Volume 10, Issue 18 – e20241018 January – December – 2024

ECORFAN

Journal-Republic of Guatemala

ISSN-On line: 2410-8849

15th ANNIVERSARY ECORFAN Special Edition

ECORFAN Journal-Republic of Guatemala, Volume 10, Issue 18: e20241018 January - December 2024, is a Continuous publication – ECORFAN-Guatemala. Kilometer 16, American Highway, House Terra Alta, House D7 Mixco Zona 1, Republic of Guatemala. WEB: www.ecorfan.org/republicofguatemala/, journal@ecorfan.org. Editor in Chief: Martínez-Herrera, Erick Obed. MsC. ISSN Online: 2414-8849. Responsible for the latest update of this number ECORFAN Computer Unit. Escamilla-Bouchán, Imelda, Luna-Soto, Vladimir, Kilometer 16, American Highway, House Terra Alta, House D7 Mixco Zona 1, Republic of Guatemala, last updated December 30, 2024.

ECORFAN Journal Republic of Guatemala

Definition of Journal

Scientific Objectives

Support the international scientific community in its written production Science, Technology and Innovation in the Field of Medicine and Health Sciences, Biological and Health Sciences, Medical Mycology, Dermatology, Immunology, Human Ecology, Parasitology, Pediatric Infectious Diseases.

ECORFAN-Mexico SC is a Scientific and Technological Company in contribution to the Human Resource training focused on the continuity in the critical analysis of International Research and is attached to CONACYT-RENIECYT number 1702902, its commitment is to disseminate research and contributions of the International Scientific Community, academic institutions, agencies and entities of the public and private sectors and contribute to the linking of researchers who carry out scientific activities, technological developments and training of specialized human resources with governments, companies and social organizations.

Encourage the interlocution of the International Scientific Community with other Study Centers in Mexico and abroad and promote a wide incorporation of academics, specialists and researchers to the publication in Science Structures of Autonomous Universities - State Public Universities - Federal IES - Polytechnic Universities - Technological Universities - Federal Technological Institutes - Normal Schools - Decentralized Technological Institutes - Intercultural Universities - S & T Councils - CONACYT Research Centers.

Scope, Coverage and Audience

ECORFAN Journal Republic of Guatemala is a Journal edited by ECORFAN-Mexico S.C in its Holding with repository in Republic of Guatemala, is a scientific publication arbitrated and indexed with semester periods. It supports a wide range of contents that are evaluated by academic peers by the Double-Blind method, around subjects related to the theory and practice of Biological and Health Sciences, Medical Mycology, Dermatology, Immunology, Human Ecology, Parasitology, Pediatric Infectious Diseases with diverse approaches and perspectives , That contribute to the diffusion of the development of Science Technology and Innovation that allow the arguments related to the decision making and influence in the formulation of international policies in the Field of Medicine and Health Sciences. The editorial horizon of ECORFAN-Mexico® extends beyond the academy and integrates other segments of research and analysis outside the scope, as long as they meet the requirements of rigorous argumentative and scientific, as well as addressing issues of general and current interest of the International Scientific Society.

Editorial Board

Arbitration Committee

Assignment of Rights

The sending of an Article to ECORFAN Journal Republic of Guatemala emanates the commitment of the author not to submit it simultaneously to the consideration of other series publications for it must complement the Originality Format for its Article.

The authors sign the Authorization Format for their Article to be disseminated by means that ECORFAN-Mexico, S.C. In its Holding Republic of Guatemala considers pertinent for disclosure and diffusion of its Article its Rights of Work.

Declaration of Authorship

Indicate the Name of Author and Coauthors at most in the participation of the Article and indicate in extensive the Institutional Affiliation indicating the Department.

Identify the Name of Author and Coauthors at most with the CVU Scholarship Number-PNPC or SNI-CONACYT- Indicating the Researcher Level and their Google Scholar Profile to verify their Citation Level and H index.

Identify the Name of Author and Coauthors at most in the Science and Technology Profiles widely accepted by the International Scientific Community ORC ID - Researcher ID Thomson - arXiv Author ID - PubMed Author ID - Open ID respectively.

Indicate the contact for correspondence to the Author (Mail and Telephone) and indicate the Researcher who contributes as the first Author of the Article.

Plagiarism Detection

All Articles will be tested by plagiarism software PLAGSCAN if a plagiarism level is detected Positive will not be sent to arbitration and will be rescinded of the reception of the Article notifying the Authors responsible, claiming that academic plagiarism is criminalized in the Penal Code.

Arbitration Process

All Articles will be evaluated by academic peers by the Double Blind method, the Arbitration Approval is a requirement for the Editorial Board to make a final decision that will be final in all cases. MARVID® is a derivative brand of ECORFAN® specialized in providing the expert evaluators all of them with Doctorate degree and distinction of International Researchers in the respective Councils of Science and Technology the counterpart of CONACYT for the chapters of America-Europe-Asia- Africa and Oceania. The identification of the authorship should only appear on a first removable page, in order to ensure that the Arbitration process is anonymous and covers the following stages: Identification of the Journal with its author occupation rate - Identification of Authors and Coauthors - Detection of plagiarism PLAGSCAN - Review of Formats of Authorization and Originality-Allocation to the Editorial Board-Allocation of the pair of Expert Arbitrators-Notification of Arbitration -Declaration of observations to the Author-Verification of Article Modified for Editing-Publication.

Instructions for Scientific, Technological and Innovation Publication

Knowledge Area

The works must be unpublished and refer to topics of Biological and Health Sciences, Medical Mycology, Dermatology, Immunology, Human Ecology, Parasitology, Pediatric Infectious Diseasesand other topics related to Medicine and Health Sciences.

Presentation of Content

In the first article we present *State estimation of discrete event systems using fuzzy timed petri nets*, by González-Castolo, Juan Carlos, López-Mellado, Ernesto, Ramos-Cabral, Silvia and Zataraín-Durán, Omar Alí, with adscription in the Universidad de Guadalajara and Centro de Investigación de Estudios Avanzados del IPN, as the following article we present, *Environmental impact of energy consumption in academic buildings: Case study of the faculty of agricultural sciences at UAEM, Life Cycle Analysis approach*, by Brito-R., Julio Cesar & Hernández-Luna, Gabriela, with adscription in the Universidad Tecnológica de Puebla and Universidad Autónoma del Estado de Morelos, as the following article we present, *Fluidity index for smart farms supply chain*, by Bueno-Solano, Alfredo, Hernández-Valdez, Lizeth Danyra, Vega-Telles, Ernesto Alonso and Acosta-Quintana, María Paz Guadalupe, with adscription in the Universidad Tecnológica de Sonora, as the following article we present, *Exploring the Food Quality System (SQF) in Plastic Cap Manufacturing: A Scientific and Practical Approach*, by Campos-Villegas, Cesar Antonio & Pecina-Rivas Erika María, with adscription in the Tecnológico Nacional de México - Tecnológico de Estudios Superiores de Cuautitlán Izcalli.

Content

State estimation of discrete event systems using fuzzy timed petri nets

Estimación del estado de sistemas de eventos discretos utilizando redes de Petri temporizadas difusas

González-Castolo, Juan Carlos*[a], López-Mellado, Ernesto[b], Ramos-Cabral, Silvia[c] and Zataraín-Durán, Omar Alí[d]

[a] ROR Universidad de Guadalajara • KZU-7150-2024 • 0000-0003-2659-0646
[b] ROR Centro de Investigación de Estudios Avanzados del IPN • LKN-8375-2024 • 0000-0003-0880-7098
[c] ROR Universidad de Guadalajara• KHV-0681-2024 • 0000-0003-4204-1700
[d] ROR Universidad de Guadalajara • KRQ-0829-2024 • 0000-0002-7934-7765

CONAHCYT classification:

Area: Engineering
Field: Engineering
Discipline: Systems engineer
Subdiscipline: System analysis

https://doi.org/10.35429/EJRG.2024.10.18.1.9

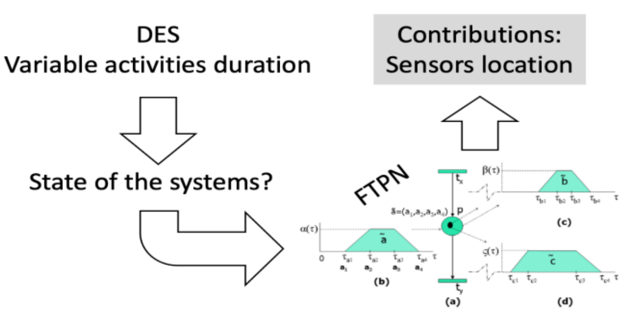
History of the article:
Received: January 11, 2024
Accepted: December 14, 2024

Check for updates

* ✉ [jcgcastolo@gmail.com]

Abstract

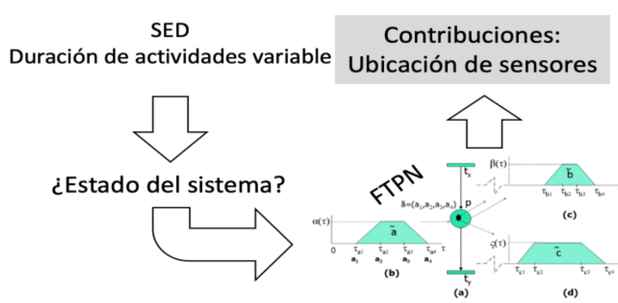
In this work, an extension is made to the inference of the state of discrete event systems using knowledge about the duration of activities. The mentioned systems are characterized by the absence of sensors and where the activities have a variable duration. This causes the uncertainty about the state of the system to increase. The problem is addressed by calculating the fuzzy marking of the *Fuzzy timed Petri Net* (FTPN). In this formalism, fuzzy sets are associated with the places, which have information about the variation of the end of the activities. To keep this uncertainty limited, the location of a minimum set of sensors is studied and rules are established for their placement in order to keep limited the uncertainty in the approximation of the marking in Marked Graph structures and State Machines. In this situation, the estimation device obtains and updates a belief that approximates the condition of the system.



