2674 of 2013. Measures include drain grates and cockroach traps, durable mesh on windows and openings to prevent insect and rodent entry, and UV light traps located in critical areas to capture flying insects. PVC strip curtains are installed at main access points to create a barrier without affecting personnel flow, and sealing joints isolate floor–wall–ceiling interfaces to

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eliminate pest harborage. Rodent traps are placed around the exterior perimeter to strengthen protection before pests enter the facility. This integrated set of barriers ensures a hygienic and safe environment, minimizing contamination risks and ensuring food safety across all plant areas.

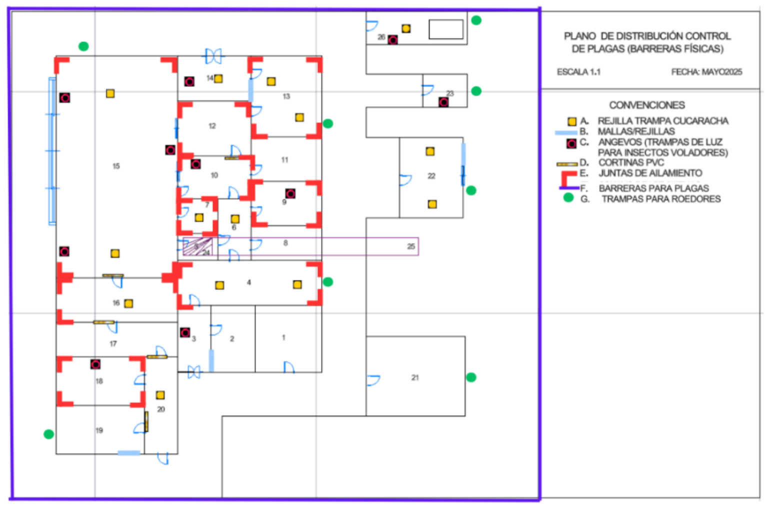

Figure 7. Pest control distribution plan (physical barriers)
Source: Authors (2025)

The plant design aligns with food safety, operational efficiency, and regulatory compliance principles established by Resolution 2115 of 2007 and Resolution 2674 of 2013. The infrastructure includes an elevated tank as the primary source of drinking water, distributed through blue piping to critical areas such as the laboratory, changing rooms, restrooms, and processing. The hydraulic network is clearly differentiated: green carries wort water, red carries finished beer, gray collects wastewater (restrooms and processing) toward the WWTP, and yellow manages stormwater drainage. This segregation prevents cross-contamination and improves flow traceability.

Daily drinking water consumption is estimated at approximately 4,150 liters per day, distributed among sanitary use (450 L), area cleaning and disinfection (1,200 L), and production (2,500 L for 500 liters of beer), demonstrating the need for a robust and properly sized water system to ensure operational continuity and sanitary quality of the final product.

Waste-handling area distribution plan

Figure 8 shows the waste distribution plan for the craft brewery and represents the design of waste evacuation routes, established under hygiene, efficiency, and regulatory compliance criteria. This system ensures segregation at source, prevents cross-contamination, and optimizes waste transport from generation points to final disposal, aligned with GMP and Colombia's current environmental and sanitary regulations.

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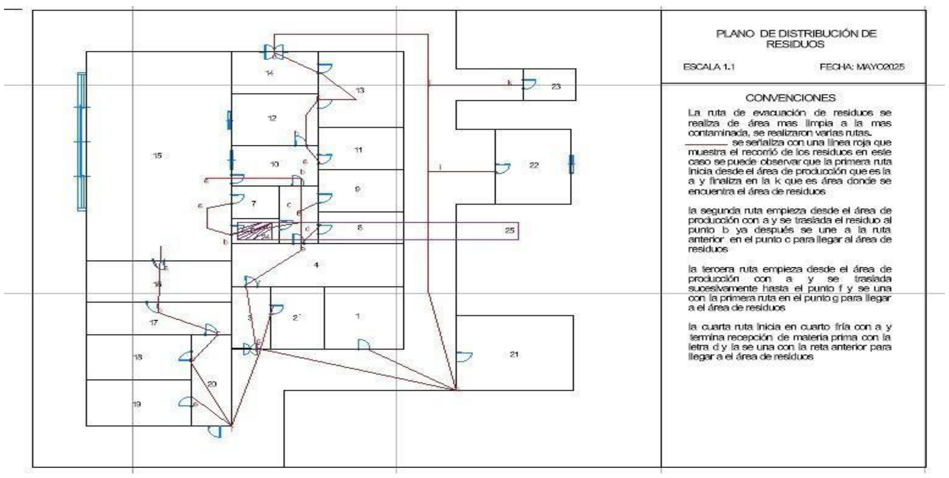

