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The implementation of an integrated Lean Management-HACCP model: application in the food industry in Casablanca,Morocco

Mensouri Samya1[1]*, Benlamlih Imad 2[2], BenhoussaYasmine3[3], Saile Rachid 4[4], KettaniAnass5[5],

[1] * PhD Student in the implication of lean management in the food sector *ORCID* : https://orcid.org/0009-0000-9526-3193. *Phone :* +212 661833055; *e-mail:* mensourisamya@gmail.com
*Corresponding author
[2] PhD Student, Faculty of Sciences Ben *ORCID* : https://orcid.org/0000-0002-2997-7451. *Phone* : +212 661880725; *e-mail* :imad.benlamlih@gmail.com
[3] PhD Student in the Industrial risk management and corporate social responsibility*ORCID*: https://orcid.org/0000-0003-1440-8501.*Phone:* +212 631842828; e-*mail:* yasmine.benhoussa@gmail.com
[4] PhD in Biochemistry *ORCID* : https://orcid.org/0000-0002-7411-0523. *Phone* : +212 661218525; *e-mail* : rachid.saile@univh2c.ma; sailerachid@yahoo.fr
[5]PhD in Bioinformatics Sciences Paul Sabatier *ORCID*: https://orcid.org/0000-0002-7572-9002. *Phone* : +212661333047; *e-mail* : a.kettani@cm6.ma; kettanianass@yahoo.fr

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Abstract
In a context where the food industry is constantly seeking to improve the quality, safety and efficiency of its operations, the integration of Lean Management principles and HACCP practices is emerging as a powerful and innovative approach. The aim of this strategic merger is to create a robust model that guarantees maximum efficiency, while meeting the growing requirements in terms of food safety and risk management. This study explores the design of such a model, highlighting five essential components to achieve 100% efficiency.This article presents a proposal for the implementation of an integrated model combining both the Lean Management and HACCP approaches in an industrial agri-food company specialising in the manufacture of pastries, Viennese pastries and bakery products located in Casablanca, Morocco.The work comprises three parts: the first concerns the implementation of lean management tools in the production chain, which has produced remarkable gains: 92% implementation of the zero-waste method, a reduction in the rate of breakdowns, resulting in an OEE of 76%, 100% of products manufactured on a 'Just in Time' basis, 50% for the application of the SMED method, the production of 95% of compliant products, and waiting times have been reduced to 50%.The second part deals with the implementation of HACCP tools on the production line that is the subject of our study, which has enabled us to achieve very significant gains of over 80% in the elimination of the risks studied. The third part proposes the design of a model aimed at achieving 100% efficiency by merging Lean Management and HACCP. This model is based on five main components: the use of common tools and practices, the shared use of resources, mutual reinforcement and the creation of a new global and integrated approach.The implementation of this conceptual model will offer food businesses the opportunity to reduce costs and increase productivity, while maintaining the food safety standards required in this specific area of the industry.
Key words: Lean Management, HACCP, minimize waste, food industry, Lean Tools, agri-food integrated model, Morocco

Implantación de un modelo integrado Lean Management-HACCP: aplicación en la industria alimentaria de Casablanca,Marruecos

Resumen

En un contexto en el que la industria alimentaria busca constantemente mejorar la calidad, la seguridad y la eficiencia de sus operaciones, la integración de los principios de Lean Management y las prácticas APPCC se perfila como un enfoque potente e innovador. El objetivo de esta fusión estratégica es crear un modelo sólido que garantice la máxima eficiencia, al tiempo que satisface los crecientes requisitos en materia de seguridad alimentaria y gestión de riesgos. Este estudio explora el diseño de un modelo de este tipo, destacando cinco componentes esenciales para alcanzar el 100% de eficiencia.Este artículo presenta una propuesta de implantación de un modelo integrado que combina los enfoques Lean Management y APPCC en una empresa industrial agroalimentaria especializada en la fabricación de bollería, pastelería y productos de panadería situada en CASABLANCA, MARRUECOS.El trabajo consta de tres partes: la primera se refiere a la implantación de herramientas de gestión ajustada en la cadena de producción, que ha producido notables ganancias: un 92% de implantación del método de cero residuos, una reducción de la tasa de averías, que se traduce en un OEE del 76%, un 100% de productos fabricados según el método "Just in Time", un 50% de aplicación del método SMED, la fabricación de un 95% de productos conformes, y los tiempos de espera se han reducido al 50%.La segunda parte trata de la implantación de herramientas APPCC en la línea de producción objeto de nuestro estudio, lo que nos ha permitido obtener ganancias muy significativas de más del 80% en la eliminación de los riesgos estudiados. La tercera parte propone el diseño de un modelo destinado a alcanzar el 100% de eficacia mediante la fusión del Lean Management y el APPCC. Este modelo se basa en cinco componentes principales: el uso de herramientas y prácticas comunes, el uso compartido de recursos, el refuerzo mutuo y la creación de un nuevo enfoque global e integrado.

La aplicación de este modelo conceptual ofrecerá a las empresas alimentarias la oportunidad de reducir costes y aumentar la productividad, manteniendo al mismo tiempo las normas de seguridad alimentaria exigidas en este ámbito específico de la industria.