State estimation, Timed fuzzy Petri nets, Fuzzy marking equation

Resumen

En este trabajo se realiza una extensión a la inferencia del estado de sistemas de eventos discretos utilizando conocimiento sobre la duración de las actividades. Los sistemas mencionados se caracterizan por la ausencia de sensores y donde las actividades tienen una duración variable. Esto provoca que la incertidumbre sobre el estado del sistema aumente. El problema se aborda calculando el marcaje difuso de la *Red de Petri difusa temporalizada* (FTPN). En este formalismo, se asocian conjuntos difusos a los lugares, los cuales tienen información sobre la variación del final de las actividades. Para mantener esta incertidumbre limitada, se estudia la ubicación de un conjunto mínimo de sensores y se establecen reglas para su colocación con el fin de mantener limitada la incertidumbre en la aproximación del marcaje en estructuras de Grafos Marcados y Máquinas de Estados. En esta situación, el dispositivo de estimación obtiene y actualiza una creencia que se aproxima a la condición del sistema.



Estimación de estado, Redes de Petri difusas temporizadas, Ecuación de marcado difuso

Citation: González-Castolo, Juan Carlos, López-Mellado, Ernesto, Ramos-Cabral, Silvia and Zataraín-Durán, Omar Alí. [2024]. State estimation of discrete event systems using fuzzy timed petri nets. ECORFAN Journal Republic of Guatemala. 10[18]1-9: e11018109.

I. Introduction

State estimation of a dynamic system is useful when only a subset of the state variables can be directly measured. Observers are the entities providing the system state from the knowledge of the internal structure of the system and its partially measured behavior.

The state estimation problem of *discrete event systems* (DES) has been addressed using a sensor-based approach (Köhler & Zhang, 2022), (Ramírez Treviño, Rivera Rangel, & Lómez Mellado, 2003), (Anguiano-Gijón, Chávez, Cid-Gaona, & Vázquez, 2024) in which the marking of a *Petri net* (PN) model describing a DES is progressively computed from the evolution of its inputs and outputs, (H., Y., K, H, & S, 2024). Also, in (Aguayo-Lara, Gómez-Gutiérrez, Ramírez-Treviño, & Ruiz-León, 2015), (Valencia, Muñoz, & Enríquez, 2020) the optimal sensor placement is studied. In these works, the actual marking is computed after a finite number of event occurrences.

The state of a system can also be inferred from the knowledge of the duration of activities (X, C. N , & Z, 2024). However, this task becomes complex when the duration of operations is variable in addition to the absence of sensors.

In this situation the observer obtains and revises a belief that approximates the current system state. Consequently, this approach of state monitoring is useful for non-critical applications in which an approximate computation of the state is sufficient.

The uncertainty of activities duration in DES can be handled using or Stochastic Petri Nets (Yang, Duan, Lin, & Chen, 2024) or *fuzzy PN* (FPN), (Kuchárik & Balogh, 2019), (Madhloom, Noori, Ebis, Hassen, & Darwish, 2023), (Xu X.-G. , Shi, Xu, & Liu, 2019), (Deabes, Bouazza, & Algthami, 2023); this PN extension has been applied to knowledge modeling, (Xu X.-G. , Shi, Xu, & Liu, 2019), (Hua & Hu-Chen, 2023), (Hu-Chen, Jian-Xin , Zhiwu, & Guangdong , 2017), planning, (Mahulea, González, Montijano, & Silva, 2021), (X. G. & H. S. , 2009), reasoning, (Yu, Gong, Liu, & Mou, 2022), (Lee, Liu, & Chiang, 2003) and controller design (L. Saleh, J. Mohammed, Sabri Kadhim, M. Raadthy, & J. Mohammed, 2018),(Deabes, Bouazza, & Algthami, 2023).

In these works, the proposed techniques include the computation of imprecise markings.

This paper addresses the problem of state estimating of cyclic DES that exhibit variations on the duration of activities, by approximating the marking of a FTPN model.

A definition of FTPN is presented in which the ending time uncertainty of activities is expressed with fuzzy sets associated with places. Previous results presented in (González-Castolo & López-Mellado, 2006), (González-Castolo & López-Mellado, 2007), (González-Castolo & López-Mellado, 2011) are reviewed and extended with a characterization of the marking estimation degradation and a technique for obtaining discrete marking from approximate marking.

The remainder of this paper is structured as follows. In the next section, theories of fuzzy sets and PN are reviewed. In section III the definition of FTPN is introduced. Section IV analyses the location of measurable locations in the FTPN. Finally, the conclusion is shown.

II. Background

A. Possibility Theory

In possibility theory, a fuzzy set $\tilde{a}$ is used to delimit ill- known values or to represent values characterized by linguistic variable expressions.

The fuzzy set$\tilde{a}$ in τ is characterized by a membership function $\alpha_{\tilde{a}}(\tau)$,(Jianfeng & Genserik , 2024) which associates to each point τ in $\boldsymbol{\tau}$ a real number in the interval $[0,1]$; the value $\alpha_{\tilde{a}}(\tau)$ represents the “grade of membership” of τ in $\tilde{a}$, (Zadeh & Goguen, 1965) .

Usually, a fuzzy set is defined in a trapezoidal form; thus, a fuzzy set $\tilde{a}$ can be characterized as $\tilde{a} = (a_1, a_2, a_3, a_4)$ such that $a_1, a_2, a_3, a_4 \in \mathbb{R}$, where (a_2, a_3) and (a_1, a_4) are the core and support of $\tilde{a}$, respectively. $\tilde{a}^{\uparrow} = (a_1, a_2)$ denotes a subset of $\tilde{a}$ where the values $\alpha_{\tilde{a}}(\tau)$ grow towards 1; similarly, $\tilde{a}^{\downarrow} = (a_3, a_4) \subseteq \tilde{a}$ denotes the decreasing values of $\alpha_{\tilde{a}}(\tau)$. Figure 1(a) illustrates these notions.

ISSN: 2414-8849.
RENIECYT-CONAHCYT: 1702902

González-Castolo, Juan Carlos, López-Mellado, Ernesto, Ramos-Cabral, Silvia and Zataraín-Durán, Omar Alí. [2024]. State estimation of discrete event systems using fuzzy timed petri nets. ECORFAN Journal Republic of Guatemala. 10[18]1-9: e11018109.
https://doi.org/10.35429/EJRG.2024.10.18.1.9

Definition 1: Let $\tilde{a} = (a_1, a_2, a_3, a_4)$ and $\tilde{b} = (b_1, b_2, b_3, b_4)$ be two trapezoidal fuzzy sets. The fuzzy sets addition operation is $\tilde{a} \oplus \tilde{b} = (a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4)$,(Klir & Yuan, 1995).

Definition 2: The intersection and union of fuzzy sets are defined in terms of *min* and *max*. $(\tilde{a} \cap \tilde{b}) = min(\tilde{a}, \tilde{b}) = min\left(\alpha_{\tilde{a}}(\tau), \alpha_{\tilde{b}}(\tau)\right)$ such that $\tau \in$ support of $\tilde{a} \wedge \tilde{b}$ and $(\tilde{a} \cup \tilde{b}) = max(\tilde{a}, \tilde{b}) = max(\alpha_{\tilde{a}}(\tau), \alpha_{\tilde{b}}(\tau))$ such that τ belongs to the support of $\tilde{a} \vee \tilde{b}$, where the *min (max)* operator gets the minimum (maximum) τ of $\boldsymbol{\tau}$. It uses these intersection and union operators as a *t-norm* and a *s-norm*, respectively. The null element for *min (max))* operation is $1(0)$.

Definition 3: Let $\tilde{a}$ and $\tilde{b}$ two fuzzy sets such that $\propto_{\tilde{a}} (\tau) + \propto_{\tilde{b}} (\tau) \leq 1$. The *sum* operation between $\tilde{a}$ and $\tilde{b}$ is computed as:

$$sum(\tilde{a}, \tilde{b}) = \alpha_{\tilde{a}}(\tau) + \alpha_{\tilde{b}}(\tau) \quad (1)$$

Definition 4: Let $\tilde{a}$ a fuzzy set and *w* a real number. The product between $\tilde{a}$ and *w* is defined as:

$$prod(\tilde{a}, w) = w \cdot \alpha_{\tilde{a}}(\tau) \quad (2)$$

such that $w \cdot \alpha_{\tilde{a}}(\tau) \leq 1; \tau \in \boldsymbol{\tau}$.

Definition 5: The distribution of possibility before and after $\tilde{a}$ are the fuzzy sets $\tilde{a}^{<} = (-\infty, a_2, a_3, a_4)$ and $\tilde{a}^{>} = (a_1, a_2, a_3, +\infty)$, respectively. They are defined in (Andreu , Pascal , & Valette , 1997) as a function $\alpha_{(-\infty,\tilde{a}]}(\tau) = \sup \alpha(\acute{\tau})$ and $\alpha_{(\tilde{a},+\infty]}(\tau) = \sup_{\acute{\tau} \leq \tau} \alpha(\acute{\tau})$, respectively, (Figure 1(c), (d)).

B. Petri Nets

Definition 6: An ordinary PN *structure G* is a bipartite digraph represented by the 4-tuple *G (P, T, I, O)* where $P = \{p_1, p_2, \ldots, p_n\}$ and $T = \{t_1, t_2, \ldots, t_m\}$ are finite sets of vertices called respectively places and transitions, $I(O): P \times T \rightarrow \{0,1\}$ is a function that represents the arcs from places to transitions (transitions to places).

Pictorially, places are represented by circles, transitions are represented by rectangles, and arcs are depicted as arrows.

The symbol $\bullet t_j$ $(t_j\bullet)$ denotes the set of all places p_i such that $I(p_i, t_j) \neq 0$ $(O(p_i, t_j) \neq 0)$. Analogously, $\bullet p_i$ $(p_i\bullet)$ denotes the set of all transitions t_j such that $O(p_i, t_j) \neq 0$ $(I(p_i, t_j) \neq 0)$.

The pre-incidence matrix of G is $C^- = [c_{ij}^-] = I(p_i, t_j)$; the post-incidence matrix of G is $C^+ = [c_{ij}^+]$ where $c_{ij}^+ = O(p_i, t_j)$; the incidence matrix of G is $C = C^+ + C^-$.

A marking function $M: P \rightarrow \mathbb{Z}^+$ represents the number of tokens (depicted as dots) residing inside each place. The marking of a PN is usually expressed as an n-entry vector.

Definition 7: A *Petri Net system* or *Petri Net* (PN) is the pair $N = (G, M_0)$, where G is a PN structure and M_0 is an initial token distribution.