Figure 8. Waste-handling area distribution plan
Source: Authors (2025)

The waste evacuation system converges from six origin points in production areas ('a', 'b', 'c', 'd', 'x', 'y') into a single final collection point ('k'). All routes, shown through variations of a red line, ensure controlled and unidirectional flow, which is essential for hygienic and safe waste management. This design follows the principle that waste must always move from cleaner (or less contaminated) areas toward dirtier (or more contaminated) areas, preventing cross-contamination, in accordance with GMP and biosafety standards.

In the same line, implementation requires strict compliance with Resolution 2184 of 2019 (Ministry of Environment and Sustainable Development), which establishes the national color code for source separation (white for recyclable, green for compostable organics, and black for non-recyclable), in accordance with Decree 1076 of 2015. Resolution 2674 of 2013 establishes that containers and routes must be leak-proof, easy to clean, and clearly identifiable, while Decree 1072 of 2015 requires that personnel use appropriate personal protective equipment (PPE). For hazardous waste, Decree 4741 of 2005 regulates packaging, labeling, and final disposal through authorized managers. Overall, the efficiency of this converging route network is a cornerstone for ensuring product safety and environmental protection in the brewery.

Occupational Health and Safety (OHS) plan

Implementing an Occupational Health and Safety (OHS) system in the plant design is essential to protect worker integrity and ensure operational continuity during emergencies. The OHS layout plan graphically establishes the strategic placement of ABC and CO_2 fire extinguishers and evacuation routes key elements to control and mitigate fire risks and other emergencies.

Figure 9 shows a signage system with evacuation routes marked in green, connecting areas such as storage, processing, offices, and changing rooms to emergency exits. These routes comply with Resolution 2400 of 1979, which requires visible directional signage. All doors open in the direction of evacuation, ensuring safe movement and best practices.

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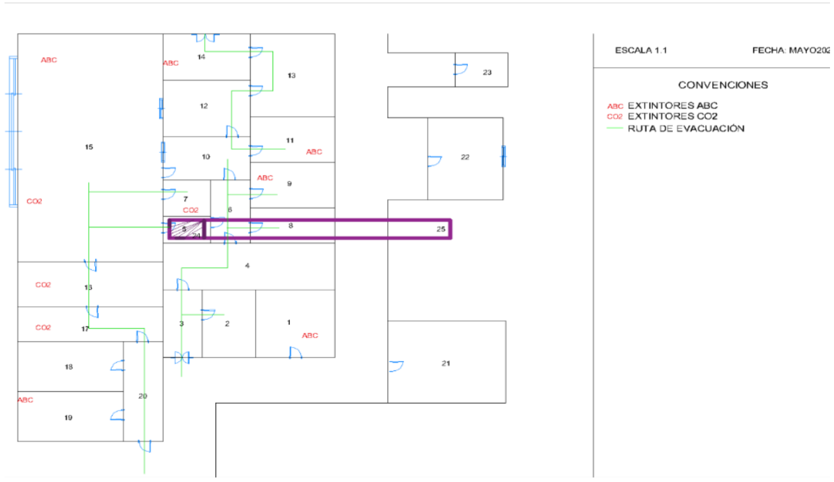

Figure 9. OHS system distribution plan (Authors, 2025)

The plan also indicates the location of ABC and CO_2 extinguishers in high-risk areas such as laboratories, processing, storage, and dispatch, following coverage criteria and rapid access. Red signage with white letters complies with Resolution 2400 of 1979. Proper implementation requires periodic inspections and staff training in extinguisher use, first aid, and evacuation, strengthening preventive management and safety culture.