Palabras clave: Lean Management, APPCC, minimización de residuos, industria alimentaria, herramientas Lean, modelo integrado agroalimentario, Marruecos

La mise en œuvre d'un modèle intégré Lean Management-HACCP : application dans l'industrie alimentaire à Casablanca, Maroc

Résumé

Dans un contexte où l'industrie alimentaire cherche constamment à améliorer la qualité, la sécurité et l'efficacité de ses opérations, l'intégration des principes du Lean Management et des pratiques de l'HACCP émerge comme une approche puissante et innovante. Cette fusion stratégique vise à créer un modèle robuste qui garantit une efficacité maximale, tout en répondant aux exigences croissantes en matière de sécurité alimentaire et de gestion des risques. Cette étude explore la conception d'un tel modèle, mettant en lumière cinq composantes essentielles pour atteindre une efficacité de 100 %. Cet article présente une proposition de mise en œuvre d'un modèle intégré combinant à la fois l'approche Lean Management et HACCP dans une entreprise agroalimentaire industrielle spécialisée dans la fabrication de pâtisseries, de viennoiseries et de produits de boulangerie située à Casablanca, Maroc.Le travail englobe trois parties : la première sur l'implémentation des outils lean management dans la chaîne de production, qui engendre des gains remarquables : 92% de réalisation de la méthode zéro gaspillage, une réduction du taux des pannes donc une TRS allant à 76%,100% des produits fabriqués en 'Juste à Temps' ,50%pour l'application de la méthode SMED, la réalisation de 95% des produits Conformes et les temps d'attente sont réduits à 50%.

La deuxième sur la mise en place des outils de l'approche HACCP sur la ligne de production sujette de notre étude, qui a permis de réaliser des gains très importants qui dépasse les 80% pour l'élimination des risques étudiés. La troisième partie propose la conception d'un modèle visant à réaliser une efficacité de 100 % en fusionnant le Lean Management et l'HACCP. Ce modèle repose sur cinq composantes principales : l'utilisation d'outils et de pratiques communs, l'utilisation

partagée des ressources, le renforcement mutuel, l'utilisation d'outils et de pratiques communs et la création d'une nouvelle approche globale et intégrée.La mise en œuvre de ce modèle conceptuel offrira aux entreprises du secteur alimentaire la possibilité de réduire les coûts et d'augmenter la productivité, tout en maintenant les normes de sécurité alimentaire requises dans ce domaine spécifique de l'industrie.
Mots-clés : Lean Management, HACCP, minimiser les déchets, industrie alimentaire, outils Lean, modèle intégré agroalimentaire, Maroc

A implementação de um modelo integrado Lean Management-HACCP: aplicação na indústria alimentar de Casablanca, Marrocos

Resumo
Num contexto em que a indústria alimentar procura constantemente melhorar a qualidade, a segurança e a eficiência das suas operações, a integração dos princípios da Gestão Lean e das práticas HACCP surge como uma abordagem poderosa e inovadora. O objetivo desta fusão estratégica é criar um modelo robusto que garanta a máxima eficiência, ao mesmo tempo que satisfaz os requisitos crescentes em termos de segurança alimentar e gestão de riscos. Este estudo explora a conceção de um modelo deste tipo, destacando cinco componentes essenciais para atingir 100% de eficiência.Este artigo apresenta uma proposta de implementação de um modelo integrado que combina as abordagens Lean Management e HACCP numa empresa industrial agroalimentar especializada no fabrico de pastelaria, pastelaria vienense e produtos de panificação situada em Casablanca, Marrocos.O trabalho é composto por três partes: a primeira diz respeito à implementação de ferramentas de gestão lean na cadeia de produção, que produziu ganhos notáveis: 92% de implementação do método zero desperdício, uma redução da taxa de avarias, resultando num OEE de 76%, 100% dos produtos fabricados numa base "Just in Time", 50% para a aplicação do método SMED, a produção de 95% de produtos conformes e os tempos de espera foram reduzidos para 50%.A segunda parte trata da implementação de ferramentas HACCP na linha de produção objeto do nosso estudo, o que nos permitiu obter ganhos muito significativos de mais de 80% na eliminação dos riscos estudados. A terceira parte propõe a conceção de um modelo que visa atingir 100% de eficácia através da fusão do Lean Management e do HACCP. Este modelo baseia-se em cinco componentes principais: a utilização de ferramentas e práticas comuns, a utilização partilhada de recursos, o reforço mútuo e a criação de uma nova abordagem global e integrada.A implementação deste modelo concetual oferecerá às empresas do sector alimentar a oportunidade de reduzir custos e aumentar a produtividade, mantendo os padrões de segurança alimentar exigidos nesta área específica da indústria.
Palavras-chave: Gerenciamento Lean, HACCP, minimização de desperdício, indústria de alimentos, ferramentas Lean, modelo integrado agroalimentar, Marrocos

1. Introduction

The food industry sector is a sensitive sector which requires strict health and legal rules. Food product manufacturers are subject to a food safety management system according to the HACCP method which requires caution, foresight, analysis and correction of food risks.
Likewise, the food industry is facing new challenges to respond to the growth of the competitive market experienced by the diversity of offers and the narrow profit margin.
In addition, sheltered from international crises (Covid 19, geopolitical crisis, climatic conditions, high costs of materials, etc.) industrial agri-food companies are increasingly obliged to optimize their production costs, minimize waste and improve the quality of their production by adopting an approach that ensures the agility of their food chain (Idrissi and Benazzouz , 2019) .
Indeed, “Lean Thinking” has become a concern for the heads of industrial agri-food companies as an essential solution to be implemented in parallel with the HACCP method in order to reduce non-added value and waste in the manufacturing process of products. agri-food products while guaranteeing their health safety (Domínguez and al.,2021).