In a PN, a transition t_j is enabled at the marking M_k if $\forall p_i \in P, M_k(p_i) \geq I(p_i, t_j)$; an enabled transition t_j can be fired reaching a new marking M_{k+1} which can be computed using the PN state equation:

$$M_{k+1} = M_k + C^+ v_k - C^- v_k \quad (3)$$

where $v_k(i) = 0, i \neq j, v_k(j) = 1$.

The *reachability set* of a PN is the set of all possible markings reachable from M_0, firing only enabled transitions; this set is denoted by $R(G, M_0)$.

A *structural conflict* is a PN substructure in which two or more transitions share one or more input places; such transitions are simultaneously enabled and firing one of them disables the others.

Definition 8: A transition $t_k \in T$ is *live*, for a marking M_0, if $\forall M_k \in R(G, M_0), \exists M_n \in R(G, M_0)$ such that t_k is enabled $\left(M_n \xrightarrow{t_k}\right)$. A PN is *live* if all its transitions are live.

Definition 9: A PN is said to be *1-bounded*, or *safe*, for a marking M_0, if $\forall p_i \in P$ and $\forall M_j \in R(G, M_0)$, it holds that $M_j(p_i) \leq 1$.
In this work it deals with *live* and *safe* PN.

González-Castolo, Juan Carlos, López-Mellado, Ernesto, Ramos-Cabral, Silvia and Zataraín-Durán, Omar Alí. [2024]. State estimation of discrete event systems using fuzzy timed petri nets. ECORFAN Journal Republic of Guatemala. 10[18]1-9: e11018109.
https://doi.org/10.35429/EJRG.2024.10.18.1.9

III. Fuzzy Timed Petri nets

A. Basic Operators

First, some useful operators are introduced.
Definition 10: Let $\tilde{a}$ and $\tilde{b}$ two fuzzy sets such that $a_2 < b_3$. The extended union operation between $\tilde{a}$ and $\tilde{b}$ is

$$ext\left(\tilde{a}, \tilde{b}\right) = \min\left(\tilde{a}^{>}, \tilde{b}^{<}\right) \quad (4)$$

this operation is illustrated in Figure 1(e).

Definition 11: The latest (earliest) operation selects the latest (earliest) fuzzy set among n fuzzy sets; they are calculated as follows:

$$latest\ (\tilde{a}_1, \dots, \tilde{a}_n) = min\left(max(\tilde{a}_1^{<}, \dots, \tilde{a}_n^{<}), min(\tilde{a}_1^{>}, \dots, \tilde{a}_n^{>})\right) \quad (5)$$

$$earliest(\tilde{a}_1, \dots, \tilde{a}_n) = min\left(min\ (\tilde{a}_1^{<}, \dots, \tilde{a}_n^{<}), max\ (\tilde{a}_1^{>}, \dots, \tilde{a}_n^{>})\right) \quad (6)$$

Box 1

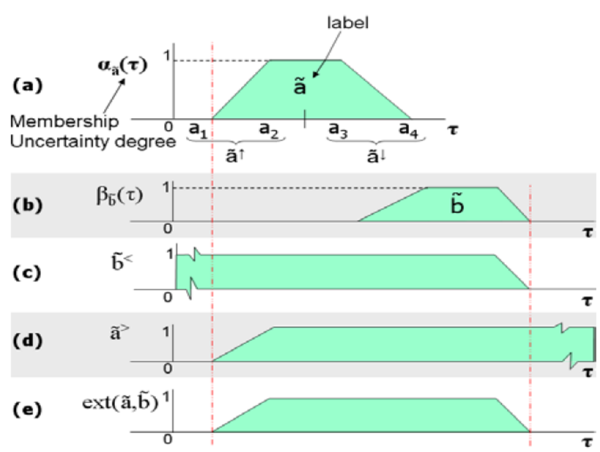


Figure 1
Fuzzy sets and operations
Source: (González-Castolo & López-Mellado, 2011)

Definition 12: The *conjugation operator* is defined as $arg1 \overset{oper}{\bullet} arg2$, where *arg1*, *arg2* are arguments that can be matrices of fuzzy sets; • is the *fuzzy and* operation and *oper* is any operation referred as +, −, *latest, min,* etc. For two fuzzy sets $\tilde{a} \overset{oper}{\bullet} \tilde{b} = oper\left(and(\tilde{a}, \tilde{b})\right)$. For matrices $\tilde{A}(m \times r)$ and $\tilde{B}(r \times n)$, $\tilde{A} \overset{oper}{\bullet} \tilde{B} = \left[\underset{k=1,\dots,r}{oper}\left(and\left(\tilde{a}_{ik}, \tilde{b}_{kj}\right)\right)\right], i = 1, \dots, m$ and $j = 1, \dots, n$, (González-Castolo & López-Mellado, 2011).

B. Formalism Description

Definition 13: A *fuzzy timed Petri net structure* is a 3- tuple $FTPN = (N, \Gamma, \delta)$; where $N = (G, M_0)$ is a PN, $\Gamma = \{\tilde{a}_1, \tilde{a}_2, \dots, \tilde{a}_n\}$ is a collection of fuzzy sets, $\delta: P \to \Gamma$ is a function that associates a fuzzy set $\tilde{a}_i \in \Gamma$ to each place $p_i \in P$.

The values $\tilde{\tau}\uparrow, \tilde{\tau}\downarrow$, corresponds to ranges $(a_1, a_2), (a_3, a_4)$, respectively. When $\tau \in \tilde{\tau}\uparrow$ $(\tilde{\tau}\downarrow)$, the function $\alpha(\tau)$ goes towards $1(0)$.
A fuzzy set $\tilde{a}$ is referred indistinctly by the function $\alpha(\tau)$ or the characterization (a_1, a_2, a_3, a_4).

Fuzzy timing of places. The fuzzy set $\tilde{a} = (a_1, a_2, a_3, a_4) \in \Gamma$ Figure 2(b) represents the *static* possibility distribution $\alpha(\tau) \in [0,1]$ of the event at which an activity stops, i.e. the instant when a token leaves a place $p \in P$. The activity duration is considered from the instant when p is marked. This set does not change during the FTPN execution.

Fuzzy timing of tokens. The fuzzy set $\tilde{b} = (b_1, b_2, b_3, b_4)$ Figure 2(c) represents the *dynamic* possibility distribution $\beta(\tau) \in [0,1]$ associated to a token residing within a $p \in P$; it also represents the instant τ at which such a token may leave the place.

This instant is computed from the instant when p is marked. $\tilde{b}$ is computed from $\tilde{a}$ every time the place is marked during the marking evolution of the FTPN.

A token begins to be available for enabling output transitions at $\beta(b_1)$. Thus $\tilde{b}^{>}$ represents the possibility distribution of available tokens.

The fuzzy set $\tilde{c} = (c_1, c_2, c_3, c_4)$, known as *fuzzy timestamp*, Figure 2(d) is a dynamic possibility distribution $\varsigma(\tau) \in [0,1]$ that represents the duration of a token within a place $p \in P$. This notion is close to that introduced in (Murata, 1996)

ISSN: 2414-8849.
RENIECYT-CONACHYT: 1702902

González-Castolo, Juan Carlos, López-Mellado, Ernesto, Ramos-Cabral, Silvia and Zataraín-Durán, Omar Alí. [2024]. State estimation of discrete event systems using fuzzy timed petri nets. ECORFAN Journal Republic of Guatemala. 10[18]1-9: e11018109.
https://doi.org/10.35429/EJRG.2024.10.18.1.9

Box 2

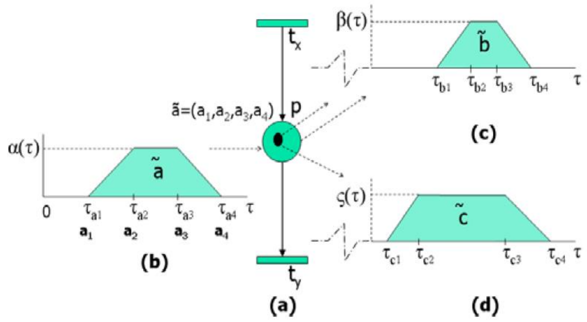


Figure 2
a) FTPN, (b) The fuzzy set associated to places. (c) Fuzzy set to place or mark associated. (d) Fuzzy timestamp
Source: (González-Castolo & López-Mellado, 2011)

Fuzzy enabling date

Definition 14: The fuzzy enabling date $e_{t_k}(\tau)$ of the transition t_k is a possibility distribution of the instant τ at which t_k is enabled. It is computed from the outgoing instants $\tilde{b}_{p_i}$ of the tokens within the input places to t_k as (7).

$$e_{t_k}(\tau) = latest\left(\tilde{b}_{p_i}\right) \forall p_i \in \bullet t_k \quad (7)$$

Fuzzy firing date

Definition 15: The fuzzy firing transition date $o_{t_k}(\tau)$ of a transition t_k expresses the possibility distribution of the instant at which t_k may fire. It is determined with respect to the set of transition $\{t_j\}$ in conflict simultaneously enabled.

$$o_{t_k}(\tau) = min\left(e_{t_k}(\tau), earliest\left(e_{t_j}(\tau)\right)\right) \forall_{t_k} \in p_n \bullet; \; p_n \in \bullet t_j \quad (8)$$

Computation of $\tilde{b}$

Now, using the above notions, it can state the calculation of the residency of the $\tilde{b}$ tokens. For a given place p_s, the possibility distribution $\tilde{b}_{p_s}$ may be computed from $\tilde{a}_{p_s}$ and the firing dates o_{t_j} *(τ)* of a $t_j \in \bullet p_s$ using the following expression:

$$\tilde{b}_{p_s} = ext\left(o_{t_j}(\tau)\right) \oplus \tilde{a}_{p_s} \;\; \forall t_j \in \bullet p_s \quad (9)$$

Fuzzy timestamp computation

Definition 16: The fuzzy timestamp $\tilde{c}_{p_s}$ is computed from the occurrence dates of both $\bullet p_s$ and $p_s \bullet$.

$$\tilde{c}_{p_s} = ext\left(earliest\left(o_{t_i}(\tau)\right)\right), latest\left(o_{t_j}(\tau)\right) \forall t_i \in \bullet p_s, t_j \in p_s \quad (10)$$

Actually, $\tilde{c}_{p_s}$ represents the fuzzy marking in p_s at instant τ.