A good coordination between SLP and sanitary regulations supports workflows that prevent cross-contamination and facilitate cleaning and disinfection procedures essential in the food industry (35). Optimizing plant design through SLP not only improves logistics and relationships among non-logistics processes, but also enables the gradual inclusion of safety and sustainability factors in planning (36). This strategic methodology focuses on optimizing space, reducing unnecessary movement, and improving flow of materials and personnel critical for operational efficiency and safety in complex production environments (37).

Accordingly, plan design incorporated drawings aligned with the basic sanitation program required by sanitary regulations, including pest-control physical barrier plans, the hydraulic and sanitation distribution, waste evacuation plan, and OHS plan. This ensures traceability, food safety, water efficiency, and compliance with the regulations referenced above.

3D digital prototype

A 3D digital prototype of the Majaguillal craft brewery production plant was developed under full compliance with applicable sanitary regulations. The prototype was created in SketchUp 3D, enabling a detailed visual representation of infrastructure, area distribution, and internal flows, ensuring that the projected design meets hygiene, safety, and production efficiency criteria. Figure 10.

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Figure 10. 3D model (SketchUp)—main entrance and full-area view
Source: Authors (2025)

Figure 11 presents the 3D model developed in SketchUp, where areas are distributed compactly and efficiently, following production-flow criteria and GMP. By incorporating an agritourism approach, the design must meet sanitary and safety standards while also providing attractive visitor spaces. This requires adequately separating production areas from public areas through barriers and biosafety protocols, ensuring hygiene and a positive tourism experience without interfering with operations (38).

Figure 11. 3D model (SketchUp)—views from multiple angles
Source: Authors (2025)

Conclusions

The diagnosis of technical, sanitary, and sustainability requirements established in Colombian regulations allowed the definition of essential guidelines for installing the craft brewery in Puerto Gaitán. The analysis highlighted the importance of complying with Resolution 2674 of 2013, Decree 162 of 2021, Resolution 2115 of 2007, and applicable NTC standards to guarantee food

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safety, security, and quality. Regulatory compliance is the foundation for consolidating the project, minimizing regulatory risk, and strengthening consumer trust.

Plant design and prototyping supported by systematic layout planning, technical drawings, relationship matrices, and digital prototypes made it possible to structure an efficient, hygienic, and adaptable operating model tailored to regional needs, demonstrating technical and productive feasibility.

The proposed replicable model shows that this scheme can be implemented in other emerging agritourism regions with similar characteristics, offering a reference point for new ventures. Beyond productive viability, the proposal supports economic diversification and strengthens agritourism by integrating products with territorial identity, such as tropical fruit–enriched craft beer.

CrediT authorship contribution statement

Conceptualization - Ideas: Angie Beltrán, Derly Henao, Merly Daza, Michell Hernández, Sandra Delgado. Data curation: Derly Henao, Merly Daza, Michell Hernández. Formal analysis: Derly Henao, Merly Daza, Michell Hernández. Investigation: Angie Beltrán, Derly Henao, Merly Daza, Michell Hernández. Methodology: Derly Henao, Merly Daza, Michell Hernández, Sandra Delgado. Project Management: Sandra Delgado. Resources: Sandra Delgado. Software: Michell Hernández, Derly Henao. Supervision: Sandra Delgado. Validation: Derly Henao, Merly Daza, Michell Hernández. Writing - original draft - Preparation: Angie Beltrán, Derly Henao, Merly Daza, Michell Hernández. Writing - revision and editing -Preparation: Sandra Delgado, Derly Henao, Merly Daza.

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