In this context, this paper proposes a combination of the two approaches Lean Management and HACCP in the context of an agri-food industry based in Casablanca, Morocco, specialized in the manufacture of pastry, viennoiserie and bakery products. The objective is to develop a conceptual model that integrates these two approaches simultaneously.
To achieve this objective, the first section of this paper presents the contribution of the combination of 'Lean Management' and 'HACCP' approaches in the food sector. The 2nd section presents a case study of the implementation of an integrated Lean Management-HACCP model in the industrial food company of pastry and pastries in Casablanca subject of our research, to conclude with the discussion of the results and the recommendations.

2. The contribution of combined 'Lean Management' and 'HACCP' approaches in the agri-food industry sector

2.1. The common specificities of the two approaches: Lean Management-HACCP

According to the results of several research studies, the authors note that the implementation of a combined Lean Management approach makes it possible to improve several types of performance in the agri-food sector (Gładyszand al., 2020) ; (Lehtinen and Torkko, 2005).
These common improvements of these two approaches can be summarized in Six essential elements that can be proposed in an integrated Lean Management-HACCP model:

- Quality orientation and customer satisfaction : Both approaches emphasize customer satisfaction and the provision of high-quality products or services.
- Proactive Basic Approach : HACCP and Lean Management takes a proactive approach to identifying and preventing potential problems before they occur.
- Focused on continuous improvement : Both approaches encourage continuous improvement by identifying problems, implementing control measures and constantly seeking to improve processes.
- Improving employee involvement: Both approaches recognize the importance of employee involvement and commitment in implementing best practices and improving processes.
- Emphasis on risk management : HACCP focuses specifically on managing risks related to food safety. While Lean Management identifies and manages risks related to quality, operational efficiency and customer satisfaction.
- Promoting operational efficiency : Both approaches aim to optimize processes, eliminate waste, reduce costs and improve the overall efficiency of the organization.

According to the presentation of these common points, the two Lean management-HACCP approaches can be complementary and used jointly to improve the overall performance of an organization .

2.2. The contributions of the combined implementation of the two approaches: Lean Management-HACCP

The joint application of HACCP and Lean Management can indeed generate several improvements in terms of improving the performance of companies in the food industry.

- Time optimization: in fact the simultaneous implementation of the two approaches makes it possible to reduce the time required to implement each approach separately.
  It should therefore be noted that the optimization of implementation time will depend on the specific situation of each company and the resources available. Good planning and an integrated approach can make it possible to achieve significant time savings when jointly applying HACCP and Lean Management.
- Shared use of resources : The combination of efforts and resources necessary for the implementation of HACCP and Lean Management allows for significant savings in time and costs. Indeed, certain training and awareness stages can be common to both approaches and we will avoid duplicating activities.

- Use of common tools and practices : Both approaches use common tools and practices, such as risk analysis, identification of good practices, standardization of processes, staff training, etc. By using them in a coordinated manner . Thus, the combination of the two approaches will make it possible to avoid redundancies and optimize the time necessary for their implementation.
- The creation of a new comprehensive and integrated approach : HACCP and Lean Management share certain common principles and methodologies, such as the identification of critical control points, process analysis, waste reduction and improvement. keep on going. By combining these two approaches, it is possible to exploit synergies and benefit from a more comprehensive and integrated approach.
- Mutual reinforcement : HACCP focuses specifically on food safety, while Lean Management aims to improve operational efficiency and customer satisfaction. By combining these two approaches, simultaneous improvements can be achieved in areas related to the food industry.

3. The implementation of an integrated Lean Management-HACCP model: Case study on an industrial pastry and pastries food company in Casablanca.

3.1. Methodologicalapproach

3.1.1. Context and interest

In the food industry, the simultaneous involvement of Lean Management and HACCP presents several advantages (Domínguez and al., 2021). Lean Management makes it possible to optimize production processes, reduce waste, improve productivity and minimize costs. As for HACCP, it focuses on food safety by ensuring compliance with food safety standards and identifying critical control points and implementing specific control measures.

Indeed, the combination of these two approaches in a food business can improve the quality and safety of their products, while reducing the risks of contamination and the associated costs.

3.1.2. Problematic

This research paper allows us to see to what extent the implementation of the Lean Management approach reconciled with HACCP will make it possible to improve productivity indicators in the case of a pastry company which is the subject of our study? This involves studying the productivity indicators of this company by implementing the Lean management approach and the HACCP approach separately and comparing them with the indicators obtained after the implementation of the proposed model integrating the two approaches. at a time.

3.1.3. Methodologyfollowed

In order to achieve our objective our applied methodology is as follows:

- 1st step : this step consists of detecting waste in the production line and applying appropriate Lean-management tools to reduce or eliminate this waste. At the end of this step, the improvement indicators are recorded. (Womack, James P., and al.,2003)
- 2nd step : it consists of determining the risks in the production chain and the application of the tools of the HACCP approach for the elimination or reduction of these risks. Likewise, the indicators at the end of this step are saved. (Codex Alimentarius Commission, 2003)
- 3rd step : consists of applying the tools of the proposed integrated Lean Management-HACCP model to the risks detected, recording the results and comparing the results with those of the 1st and 2nd steps.(Samya and al.,2023).