D. Uncertainty background

Definition 16: The *ending uncertainty* (*eU*) is the uncertainty of possibility to find a mark in a place p_j or a previous place p_{j-1} in a circuit, (González-Castolo & López-Mellado, 2011).

Proposition 17: The *ending uncertainty trace* (*eUt*) is defined with the function $\xi(\tau)$ that represents the marking *eU* in the path, (González-Castolo & López-Mellado, 2011).

The fuzzy state equation of *Fuzzy Time Marked Graphs* (FTMG) was presented in (González-Castolo & López-Mellado, 2007) as (11).

$$\breve{M}(\tau) = \min\left(M(\tau - \Delta\tau) + C^{+}\Delta_{\tilde{O}\uparrow} - C^{-}\Delta_{\tilde{O}\downarrow}, \vec{1}\right) \quad (11)$$

In (González-Castolo & López-Mellado, 2007), the procedure to obtain the fuzzy marking of *Fuzzy Time State Machines* (FTSM) was presented. Remembering that due to the uncertainty that induces the FTSM structure, the process to obtain the tokens is more complex that FTMG.

IV. Location of measurable places in a FTPN

In (González-Castolo & López-Mellado, 2011), the minimum number of measurable locations to keep bounded the uncertainty in the FTMG and FTSM is determined. It will now analyze the location of these measurable locations and the quality of the marking approximation.

A. Location of measurable places in a FTSM

In proposition 17, the boundedness condition of the *eUt* in a FTSM is given, which establishes that it is necessary to have a measurable place for each circuit. Analyze the following scenarios through a simple example of a FTSM with two t-components (Figure 3).

In the first scenario (Figure 3(a)) there is only one measurable place that belongs to both circuits; with this, the boundedness condition is fulfilled using a single sensor.

ISSN: 2414-8849.
RENIECYT-CONAHCYT: 1702902

However, although uncertainty is limited when the measurable place is not marked, it approximates only the path it follows, such as that obtained without measurable places.

In a second scenario, there are two measurable places (Figure 3(b)); thus, it is possible to know which path is being executed when a measurable place is marked; However, when the decision is unmarked, after approximating the marking of the place p_1, there approximates the path to be followed only until a measurable location is marked again.

Finally, in a third scenario (Figure 3(c)) the measurable places are located just after the decision place p_1, so the path being executed is known from the start.

It is evident that the third scenario is the most convenient since the calculation of the branching relationship is avoided and in general, it can affirm that this characteristic is maintained by locating the measurable places after each decision place.

Box 3

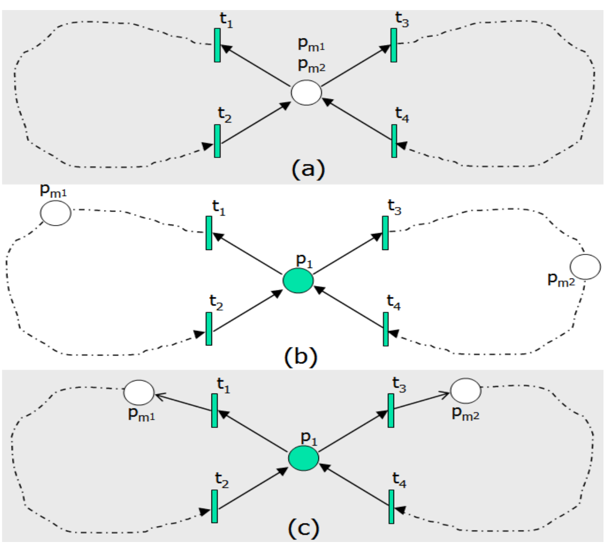


Figure 3
Fuzzy marking evolution

Source: Own elaboration

B. Location of measurable places in a FTMG

In (González-Castolo & López-Mellado, 2011), the boundedness condition of the *eUt* in a FTMG is given, which establishes that it is necessary to have at least one measurable location in the system. It now analyzes the following scenarios (Figure 4).

In the first scenario (Figure 4(a)) the measurable place p_m is located on one of the parallel paths starting from the distribution transition t_d where there are several non-measurable places between t_d and p_m. When p_m is marked, the review-update procedure explained above is performed, which is done to reduce uncertainty.

In the second scenario (Figure 4(b)) it has a measurable place p_m immediately after the synchronization transition td. Now that p_m has a mark, the certain is obtained.

Finally, in a third scenario (Figure 4(c)) the measurable place is located just before the synchronization transition t_d; the conditions on uncertainty are like those of the previous scenario.

The second and third scenarios are the most convenient for the location of the measurable place since the review-update procedure of the uncertainty in the rest of the parallel branches that start from the distribution transition is avoided.

Box 4

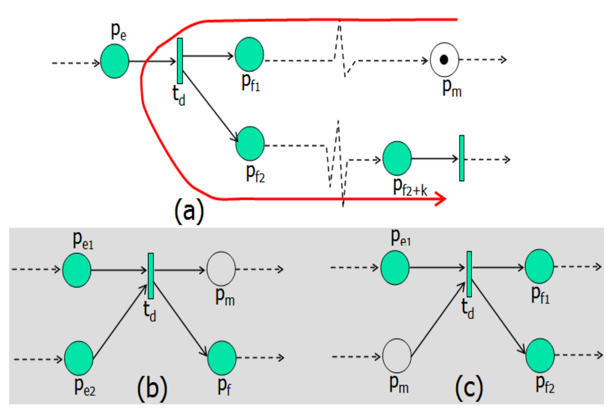


Figure 4
Location of places with associated sensor signals

Source: Own elaboration

C. Marking approximation quality

The bound of the degree of certainty $D(\tau)$ of the marking of the FTPN determines the quality of the estimation of the state. It will analyze here the evaluation of this quality and propose a procedure to adjust the quality by introducing sensors.

Evaluating the estimation quality considering FTPN models with the minimum number of sensors, the estimation quality is determined by evaluating $D(\tau)$ at the instant when a measurable place is marked in periodic operation. In the case of FTMG the calculation is obvious since there is a t-invariant (Figure 5).

Box 5

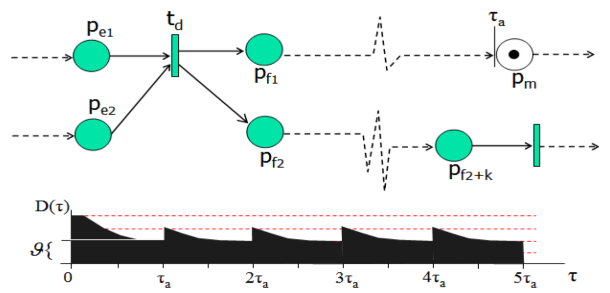


Figure 5
Quality of state estimate ϑ

Source: Own elaboration

In the case of FTSM it is necessary to make this evaluation $V(\tau)$ in each of the possible paths between two measurable places; the lowest evaluation determines the quality of the entire net. In the case of placing sensors in the immediate locations of the decision places, which may not be a minimum allocation of measurable places (Figure 6), the analysis would be limited to the evaluation of the circuits.

Box 6

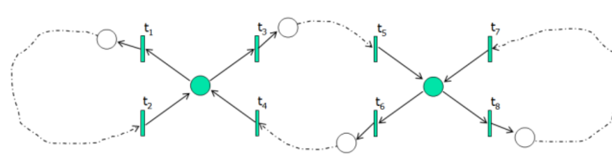


Figure 6
FTSM with more than one measurable place by t-component

Source: Own elaboration

D. Tuning to a desired quality

It is possible to maintain a desired quality value above a specific threshold ϑ by adding additional sensors to the system.

For a given FTPN model with a certain distribution of measurable locations (which can be the minimum or the so-called best in each of the subclasses), the general idea is to run the model from the initial marking, continuously evaluating $D(\tau)$. When $D(\tau) < \vartheta$ then it is necessary to place a sensor associated with the location on the trajectory where $V^i(\tau)$ is lowest.

By performing this procedure iteratively, it can determine the minimum number of measurable locations that ensure the quality desired ϑ.

Conclusions

This paper addressed the problem of DES state estimation for which activity durations are poorly known; fuzzy sets represent the uncertainty of the end of activities. Current research addresses the inclusion of sensors in FTPN to reduce the uncertainty about marking the observed locations to zero and to keep the uncertainty of marking bounded for any evolution of the system.

The inclusion of sensory information in the fuzzy model, called semi-fuzzy in this case, allows to keep the uncertainty in the approximation of marking bounded. The analysis presented shows that a reduced number of sensors is enough to give this property to the state estimation device. Furthermore, it is possible to adjust this uncertainty through a simple analysis, adding measurable locations in the model.

This approach provides a closer approximation to the real state of the DES. This method is useful for non-critical applications of state monitoring and decision making to act on the system.

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Authors' Contribution

González-Castolo, *Juan Carlos*: Contributed to the project idea. He carried out the analysis and systematization of results, as well as writing the article.

López-Mellado, *Ernesto*: Carried out the systematization of the background for the state of the art. He also contributed to the review of the article.

Ramos-Cabral, *Silvia*: She contributed to the writing and revision of the article.

ISSN: 2414-8849.
RENIECYT-CONAHCYT: 1702902

Zatarain-Durán, Omar Alí: He contributed to the revision of the article writing.

Availability of data and materials

The research did not use data.

Funding

The research did not receive any funding.

Abbreviations

DES	Discrete events systems
eU	Ending uncertain
eUt	Ending uncertainty trace
FTMG	Fuzzy timed marked graph
FTPN	Fuzzy timed Petri nets
FTSM	Fuzzy timed state machine
PN	Petri nets

References

Basic

Andreu , D., Pascal , J., & Valette , R. (1997). Fuzzy Petri net-based programmable logic controller. *IEEE Trans Syst Man Cybern B Cybern*, 952-961. doi:10.1109/3477.650056

Klir, G. J., & Yuan, B. (1995). *Fuzzy Logic. Theory and Applications.*

Murata, T. (1996). Temporal uncertainty and fuzzy-timing high-level Petri nets. *Application and Theory of Petri Nets 1996. ICATPN 1996. Lecture Notes in Computer Science*, *1091*, 29-58.
Zadeh, L., & Goguen, J. (1965). Fuzzy sets. *Information and control*, 338–353.

Support

González-Castolo, J. C., & López-Mellado, E. (2007). Approximating State of DES Using Fuzzy Timed Petri Nets., (págs. 722-728).

González-Castolo, J. C., & López-Mellado, E. (2007). Marking estimation of fuzzy timed marked graphs. *IEEE International Conference on Systems, Man and Cybernetics*, 1421-1426.

González-Castolo, J. C., & López-Mellado, E. (2011). State Estimation of Partially Observable DES Using Fuzzy Timed Petri Nets. *16 th IEEE International Conference on Emerging Technologies and Factory Automaton* (págs. 1-8). Toulouse: EFTA.

González-Castolo, J. C., & López-Mellado, E. (2011). State Uncertainty Analysis of Fuzzy Timed DES. *IEEE Conference on Automation Science and Engineering* (págs. 600-606). Trieste, Italy: CASE.

González-Castolo, J., & López-Mellado, E. (2006). Fuzzy State Estimation of Discrete Event Systems., *4293*. doi:10.1007/11925231_9

Different

Aguayo-Lara, E., Gómez-Gutiérrez, D., Ramírez-Treviño, A., & Ruiz-León, J. (2015). Sensor Placement and Observer Design for Free Choice Continuous Timed Petri Nets. *IEEE Latin America Transactions*, *13*(10), 3253-3261.

Anguiano-Gijón, C. A., Chávez, J., Cid-Gaona, A., & Vázquez, C. (2024). Assessment of Petri nets Regulation Control methodologies for automation systems. *Control Engineering Practice, 144*.

Deabes, W., Bouazza, K., & Algthami, W. (2023). Smart Fuzzy Petri Net-Based Temperature Control Framework for Reducing Building Energy Consumption. *Sensors*, *23*, 5985.

H., Y., Y., H., K, K., H, H., & S, P. (2024). Minimum Initial Marking Estimation in Labeled Petri Nets With Unobservable Transitions Based on Minimal Explanations. *IEEE Transactions on Systems, Man, and Cybernetics: Systems, 54*(6), 3427-3438.

Hua , S., & Hu-Chen, L. (2023). Fuzzy Petri Nets for Knowledge Representation, Acquisition and Reasoning (Vol. 1). Springer.

Hu-Chen, L., Jian-Xin , Y., Zhiwu, L., & Guangdong , T. (2017). Fuzzy Petri nets for knowledge representation and reasoning: A literature review. *Engineering Applications of Artificial Intelligence*, *60*, 45-56.

Jianfeng , Z., & Genserik , R. (2024). Development of a risk assessment approach by combining SPA-fuzzy method with Petri-net. *Journal of Loss Prevention in the Process Industries, 91*.

Köhler, A., & Zhang, P. (2022). State Estimation in Discrete Event Systems Modeled by Signal Interpreted Petri Nets. *IEEE Control Systems Letters*, *6*, 2078-2083.

ISSN: 2414-8849.
RENIECYT-CONAHCYT: 1702902

Kuchárik, M., & Balogh, Z. (2019). Modeling of Uncertainty with Petri Nets. En N. Nguyen, F. Gaol, T. Hong, & B. Trawiński, *Intelligent Information and Database Systems. ACIIDS 2019. Lecture Notes in Computer Science* (Vol. 11431, págs. 499-509). Springer, Cham. doi:10.1007/978-3-030-14799-0_43

L. Saleh, A., J. Mohammed, M., Sabri Kadhim, A., M. Raadthy, H., & J. Mohammed, H. (2018). Design fuzzy neural petri net controller for trajectory tracking control of mobile robot. *International Journal of Engineering & Technology, 7*, 2256-2262. doi:10.14419/ijet.v7i4.16700

Lee, J., Liu, K., & Chiang, W. (2003). Modeling uncertainty reasoning with possibilistic Petri nets. *IEEE Transactions on Systems, Man, and Cybernetics, Part B (Cybernetics), 33*(2), 214-224. doi:10.1109/TSMCB.2003.810446

Madhloom, J., Noori, Z., Ebis, S., Hassen, O., & Darwish, S. (2023). An Information Security Engineering Framework for Modeling Packet Filtering Firewall Using Neutrosophic Petri Nets. *Computers, 12*(202).

Mahulea, C., González, R., Montijano, E., & Silva, M. (2021). Path planning of multirobot systems using Petri net models. Results and open problems. *Revista Iberoamericana de Automática e Informática Industrial, 18*, 19-31.

Ramírez Treviño, A., Rivera Rangel, I., & López Mellado, E. (2003). Observability of discrete event systems modeled by interpreted petri nets. *IEEE Transactions on robotics an Automation, 1*, 557-565. doi:10.1109/TRA.2003.814503

Valencia, D., Muñoz, M., & Enríquez, F. (2020). Adequate Sensor Placement Method to Ensure Diagnosability in Interpreted Petri Net. *IEEE Latin America Transactions, 18*(12), 2081-2088.

X. G., M., & H. S. , Y. (2009). Inventory planning based on knowledgeable base and self-learning fuzzy petri nets. *16th International Conference on Industrial Engineering and Engineering Management*, 984-988.

X, L., C. N , H., & Z, L. (2024). Opacity Enforcement in Discrete Event Systems Using Modification Functions. *IEEE Transactions on Automation Science and Engineering*.

Xu, X.-G., Shi, H., Xu, D.-H., & Liu, H.-C. (2019). Picture Fuzzy Petri Nets for Knowledge Representation and Acquisition in Considering Conflicting Opinions. *Appl. Sci., 9*(5), 983.

Yang, C., Duan, R., Lin, Y., & Chen, L. (2024). A maintenance strategy for hydraulic systems based on generalized stochastic Petri nets under epistemic uncertainty. *Journal of the Brazilian Society of Mechanical Sciences and Engineering,, 46*(2), 99.

Yu, Y., Gong, H., Liu, H., & Mou, X. (2022). Knowledge representation and reasoning using fuzzy Petri nets: a literature review and bibliometric analysis. *Artif Intell Rev, 29*(56), Artif Intell Rev.

ECORFAN Journal Republic of Guatemala 10[18]1-8: e21018108

Article

Environmental impact of energy consumption in academic buildings: Case study of the faculty of agricultural sciences at UAEM, Life Cycle Analysis approach

Impacto ambiental del consumo energético en edificaciones académicas: Caso de la Facultad de Ciencias Agropecuarias de la UAEM, un enfoque de Análisis de Ciclo de Vida

Brito-R., Julio Cesar*[a] & Hernández-Luna, Gabriela [b]

[a] ROR Universidad Autónoma del Estado de Morelos • LSK-6953-2024 • 0000-0001-6450-1507 •1154670
[b] ROR Universidad Autónoma del Estado de Morelos • CAE-8952-2022 • 0000-0003-3767-3965 •004255

CONAHCYT classification:

Area: Engineering
Field: Technological sciences
Discipline: Energy technology
Subdiscipline: Energy

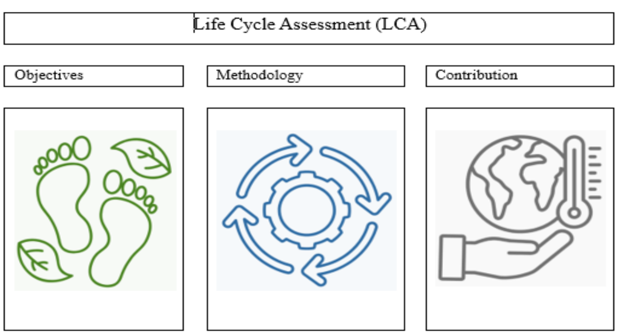
https://doi.org/10.35429/EJRG.2024.10.18.1.8

History of the article:
Received: January 30, 2024
Accepted: December 04, 2024

* ✉ [julio.brito@uaem.mx]

Abstract

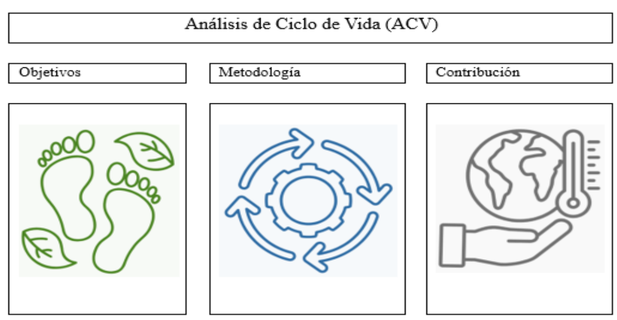
The evaluation of building energy needs during their operational phase is crucial for understanding their energy requirements. This study focuses on analyzing the energy demand of buildings within the Faculty of Agricultural Sciences at the Autonomous University of the State of Morelos during its operational phase. The methodology employed includes Life Cycle Assessment (LCA) to assess electricity consumption and associated greenhouse gas (GHG) emissions. The results revealed a significant increase in energy demand between 2022 and 2023, with significant environmental implications in terms of resource depletion and GHG emissions. These results underscore the urgency of implementing energy efficiency measures and adopting more sustainable practices in academic environments to mitigate environmental impacts and contribute to the fight against climate change.



Energy, Life Cycle Assessment (LCA), Building

Resumen

Es necesario evaluar las necesidades energéticas de los edificios, especialmente durante su proceso de operación, es decir, los requerimientos energéticos para su funcionamiento. Este estudio se centra en analizar la demanda energética de los edificios que conforman la Facultad de Ciencias Agropecuarias de la Universidad Autónoma del Estado de Morelos durante su fase operativa. Se utilizó la metodología del Análisis de Ciclo de Vida (ACV) para evaluar el consumo de energía eléctrica y las emisiones de gases de efecto invernadero (GEI) asociadas. Los resultados revelaron un aumento significativo en la demanda energética entre 2022 y 2023, con implicaciones ambientales destacadas en términos de agotamiento de recursos y emisiones de GEI. Estos hallazgos resaltan la importancia de implementar medidas de eficiencia energética y adoptar prácticas más sostenibles en entornos académicos para mitigar los impactos ambientales y contribuir a la lucha contra el cambio climático.