3.1.4. Application of the Lean - Management approach

In this phase, we applied a series of Lean-Management tools including JIDOKA, Just In Time, 5S, PDCA, Poka Yoke , SMED (Single Minute Exchange of Die), Standardization , Takt Time and Zero Waste. The choice of these tools are chosen with the objective of their use in food production environments (Idrissi and Benazzouz , 2019) and with the idea of its use in the Lean-HACCP project (Domingezand al., 2021) ; (Samya and al.,2023).

Table 1 summarizes the waste detected, the Lean-management tools applied to each type of waste as well as the results obtained after their application:

Table 1: Results of Lean management actions implemented on waste detected within the factory

Wastedetected	Applied Lean Management tools	Corrective actions applied over a period of 4 months according to the 'Lean Management' tools used	Gain after implementing Lean Management Tools
218 batches of raw materials out of 752 have an expiry date (DLC). 752 ⟶ 100% 218 ⟶ (218* 100) / 752 ≈ 29% • Which represents: 29 % waste (products have passed their use-by date).	Zero Waste	Purchasing raw materials only when necessary and in sufficient quantity. • Only 60 batches of expired raw materials: Purchasing raw materials only when necessary and in sufficient quantities gives : 752 ⟶ 100% 60 ⟶ (60* 100) / 752 ≈ 8 %	Only 8% waste (products with an expired use-by date) ≈ Zero waste Therefore 92% of raw materials that have not expired (still have a valid use-by date).
5 machines down/8 hours According to the calculation below the table : - OEE (OverallEquipmentEfficiency) = 55.8%	JIDOKA (Autonomation)	• Regular maintenance of machines through the creation of an action plan and the execution of preventive maintenance	A reduction in the breakdown rate to 2 Machines/8 hours OranOEE of 76%
30% of products are not requested by the customer and manufactured and stored anyway. • Generation of additional costs without any added value.	Just In Time	• Just-in-time production through the implementation of a “Pulled flow” system.	No stocked products instead of 30%. 100% of products manufactured in JIT
The series changeover time is 20 min .	5S- SMED	• Application of the 5S method which consists of Sort/Classify/Clean/Maintain/Formalize. • Conversion of internal activities (any activity that takes place	Series changeover time reduced from 20 min to 10 min

		during the series changeover and when the equipment is stopped) into external activities (any activity that can be carried out when the equipment is in production for the reduction of downtime facility • Investment in new equipment. • The use of a pull or "Kanban" system which made it possible to create a faster cycle in production.	= 50% completion
-Defects detected in products fall into 2 categories: Either they have to be scrapped or reworked. -In these cases, there is no point in producing quickly if a high percentage of products are likely to cause problems for the customer. • 20% ofproductswithdefects /month	POKA YOKE	• Integration of downstream quality control to ensure that a result is undoubtedly obtained before production. • Slowing down the process from the outset and resolving problems instantly, rather than incurring the costs of monitoring and scrapping after the fact. • Recommendation to focus on each anomaly, and identify inconsistencies by operators in order to report them. • This involves openness to problems and daily dialogue on the part of management according to the recommendations of (Vigarello,2022)	Only 5% of non-compliant products per month In other words, 95% of products are compliant.
Existence of unnecessary actions which result in wasted time: • Performing repetitive movements without any added value • Search for tools, control, measure and verify parts after assembly.	Zero waste	• Creation of suitable physical conditions for employees as well as operators to avoid stretching and strain during movements and displacements. • Self-monitoring at each workstation. • Reorganization of the production space including the sequencing of processes as well as the reduction of distances between production lines, operators and equipment. • Respecting workstation ergonomics in order to preserve the health of employees and offer them maximum safety, comfort and efficiency within the factory.	Obtaining Zero Waste Or 100% gain

Existenceofwaiting times: • 20 min wait for materials to arrive; • 10 minutes of waiting for instructions from superiors to start the day's production. • Adapting in an inflexible and slow manner to sudden changes.	Standardization	• Preparing the raw materials and the day before and placing them under storage conditions near the production line to ensure a continuous flow (moving from one model to another without making series) and eliminating waiting times. • Standardization of work instructions by achieving a repetitive operating mode with fewer changes. • Recruitment of versatile and productive workers (less stress, more fluidity and less waiting) capable of adapting quickly to work requirements.	Waiting times reduced from 20 min to 10 min and from 10 min to 5 min which represents 50% completion

For the 1st type of waste, which represents a quantity of raw materials in excess of demand, additional materials taking up more space, finished products that cannot be sold because of their expiry dates. In this way, raw materials are purchased only when necessary and in sufficient quantities, and out-of-date products are managed through :

-Compliance with the FEFO method: The first expire first out method means that products with expiry dates that are close to their expiry date will be stored in the front, ready to be used first,

- Have the average monthly consumption of each product at risk of expiry;

Based on these actions, we can deduce a reduction of 8% in 60 products out of 752 that have passed their use-by date, which means that we have reached a threshold of almost zero waste.

For waste number 2, it indicates a slowdown or a complete stoppage of the production line due to equipment malfunction. We can see how 5 machines break down with a 10 minute stoppage for every 8 hours worked.

This implies a waste of 50 minutes. As for defective products that need to be reworked, this causes a delay of 10 minutes/8 hours. Meal times are set at 20 minutes, but staff consume an additional 10 minutes. The OEE was 55.8%.