Energía, Análisis de Ciclo de Vida (ACV), Edificio

Citation: Brito-R., Julio Cesar & Hernández-Luna, Gabriela. [2024]. Environmental impact of energy consumption in academic buildings: Case study of the faculty of agricultural sciences at UAEM, Life Cycle Analysis approach. ECORFAN Journal Republic of Guatemala. 10[18]1-8: e21018108.

Introduction

Our globalized way of life is based on an energy model focused on the consumption of fossil sources such as oil, coal and natural gas, as well as the irrational use of fuels for the generation of electrical energy.

This model is not only unsustainable in the long term due to the depletion of natural resources, but also contributes significantly to climate change through the emission of greenhouse gases (GHG). In 2022, worldwide, 63% of electrical energy was generated from fossil sources, and in Mexico this figure reached an alarming 77% (IEA, 2022).

Universal access to an affordable, reliable, sustainable and modern level of energy is essential to meet other Sustainable Development Goals (SDGs), established by the United Nations (UN) in 2015. These goals form the axis of efforts. to address climate change through the 2030 Agenda.

Climate change, defined as long-term changes in the Earth's climate, includes an increase in global average temperature, sea level and changes in precipitation patterns. GHG emissions, produced mainly by the burning of fossil fuels, are one of the main drivers of these changes.

The impacts of climate change are profound and varied, affecting both the environment and human health. Extreme weather conditions such as heat waves, droughts and floods are becoming more frequent, as are vector-borne diseases and a decline in air and water quality. These phenomena have direct and indirect consequences on the health and well-being of people, especially the most vulnerable populations.

In this context, it is crucial to evaluate and reduce the energy consumption of buildings, especially in the academic sector, which can serve as a model for other institutions. This study focuses on the Faculty of Agricultural Sciences of the Autonomous University of the State of Morelos (UAEM), using the Life Cycle Analysis (LCA) methodology to evaluate the environmental impacts associated with the consumption of electrical energy during its operational phase.

The use of LCA in this analysis allows for a comprehensive assessment of the environmental impacts of the energy consumed.

This provides a solid basis for identifying key areas for improvement and developing effective strategies for reducing energy consumption and GHG emissions. This approach is essential to promote sustainability in academic buildings and contribute to global efforts to combat climate change.

Objectives

In the context of sustainable development and the contribution to global climate change mitigation, it is essential to identify through a specialized methodology the Greenhouse Gas contributions (La Roche, 2010) associated with buildings. Firstly, the energy consumption of the object of study and then the assessment of annual GHG emissions generated by the demand for electricity in buildings for their operation.

These studies are the basis for proposing actions that contribute to stabilizing the increase in the global average temperature to 1.5 °C proposed in 2015 through the Paris Agreement in the United Nations Framework on Climate Change (UNFCCC, 2015). In 2022, Mexico emitted 407 $MtCO_2$, ranking 15th in terms of countries contributing to global emissions (GCA, 2022).

Environmental problems today, involve discovering the incidence of construction and the impacts generated through habitability. Therefore, as global trainers of leaders in technological innovation, universities must lead the transition to the management and planning of renewable energy in their physical and natural environments, the implementation of projects to mitigate environmental impacts caused by direct emissions (WEF, 2022) from electricity consumption of students, faculty and staff in the buildings they use.

The Autonomous University of the State of Morelos is a public university founded in 1953, has more than 150,000 m2 of construction, the enrolment for 2022 amounts to 40,000 high school, undergraduate and graduate students and has a presence in more than 20 municipalities of the 34 in the state of Morelos, which represents 60% of the total Zapatista territory.

ISSN: 2414-8849.
RENIECYT-CONAHCYT: 1702902

It has 9 academic units at the secondary level and 35 at the higher level that make up the research centers and institutes, schools, faculties and regional headquarters. It has a teaching staff of 2,000 unionized teachers and close to 1,000 trust academics. To support institutional activities, there are more than 2,000 people, half of them unionized and the rest trustworthy.

Since 2002, the UAEM has been working to promote an environmental culture among its university, civilian and general community, founding the "University Environmental Management Program" (PROGAU by its Spanish capital letters) (UAEM, 2024), which main objective was to reduce environmental effects derived from anthropogenic activities, to finally implement actions to develop a culture of care, conservation and protection of the environment in favor of climate change mitigation.

The PROGAU generated strategies and lines of action through five aspects: integrated waste management, environmental education, natural environment and landscape architecture, efficient water and energy management, health and safety (PIDE, 2018).

By 2017 it became the General Directorate of Sustainable Development, "Dirección General de Desarrollo Sustentable" (DGDS by its Spanish capital letters); with activities to regulate the "Unidad de Desarrollo Sustentable", in terms of their behavior to face of environmental problems within the UAEM itself. And finally, as of 2024, it has become the Sustainable Development Unit, attached to the Faculty of Agricultural Sciences. It is responsible of carrying out activities for the use of resources, the composting center and a zero-waste policy.

The objective of this study is to identify electrical energy demand of the buildings that make up the Faculty of Agricultural Sciences through the energy consumption of its students, faculty and staff, its most energy intensive components of this type of service buildings, verification with the consumption register before the Federal Electricity Commission "Comisión Federal de Electricidad" (CFE, by its Spanish capital letters), to subsequently quantify the GHG emissions with the support of the international and specialized methodology of Life Cycle Analysis (LCA).

Finally generate the corresponding GHG report, as other universities have done for their GHG inventories (Saavedra, 2020) (Bautista et al., 2022).

Methodology

The LCA methodology evaluates the possibility of environmental hazards, measures the amount of materials, energy and waste released into the environment, and assesses the effects of processes on human health, the general quality of the environment and the depletion of raw materials; it is possible to identify potential environmental impacts (Larrey-Lassalle et al. 2017) (Guerin-Schneider et al., 2018).

Each phase of the life cycle of a specific product or service is covered by the analysis, starting with the first step of the life cycle assessment, which involves obtaining data on the raw materials needed for production, and then moving on to the manufacturing, distribution and consumption phases, as is the case of the latter stage, which is the focus of this study.

The ISO (International Organization for Standardization) 14001-14043 (ISO, 2006) define the four components of the LCA framework, as shown in Figure 1, starting with the definition of the objective and scope, the inventory analysis, i.e., the set of inputs and outputs that make up the investigated process, to move on to the impact assessment phase and finally the interpretation of the results. As can be seen, there is a correlation in each of them; the results in any of the components can be used as the main source of data for the previous or following phases of the LCA.

Box 1

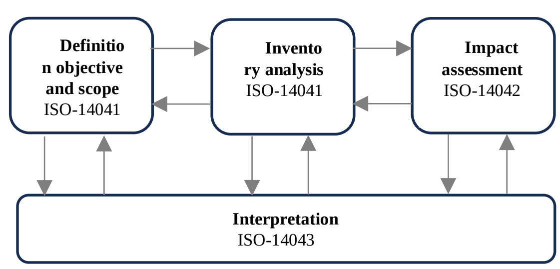


Figure 1
Principles and framework of the LCA methodology
Source: ISO. (2006). International Organization for Standardization

ISSN: 2414-8849.
RENIECYT-CONAHCYT: 1702902

Currently, most of the research and life cycle analysis in the field of buildings is mainly concentrated in Europe. This continent is the epicenter of much of the life cycle analysis studies due to the presence and significant participation of companies and institutions supplying data necessary to carry out this type of evaluations (Leda et al., 2023). In general, buildings are designed to have an operational life that can range from 20 to 50 years, although they can last much longer with proper maintenance and periodic renovations (Hernández-Moreno, 2010) (Hernández-Moreno, 2011) (Macías-Bernal, et al., 2014) (Aguirre et al., 2024).

The cut-off points for the analysis of the electrical energy demand of the buildings that make up the academic unit will be set at 0.06% in relation to the average useful life of a building. The study of electrical energy consumption was carried out for the buildings of the Faculty of Agricultural Sciences, belonging to the Autonomous University of the State of Morelos, activities inherent to the Academic Unit, in this case to the activities of higher and postgraduate students, professors and staff. The buildings are used as part of its professional training, research, development and innovation activities Two annual consumption scenarios were analyzed, as shown in Table 1, corresponding to the years 2022 and 2023. The information was requested from the Academic Unit's management and later verified through the internal *"commercial system"* (SICOM, by its Spanish capital letters) server of the electricity supplier, the CFE.

Box 2

Table 1

Electrical energy consumption, Faculty of Agricultural Sciences

Month / Year	Consumption kWh anual	
	2022	2023
january	3,967	6,132
february	3,728	7,225
march	5,705	8,490
april	5,205	6,309
may	8,375	8,716
june	5,958	7,503
july	4,253	6,225
august	7,063	6,741
september	8,288	7,944
october	8,113	7,629
november	8,128	7,246
december	6,096	5,925
Total	74,879	86,085

Source: Own elaboration with data provided by the Faculty of Agricultural Sciences

The emissions quantification was carried out considering the system boundary from door to door; that is, in the operation and energy consumption stage of the building, using the OpenLCA software (Green Delta, 2022) because it is free, fast and reliable in the evaluation of Life Cycle Assessment (LCA) (Mutel et al., 2009), have a large database such as Nexus and Ecoinvent (Rodríguez et a., 2016) (McCarl et al., 2017), essential in this type of studies (Atmaca et al., 2015) (Molina-Moreno et al., 2017) (Nydahl et al., 2019).

Then midpoint impact categories were analyzed including: Abiotic Depletion Potential (ADP kg Sbeq), Fossil Fuel Depletion Potential (FDP MJ), Acidification Potential (AP kg SO_2eq), Eutrophication Potential (EP kg PO_4eq), Freshwater Ecotoxicity Potential (FAETP kg 1,4-DBeq), Global Warming Potential (GWP kg CO_2eq), Human Toxicity Potential (HTP kg 1,4-DBeq), Ozone Depletion Potential (ODP kg CFC-11eq), Photochemical Ozone Creation Potential (POCP kg C_2H_4eq) and Terrestrial Ecotoxicity Potential (TETP kg 1,4 DBeq), considering the midpoint CML-IA (baseline) impact assessment method as endpoint (CML-IA Baseline, 2016) because it is the assessment method mostly used in LCA studies (Ortíz et al., 2022).

Results

The results of the midpoint impact analysis for the selected 2022 and 2023 scenarios reveal that the most affected categories are Fossil Fuel Depletion Potential (FDP), Global Warming Potential (GWP100a), Freshwater Ecotoxicity Potential (FAETP) ann Human Toxicity Potential (HTP).

The CML-IA endpoint analysis showed that resource depletion was the most affected category, followed by climate change, human and ecosystem health, which aligns with the findings of the midpoint analysis.

It is notable that both analyses indicate impacts to all four endpoint aspects, which is of concern. These results are shown in Figure 2.

ISSN: 2414-8849.
RENIECYT-CONAHCYT: 1702902

Box 3

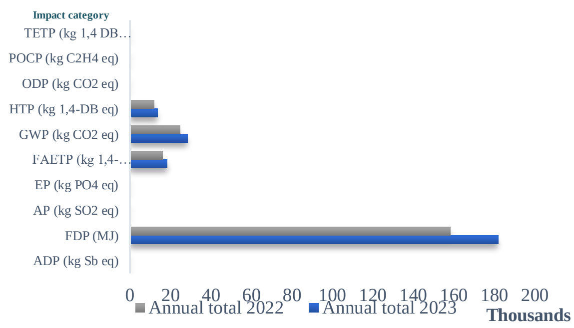


Figure 2

Results of the analysis by category of impact in the 2022 and 2023 scenarios for energy consumption in the Faculty of Agricultural Sciences of the UAEM.

The results for the category of Fossil Fuel Depletion Potential (FDP) are shown in Figure 3, the average result of energy resource consumption is just over 13,000 MJ for the year 2022, while for the year 2023 it recorded resource depletions of just over 15,000 MJ, for the months of September and November 2022 and also March 2023. This indicator is up to 18% above the average. Coincidentally, for the month of May in both years the indicator is 20% above the average, the hottest month for the geographical area of the UAEM.

The months with the least impact in both years are the months of December and January, coinciding with one of the most important vacation periods for the University. The months with the lowest impact in both years are December and January, coinciding with one of the most important vacation periods for the University. For this impact category, the endpoint analysis indicates the depletion of fossil fuel sources by up to 158,000 MJ for 2022 and 182,000 MJ for 2023, representing a difference in increase of up to 15%

Box 4

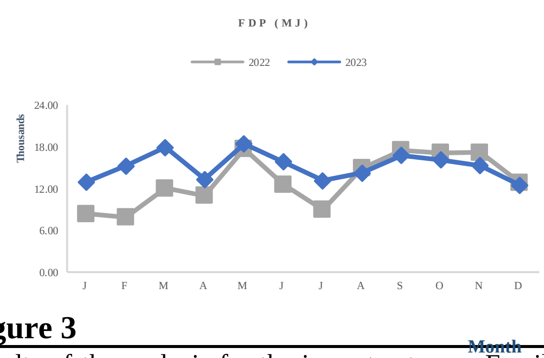


Figure 3

Results of the analysis for the impact category Fossil Fuel Depletion Potential (FDP MJ) in the 2022 and 2023 scenarios for energy consumption in the Faculty of Agricultural Sciences of the UAEM.

The results for the Freshwater Ecotoxicity Potential (FAETP) impact category are shown in Figure 4, although the impacts produced at the midpoint level are minor compared to other categories such as Fossil Fuel Depletion Potential (FDP) or Global Warming Potential (GWP), they do have significant effects on ecosystems. The figures indicate equivalent Dichlorobenzene emissions of up to 16,000 kg for 2022 and 18,500 kg for 2023, representing a 16% difference between the scenarios analyzed. The months of May, September and November 2022 and March and May 2023 are the most affected months, coinciding with the impact category of Fossil Fuel Depletion Potential (FDP).

Box 5

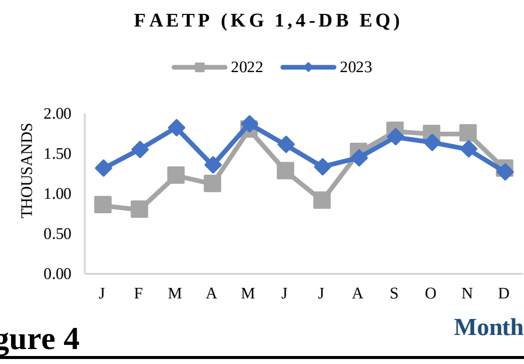


Figure 4

Results of the analysis for the impact category Freshwater Ecotoxicity Potential (FAETP kg 1,4-DB eq) in the 2022 and 2023 scenarios for energy consumption in the Faculty of Agricultural Sciences of the UAEM

The CO_2eq emissions from electricity consumption for the scenarios 2022 and 2023 are shown in Figure 5. The results amount an average to 24.7 tones CO_2eq for the first scenario, while for 2023 the average is 28.4 tones CO_2eq.

For this category, coincidentally with Fossil Fuel Depletion Potential (FDP) and Freshwater Ecotoxicity Potential (FAETP) categories, the months of least impact are January and February 2022 and December 2023, for which the Mexican winter school holiday period occurs. This is the category of greatest interest in this study, the results indicate the carbon footprint due to electricity consumption in the Faculty of Agricultural Sciences, which will be reflected not only in CO_2 emissions but also in five greenhouse gases covered by the Kyoto Protocol: Methane (CH_4), Nitrous Oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulphur Hexafluoride (SF_6).

Brito-R., Julio Cesar & Hernández-Luna, Gabriela. [2024]. Environmental impact of energy consumption in academic buildings: Case study of the faculty of agricultural sciences at UAEM, Life Cycle Analysis approach. ECORFAN Journal Republic of Guatemala. 10[18]1-8: e21018108.
https://doi.org/10.35429/EJRG.2024.10.18.1.8

For this impact category, the endpoint analysis indicates GHG emissions of up to 24,700 kg CO_2eq by 2022 and 28,400 kg CO_2eq by 2023, representing a 15% difference in emissions for the second scenario.

Box 6

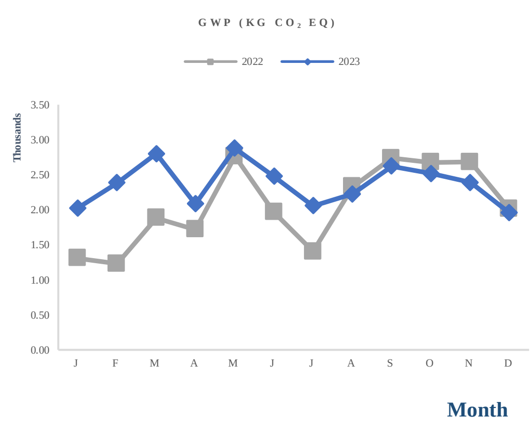


Figure 5

Results of the analysis for the Global Warming Potential impact category (GWP kg CO_2eq) in the 2022 and 2023 scenarios for energy consumption in the Faculty of Agricultural Sciences of the UAEM

Discussion and Conclusions

The Life Cycle Assessment methodology was successfully applied to evaluate the environmental impact of electricity consumption in the Faculty of Agricultural Sciences. Two annual consumption scenarios for the years 2022 and 2023 were analyzed.

The study reveals a significant 15% increase in electricity consumption in the faculty between these two years, which underlines the urgent need to implement effective measures to reduce this demand and mitigate its environmental impact.

The most worrying category is Fossil Fuel Depletion Potential (FDP), with about 200,000 MJ in 2023, indicating a depletion of fossil sources for electricity generation in Mexico. On the other hand, the lower impact categories, such as Abiotic Depletion Potential (ADP), Acidification Potential (AP), Ozone Depletion Potential (ODP), Photochemical Ozone Creation Potential (POCP) and Terrestrial Ecotoxicity Potential (TETP), show levels close to zero impact according to the analysis.

The study reveals that electricity consumption in the buildings studied generates a considerable amount of greenhouse gas emissions, especially Carbon Dioxide CO_2 (carbon footprint).

This highlights the crucial importance of reducing these emissions to contribute to climate change mitigation, in line with the targets set out in the Paris Agreement.

It is essential to intensify actions to reduce energy demand and greenhouse gas emissions in the Faculty of Agricultural Sciences. This can be achieved by implementing energy efficiency measures, using renewable energy and raising awareness of the importance of environmental sustainability.

As electrical energy consumption continues to increase, the ability to forecast the maximum energy consumption of UAEM buildings is critical to effectively manage the energy system. The selection of an appropriate model is crucial to accurately predict such consumption, given that consumption trends and characteristics vary substantially.

Public Universities, such as the Autonomous University of Morelos State, play a crucial role in leading the transition to more sustainable practices. They should promote environmental education and adopt green and renewable technologies to reduce their environmental impact.

LCA provides valuable information on the environmental impact of buildings during their operational lifetime. This approach should be widely applied to guide more sustainable design and management decisions.

It is recommended to continue to regularly monitor and evaluate energy consumption and emissions in the Faculty of Agricultural Sciences. Continuous improvement in environmental and energy practices is essential to achieve long-term sustainability goals according to Sustainable Development Goals, SDG.

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

ISSN: 2414-8849.
RENIECYT-CONAHCYT: 1702902

Author contribution

Brito-R Julio: Contributed to the project idea and to the research of the information.

Hernández-Luna, Gabriela: Contributed to the methodology use.

Availability of data and materials

Data are available from the corresponding author.

Acknowledgements

The author would like to thank the Consejo Nacional de Humanidades, Ciencias y Tecnologías (CONAHCYT) for its financial support, and the teaching staff of the Facultad de Arquitectura and the Centro de Investigación en Ingeniería y Ciencias Aplicadas of the Universidad Autónoma del Estado de Morelos for their valuable comments and suggestions. Finally, the author would like to thank Dr. Norma Angélica Juárez Salomo, Dr. Ernesto Ríos Lanz and Dr. Einar Topiltzin Contreras MacBeath for their support.