Consequently, the adoption of preventive maintenance is an effective way of avoiding any risk of defects in the machines. To achieve this:

- 5S should be applied to the workshops and equipment concerned;
- Clean and tidy up;
- Plan machine maintenance actions in accordance with the manual for each piece of equipment;
- Measure the performance of the production equipment: TRS to check the performance of the machines after each week.

The following table shows how the OEE is calculated:

	Time used	Remaining Time
Total capacity	480 min	
Meals	30 min	
Break	10 min	
Use (time required)		480-(30+10) = 440 min
Breakdowns	5 pannes * 10 min = 50 min	
Gross running time		(440-50)=390 min
Touch-ups	90 min	
Waiting time	40 min	
Net running time		390-(90+40)=260 min
Non-quality/ Non-conformity	10 min	
Addedvalue (useful time)		260-10=250 min

Availability= Gross uptime/Gross downtime = 390/440= 88%
Productivity= Net running time/Gross running time = 260/390=66%
Quality= Value Added/Net Operating = 250/260=96%

OEE = Availability*Productivity*Quality = 55.8%

After implementing the actions and optimising the times indicated, the breakdowns were reduced to 2 machines/8 hours, the time of touch-ups to 60 minutes, the waiting time to 15 minutes, the non-conformity time to 5 minutes, to achieve an efficiency rate of 76% . (Gallaire, 2008).

For waste number 3, which is based on Manufacturing the product or elements of the product before it is requested or required,

When production is higher than what must be produced according to demand by means of a "push" or "flow" production system, the batch size is subsequently twice as large as what is pre-ordered. In the circumstances, stock elimination can be observed following the application of the <<pull>> flow and the implementation of the <<just in time>> method (batch size = pre-ordered products) which implies a 100% achievement of the Just in Time method. (Shah, R., and P. T. Ward ,2003).

With regard to waste number 4, it shows a loss of time between the previous line and the next line, the adoption of the SMED method is inevitable, filming the changeover, timing each stage of the series changeover, undoubtedly makes it possible to determine internal and external activities from the outset. Secondly, the outsourcing of all internal activities that can be carried out safely when the equipment is in production. Finally, the reduction in time for external activities is of the order of 10min. (Ulutas, 2011).

Eliminating wastage 4 results in an improvement, or even an achievement, of 50%

Waste number 5 raises the point of 20% of non-conforming products/month detected on the production line, which generates 20% of defective products that must be discarded or improved without affecting the performance of the final product, this waste has been reduced to 5% of products with defects/month after a work slowdown and a stop at each anomaly revealed, which allows us to achieve almost 0 defects and therefore a realisation of 95% of Products that are conform and have no manufacturing defects.

With regard to waste number 6, we note unnecessary movements caused by poor workstation ergonomics, poor tidying, disorder and disorganisation. To remedy these anomalies, all the physical positions that were comfortable for the employees were encouraged, and all the unnecessary movements were eliminated. (Amir H.M. and al, 2014).

This implies 100% achievement.

With regard to waste number 7, it represents the waiting time for the arrival of materials which, following the organisation and preparation of raw materials a day before, a time reduction of 10 minutes was observed. In addition, the waiting time to start production was reduced by 5 minutes. With a view to standardising work by developing a repetitive operating procedure with less variability, it is essential to invest in training or recruiting workers who are capable of withstanding these sudden changes.

Eliminating waste 7 leads to an improvement, or even an achievement, of 50%.

According to Table 1, we see that the results obtained after the implementation of Lean-management tools in the production line generate significant gains justifying the improvement of the productivity performance indicators of this production line.

In the following section we applied the HACCP approach on the same production line.

4. HACCP analysis: Riskdetection

This step consists of identifying risks likely to block operational excellence and the standardization of Lean tools within the factory, and are also likely to delay the continuity and agility of the production chain. (Espinosa, M.M,2018)

Table 2: Results of risks detected, HACCP corrective actions implemented and the gain achieved

Basic HACCP tools	Risk 1	Risk 2	Risk 3	Risk 4	Risk 5	Risk 6	Risk 7
identificationofrisks	Prevention of fall accidents in a bakery	The Unsafety of Gas Cylinders in the Production Process	Problem of Hygiene of Work Surfaces	Insectinfestation	cross-contamination and alterations in the taste and odor of butter	Musculoskeletal disorders linked to unnecessary travel	Non-ownership of Food due to Failure to Respect Storage Temperatures
Determination of critical control points (CCP)	Slip prevention in cleaning and wet areas.	Installation and maintenance of the centralized gas system.	Cleanliness of work surfaces in a kitchen.	Preventionofinsectinfestation	Prevention of cross-contamination altering the taste and odor of butter	Prevention of unnecessary travel to reduce the risk of musculoskeletal disorders.	Proper storage of food according to required temperatures and specified areas.
Establishingcriticallimits	Assurance of floors that are properly cleaned, dry and equipped with non-slip coatings.	Ensuring installations comply with safety standards and carrying out regular maintenance.	Cleaning and disinfection of surfaces after each use.	Maintaining a clean, dry and well-sealed production environment to prevent insect entry and proliferation	Assurance of correct storage and good handling in dedicated areas, away from other potentially aromatic foods.	Evaluation and identification of unnecessary movements in tasks and processes, and put in place measures to minimize them.	Storing each food item at the appropriate temperature and designated area in accordance with food safety standards.
Monitoring of critical control points	Regular visual inspections of cleaning areas, use of humidity indicator	Periodic inspection of the entire system, including pipes, connections and	Visual inspection and use of surface testing to detect the presence	Working with a pest control company to carry out regular	Regular visual inspections of butter storage areas, verification of handling procedures,	Regular observations of workflows, employee movements and tasks performed to identify	Regularly checking storage areas to ensure food is stored at the correct temperature and in the correct areas.

	s, checking the condition of floor coverings.	associated equipment.	of contaminants.	inspections of production areas, raw material and finished product storage areas, and possible entry points for insects	monitoring of cleaning and disinfection practices.	unnecessary movements.	
Establishment of corrective actions	Installation of carpets or non-slip coverings after cleaning and drying	Implementation of immediate corrections of anomalies or problems identified during inspections, to resolve the problems.	Cleaning of dirty surfaces and immediate disinfection immediately.	Implement immediate corrective actions for pest control, thorough cleaning of affected areas and review of prevention procedures.	Immediate removal of affected butter if signs of cross-contamination are detected, cleaning the area and reviewing storage and handling procedures.	Review of procedures, reorganization of work spaces, carrying out training on best practices if unnecessary travel is identified.	Move immediately to appropriate areas or refrigerated/heated as needed if If food is stored improperly, it must be
Setting up a verification system	Recording of inspections, cleaning procedures and measures taken to	Recording of inspections, maintenance work and repairs carried	Recording of inspections and surface test results.	Monitoring of inspections carried out by the pest control compan	Recording inspections, tracking storage and handling procedures, cleaning and disinfection	Recording observations and actions taken to reduce unnecessary travel.	Recording temperature checks and storage location.

	prevent falls.	out.		y , correcti ve actions taken and possible preventi ve measur es.	reports.		
Staff training and awareness	Training staff on fall hazards, safe cleaning methods and proper use of safety equipme nt.	Training of personne l involved in the installati on, maintena nce and inspectio n of the centraliz ed gas system.	Training staff on cleaning procedure s and use of surface testing.	Raising staff awaren ess of good cleanin g, storage and preventi on practice s in coordin ation with the pest control compan y.	Raising staff awareness of good storage, handling and cleaning practices to avoid cross-contaminati on.	Raising staff awareness of the risks of unnecessary travel and providing training on best practices.	Training staff on proper storage temperatures and designated storage areas
Evaluation and continuous improvem ent	Periodic review of records to ensure complian ce with preventio n measures . Regular review of cleaning and preventio n	Regular analysis of records to ensure complian ce with security and complian ce standards . Periodic review of installati on and	Regular review of records to ensure cleanlines s of surfaces.	Regular analysis of inspecti on reports and records to verify the effectiv eness of preventi on and interven tion measur	Periodic analysis of inspection data and records to ensure compliance with procedures . Regular review of storage, handling and cleaning procedures to prevent	Regular analysis of observations to ensure compliance with practices aimed at avoiding unnecessary travel. Constant review of processes and workspaces to optimize efficiency	Periodic analysis of records to ensure compliance with storage standards. Constant review of storage and monitoring procedures to ensure temperatures and zones are respected.

	procedures to ensure their effectiveness.	maintenance procedures to ensure their effectiveness.		es. review of cleaning, storage and prevention procedures in collaboration with the pest control company to ensure their effectiveness.	cross-contamination.	and reduce the risk of musculoskeletal disorders	
Adequate documentation	Retaining records of inspection, cleaning and preventative measures for future reference.	Retaining records of inspection, maintenance, training and system specifications for future reference. Training of personnel involved in the installation, maintenance and inspection of the	Retention of inspection records and test results.	Retention of inspection reports, corrective actions, training and procedures for future reference.	Retain records of inspection, storage, handling and cleaning procedures for future reference.	Retention of records of observations, actions taken and training provided for future reference.	Retaining temperature and location verification records for future reference.

		centralized gas system.					
Win Rate	100% completion	100% completion	100% completion	100% completion	100% completion	80% completion	90% completion

According to Table 2 we see that the implementation of the tools of the HACCP approach on the production line subject to our study made it possible to achieve very significant gains which exceed 80% for the elimination of the risks studied.

This is also achieved by the recommendations generated from the results of the implementation of HACCP for the elimination of the risks detected in particular:

- For the 1st risk : A new order for safety shoes with unhooked heels has been made for enhanced safety, particularly on ladders and with a single density sole which improves grip on all types of ground.
- For the 2nd risk : An internal gas technical installation was constantly operated with the aim of avoiding any type of fire.
- Forthe3rd risk :
  - Solicitation of the services of a service provider with the aim of increasing the number of cleaning agents so that they can respectively occupy a laboratory, and monitor it according to an action plan recommended by the team of quality.
  - Hygiene training dedicated to cleaning agents was provided.
- Forthe4th risk :
  - Treatment of insects entirely through a leading company, responsible for rodent control, disinsection and disinfection of all factory premises and which calls on pest control experts for the extermination of all types of pests, in the intention to preserve the health of staff.
  - A certificate was issued to this effect, certifying the treatment carried out on all premises.
- Forthe5th risk :
  - In light of this approach, we proceeded to ban the storage of butter, but also of all fats near fish, spices, or other flavors. In other words, these materials must be separated and well covered, rolled up, keeping their original packaging.
  - We see 100% achievement after the implementation of the action plans assigned to risks 1, 2, 3, 4 and 5.
- For the 6th risk : We tried to make the tasks carried out by the operators clearer by implementing new protocols detailed as follows:
  - Order new high tables for the pastries laboratory (1m12);
  - Approachtheoperator'scommissary;
  - Order other easily manageable containers;
  - Adjust the operator's posture appropriately to the location of the equipment;
  - Place the necessary tools near each manipulator.
  - The completion of these attempts has reached an acceptable threshold of achievement, due to the shortage of tables (A) and the delay in receiving the containers (C), thus leading to the execution of elements B, D and E, this which represents 80%.
- For the 7th risk: Check upon receipt (upstream) that the packaging of these products is in intact condition;
  - Ensure compliance with cleaning and disinfection of surfaces according to the hygiene plan suggested by the quality team, and design a course of action consistent with good storage practices depending on the type of food and the conditions required;
  - Try to optimize a field to create a new cold room for storage given the lack of space in the rooms (Food stock more than the space recommended by the rooms).
  - By accomplishing these means, we had the ability to reach a level of 90% achievement.

5. Summary of results: Application of the Lean management- Haccp integrated model

In this section, we have implemented the tools of the integrated Lean Management-HACCP model on a 2nd ^{line} identical to the 1st line on which we have put the Lean Management and HACCP approaches separately.

Table 3 summarizes the details of the implementation of this model and the results obtained:

Table 3: Results of the implementation of the integrated Lean management -HACCP model

Combined Lean-HACC TOOL	Lean tool	Haccptools	Completionrate
1. Time optimization : To reduce work accidents linked to the ground, the Lean tool that can be used is 5Scombined with Hazard Identification andDetermination of critical control points (CCP).	5S tool	-Identification of risks -Determination of critical control points (CCP)	100%
2. use of resources: The PDCA tool plays a vital role in establishing corrective actions and monitoring critical control points,particularly with regard to occupational health. A concrete example would be the transition to a centralized gas installation instead of using individual gas cylinders. Using PDCA in this context makes it possible to identify a specific occupational safety and health problem, implement an effective solution, monitor its implementation and take corrective action if necessary. This helps improve the safety and health of employees while optimizing work processes.	PDCA tool	-Establishment of corrective actions -Monitoring critical control points -Periodic inspection of the entire system, including pipes, connections and associated equipment. - If anomalies or problems are identified during inspections, immediate corrective actions must be taken to resolve the problems.	100%

3. Mutual reinforcement : Poka -Yoke , by integrating quality rather than controlling defects downstream, offers the possibility of obtaining results even before production begins. As part of HACCP, it makes it possible to set up an integrated quality-safety verification system, including the recording of inspections and the results of hygiene and surface cleaning tests. This combination provides dual control for both quality and safety.	The Poka-Yoke	-Establishment of an integrated quality-safety verification system -Recording inspections and surface hygiene and cleaning test results.	100%
4. Use of common tools and practices: The use of common tools and practices within Lean Management and HACCP is essential to ensure quality, food safety and operational efficiency in the food industry. To achieve this, adequate Documentation is required to record procedures, HACCP plans, product specifications, inspection reports and much more. In addition, training staff in good practicesHACCP is crucial to ensure that everyone understands and follows the procedures properly . By making staff aware of the importance of these practices, we strengthen their commitment and responsibility.	Standard (Standardizedwork)	-Adequate documentation -Staff training and awareness	100%

The integration of work standardization , a Lean tool, makes it possible to avoid redundancies and optimize the time necessary to implement these practices. It ensures that processes are clearly defined and followed, which contributes to consistent product quality and food safety. By combining all of these approaches, a company can create a culture of quality, food safety and continuous improvement, which is essential to succeed in the food industry while meeting consumer standards and expectations.			
5. The creation of a new comprehensive and integrated approach: The combination of these elements, such as Single Minute Exchange of Die (SMED), Zero Waste, Takt time , evaluation and continuous improvement of HACCP, creates a comprehensive, integrated approach to process optimization in the food industry. • Reduction of production changeover times (SMED):** By reducing the time needed to move from one process to another, food safety needs can be responded to more quickly. This allows for more agile adaptation to changing	Single Minute Exchange of Die (SMED) Zero waste Tact time	Evaluation and continuousimprovement	100%

market requirements. • Elimination of waste (Zero waste) : Reducing waste means minimizing the risks of contamination, product loss and unnecessary use of resources. Thishelpsensurefood safety byavoidingproductionerrors. • Alignment with market demand(Takt time): By producing at the rate of real market demand, we avoid overproduction and the creation of unnecessary stocks, which reduces food safety risks linked to product deterioration. • Continuous Food Safety Assessment (HACCP) : HACCP provides a structured framework for assessing and managing food safety risks on an ongoing basis. When combined with Lean principles, it creates a culture of continuous improvement in food safety. Overall, this combination helps optimize food safety, reduce costs, minimize waste and ensure food production is aligned with market demand. It also promotes a culture of continuous improvement that integrates food safety into all aspects of food production.			

6. Discussions of results and recommendations

The combination of Lean and HACCP tools in the food industry is essential with the aim of aiming for a 100% achievement rate for each combined tool. This means that each tool and practice must be fully implemented to ensure the best results in terms of quality, food safety and operational efficiency. The discussions below demonstrate how to achieve a 100% completion rate for each combined tool:

1) Use of common tools and practices : Includes 5S + Hazard Identification + Determination of Critical Control Points (CCP).
Implementing this combined tool requires:

- Ensure 5S is fully implemented in all work areas, eliminating potential hazards on the floor and maintaining a clean and organized environment.
- Identify all food safety hazards in the production process.
- Determine critical control points (CCPs) for each process and implement effective control measures.

2) Shared use of resources : this point integratesPDCA+ -Establishment of corrective actions+ Monitoring of critical control points+ Periodic inspection of the entire system
The implementation of this combined tool requires:

- Use the PDCA cycle systematically to address workplace safety issues. Plan, implement, verify and act to continuallyimprovesecurity.

3) Mutual reinforcement : Poka-Yoke + Integrated quality-safety verification system + Recording of inspections and results:
The implementation of this combined tool requires:

- Integrate Poka-Yoke into process design to avoid errors and defects from the start.
- Establish an integrated quality-safety verification system to record and monitor surface hygiene and cleaning inspections and tests.

4) Use of common tools and practices : includes Documentation + Training + Standardization:
The implementation of this integrated tool requires :

- Ensure all required documentation is complete and up to date, including HACCP plans, product specifications and inspection reports.
- Provide adequate training to staff to ensure procedures are understood and correctly implemented.

- Standardize processes so that they are clearly defined and followed by everyone.

5) The creation of a new comprehensive and integrated approach : it includes SMED + Zero waste + Takt time + Evaluation and continuous improvement
Thistoolrequires:

- Reduce production changeover times (SMED) so that you can respond quickly to food safety needs.
- Eliminate waste and minimize the risk of contamination (Zero waste).
- Produce at the rate of real market demand (Takt time) to avoid overproduction.
- Assess and continually improve food safety using the HACCP framework.

Thus, achieving a 100% completion rate for each combined tool requires total commitment from the entire organization. This ensures that every aspect of quality and food safety is considered and optimized to deliver the highest quality products while maintaining food safety.

7. Conclusion and perspectives :

In conclusion, the fusion of Lean principles and HACCP practices in the food industry represents a holistic approach to guaranteeing quality, food safety and operational efficiency. By aiming for a 100% achievement rate for each combined tool, companies can embark on a proactive approach to identifying, eliminating and preventing risks throughout the production chain.

The integration of 5S, hazard identification and critical control point (CCP) determination creates a safe and organised working environment, while the PDCA+ approach ensures ongoing risk management and continuous process improvement.

The deployment of Poka-Yoke and an integrated quality-safety verification system helps to reduce errors and defects, while documentation, training and standardisation ensure compliance with established norms and procedures.

At the same time, adopting practices such as SMED, Zero Waste and Takt Time helps to minimise waste, optimise production processes and respond agilely to market demand.

By investing in the rigorous implementation of these principles and practices, food companies can not only improve their competitiveness and profitability, but also strengthen consumer confidence in their products. The commitment to operational excellence and food safety must be ongoing, with regular evaluation and adaptation to changing market and regulatory standards.

Ultimately, the combined Lean-HACCP approach represents an essential pillar for building a sustainable, safe and efficient food supply chain that meets consumers' growing demands for food quality and safety.

Looking ahead, the food industry will continue to evolve. Food safety standards and government regulations will continue to tighten, requiring constant vigilance. It is crucial for companies to remain flexible, invest in staff training and explore new ways of integrating Lean principles and HACCP requirements to meet changing consumer needs and industry challenges. This combination offers a path to better quality, enhanced food safety and sustainable operational performance.

Future prospects for the integration of Lean principles and HACCP practices in the food industry are promising, offering significant opportunities for continuous improvement, innovation and sustainability. Here are some key perspectives to consider:

Emerging Technologies: The adoption of emerging technologies such as artificial intelligence, the Internet of Things (IoT) and data analytics can enhance the ability of food businesses to monitor processes in real time, anticipate potential risks and optimise production more intelligently.

Holistic Approach to Quality: Companies can broaden their approach to quality by integrating methodologies such as Total Quality Management (TQM) and fostering a culture of continuous improvement at all levels of the organisation.

Environmental Sustainability: Incorporating Lean-HACCP practices can help to reduce the environmental footprint by minimising waste, optimising the use of resources and promoting more sustainable production practices.

Training and Awareness: Focusing on ongoing staff training and awareness of emerging food risks and new regulations will help maintain a high level of compliance and adaptability.

Supply Chain Collaboration: Encouraging collaboration and close communication with supply chain partners can reinforce end-to-end food safety, from the production of raw materials to the distribution of finished products.

Evolving regulations: Keeping a close eye on changes in national and international food regulations is crucial to remaining compliant and adapting practices accordingly.

Responding to Market Trends: Anticipating and responding to market trends such as the growing demand for organic, local and sustainable products can create opportunities to differentiate products and win consumer trust.

Digitalising traceability: Digitalising traceability, using technologies such as blockchain, can enhance transparency in the supply chain, improving consumer confidence.
By proactively adapting to these opportunities, food businesses can not only achieve higher levels of operational efficiency and food safety, but also remain competitive in an ever-changing market. The key lies in flexibility, continuous innovation and a commitment to constantly improving product quality and safety.

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