Abbreviations

ADP	Abiotic Depletion Potential
AP	Acidification Potential
C_2H_4eq	Ethylene
CFC-^{11}eq	Equivalent Trichlorofluoro Methane
CFE	Federal Electricity Comission
CH_4	Methane
CO_2	Carbon Dioxide
CO_2eq	Equivalent Carbon Dioxide
DBeq	Equivalent Dichlorobenzene
DGDS	General Directorate of Sustainable Development
EP	Eutrophication Potential
FAETP	Freshwater Ecotoxicity Potential
FDP	Fossil Fuel Depletion Potential
GCA	Global Carbon Atlas
GHG	Greenhouse Gas
GWP	Global Warming Potential
HFCs	Hydrofluorocarbons
HTP	Human Toxicity Potential
ISO	International Organization for Standardization
kg	Kilogram
LCA	Life Cycle Assessment
MJ	Mega-Joules
$MtCO_2$	Mega ton of Carbon Dioxide
N2O	Nitrous Oxide
ODP	Ozone Depletion Potential
PFCs	Perfluorocarbons
PIDE	Plan Institucional de Desarrollo
PO_4eq	Equivalent Phosphate
POCP	Photochemical Ozone Creation Potential
PROGAU	University Environmental Management Program
Sbeq	Equivalent Antimony
SDGs	Sustainable Development Goals
SF_6	Sulphur Hexafluoride
SICOM	Commercial System
SO_2eq	Equivalent Sulfure Dioxide
TETP	Terrestrial Ecotoxicity Potential
UAEM	Autonomous University of the State of Morelos
UN	United Nations
UNFCC C	The United Nations Framework Convention on Climate Change
WEF	World Economic Forum

References

Background

IEA. (2022). International Agency of Energy.

La Roche, P. (2010). Cálculo de emisiones de gases de efecto invernadero en edificios: análisis del funcionamiento de varias herramientas en diferentes climas. *Informes de la Construcción, 62*(517), 61-80.

UNFCCC (The United Nations Framework Convention on Climate Change). Paris agreement. (2019).

GCA. (2022). Global Carbon Atlas.

WEF. (2022). World Economic Forum.

UAEM. (2024). Universidad Autónoma del Estado de Morelos.

PIDE. (2018). Plan Institucional de Desarrollo.

Basics

Larrey-Lassalle, P., Catel, L., Roux, P., Rosenbaum, RK, López-Ferber, M., Junqua, G. y Loiseau, E. (2017). An innovative implementation of LCA within the EIA procedure: Lessons learned from two Wastewater Treatment Plant case studies. *Environmental Impact Assessment Review, 63*, 95–106.

Guerin-Schneider, L., Tsanga-Tabi, M., Roux, P., Catel, L. and Biard, Y. (2018). How to better include environmental assessment in public decision-making: Lessons from the use of an LCA-calculator for wastewater systems. *Journal of Cleaner Production*, *187*, 1057-1068.

ISO. (2006). International Organization for Standardization.

Leda, P., Kruszelnicka, W. Leda, A., Piasecka, I., Klos, Z., Tomporoswki, A. and Opielak, M. (2023). Life Cycle Analysis of Photovoltaic Power Plant Using the CED Method. *Energies, 16*(4), 2-19.

Hernández-Moreno, S. (2010). Integration of service life in the process of management and design of buildings. *Management Research and Practice*, 2(4), 397-400.

Hernández-Moreno, S. (2011). Aplicación de la información de la vida útil en la planeación y diseño de proyectos de edificación. Acta Universitaria, 21(2), 37-42.

Macías-Bernal, J. M., Calama-Rodríguez, J. M., Chávez-de Diego, M. J. (2014). Modelo de predicción de la vida útil de la edificación patrimonial a partir de la lógica difusa. *Informes de la Construcción*, 66 (533).

Aguirre C., F., Treviño M., F., Hoyos C., C. A., y García A., M. E. (2024). Efectos del envejecimiento estructural durante la vida útil de Edificios: caso de estudio de un edificio educativo. *Memoria Investigaciones En Ingeniería*, (26), 125–142.

Green Delta. (2022). Open LCA.

Mutel, C. and Hellweg, S. (2009). Regionalized Life Cycle Assessment: Computational Methodology and Application to Inventory Databases. *Environmental science & Technology*, 43(15), 5797–5803.

Rodríguez, C., Moller, F. y Ciroth, A. (2016). ecoinvent v. 3.2 en OpenLCA. *OpenLCA, Berlín.*

McCarl, B. A., Yang, Y., Srinivasan, R., Pistikopoulos, E. N. and Mohtar, R. H. (2017). Data for WEF nexus analysis: A Review of Issues. *Current Sustainable/Renewable Energy Reports*, 4(3), 137-143.

Atmaca, A. and Atmaca, N. (2015). Life cycle energy (LCEA) and carbon dioxide emissions ($LCCO_2A$) assessment of two residential buildings in Gaziantep, Turkey. *Energy and Buildings*, 102, 417-431.

Support

Saavedra, F. E. (2020). Huella de carbono-emisiones de GEI por uso del sistema de iluminación de la Facultad de Ingeniería Ambiental de la Universidad Nacional de Ingeniería, Lima-Perú. *Tecnia*, 30(1), 121-138.

Bautista, J., Sierra, Y. y Bermeo, J. F. (2022). Emisiones de Gases de Efecto Invernadero en las Instituciones de Educación Superior. *Producción + Limpia*, 17(1), 169-186.

Molina-Moreno, F., Martí, J. V., Yepes, V. and Ciroth, A. (2017). Environmental impact shares of a reinforced concrete earth-retaining wall with buttresses. *Resilient Structures and Sustainable Construction*, 1-6.

Nydahl, H., Andersson, S., Astrand, A. and Olofsson, T. (2019). Environmental Performance Measures to Assess Building Refurbishment from a Life Cycle Perspective. *Energies*, 12 (2), 299.

CML-IA Baseline. (2016). Universiteit Leiden.

Discussions

Ortiz, J. A., Edo, B., M. D. y Gonzalo, B. M. (2022). Análisis de ciclo de vida en el sector de la edificación residencial: estado del arte. 407-419.

Article

Fluidity index for smart farms supply chain

Índice de fluidez en cadenas agroalimentarias

Bueno-Solano, Alfredo*[a], Hernández-Valdez, Lizeth Danyra [b], Vega-Telles, Ernesto Alonso [c] and Acosta-Quintana, María Paz Guadalupe [d]

[a] Instituto Tecnológico de Sonora • KVY-4884-2024• 0000-0001-5539-1924 • 293248
[b] Instituto Tecnológico de Sonora • LBH-6538-2024• 0009-0007-2393-4171
[c] Instituto Tecnológico de Sonora• LBH-6651-2024• 0000-0002-8260-3002 • 1179288
[d] Instituto Tecnológico de Sonora • GLR-5880-2022• 0000-0001-7115-9076 • 249127

CONAHCYT Classification:

Area: Social Sciences
Field: Economic Sciences
Discipline: Economic activity
Subdiscipline: Production

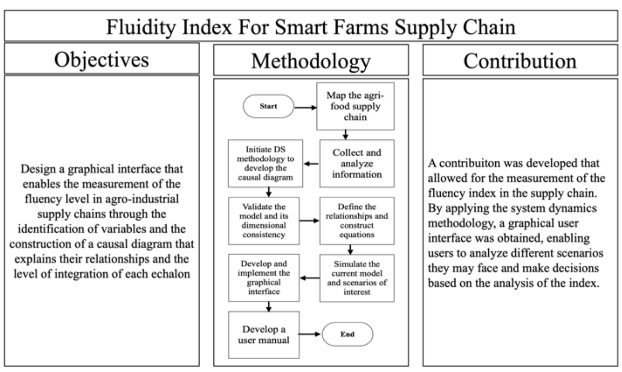
https://doi.org/10.35429/EJRG.2024.10.18.3.9

History of the article:
Received: January 17, 2024
Accepted: December 03, 2024

* [abuenosolano@itson.edu.mx]

Abstract

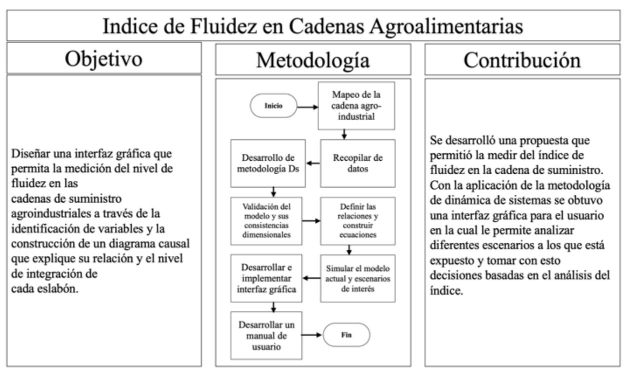
This research provides a comprehensive perspective on the supply chain of the agri-food sector in Sonora, Mexico, with a specific focus on tomatoes, one of the most prominent products in both the regional and national economy. The analysis emphasizes the importance of supply chain integration and its impact on the fluency index, utilizing system dynamics methodology to simulate and evaluate this influence.



Smart Farms, Logistics, Fluidity Index

Resumen

La presente investigación ofrece una perspectiva integral sobre la cadena de suministro del sector agroalimentario en Sonora, México, con un enfoque específico en el tomate, uno de los productos más destacados en la economía regional y nacional. El análisis se centra en la importancia de la integración de la cadena de suministro y su impacto en el índice de fluidez, utilizando la metodología de dinámica de sistemas para simular y evaluar dicha influencia.



Agroindustria, Logística, Índice de Fluidez

Citation: Bueno-Solano, Alfredo, Hernández-Valdez, Lizeth Danyra, Vega-Telles, Ernesto Alonso and Acosta-Quintana, María Paz Guadalupe. [2024]. Fluidity index for smart farms supply chain. ECORFAN Journal Republic of Guatemala. 10[18]1-9: e31018109.

Introduction

The agri-food sector in Mexico is vital to the country's economy, significantly contributing to the Gross Domestic Product (GDP). In 2018, the primary sector contributed 2.4% to the national GDP, highlighting the relevance of activities such as agriculture, livestock, fishing, and forestry.

Sonora, in particular, has established itself as a leader in the export of agri-food products due to its vast territorial extension dedicated to cultivation and its ability to generate foreign exchange through these exports. In this context, the tomato stands out as a key product due to its production volume and economic value.

The analysis of the tomato supply chain in Sonora reveals several challenges and opportunities. Supply chain integration is identified as a crucial factor for improving the sector's efficiency and competitiveness. Integration allows better coordination of information, resources, and materials flows among the various actors in the chain, from producers to distributors and marketers. Bautista Santos and others (2015) define supply chain integration as the interrelation and alignment of internal and external processes and flows of companies to satisfy the customer efficiently.

Despite its importance, supply chain integration in the Mexican agri-food sector has significant deficiencies. Only 13% of organizations have an integrated system for synchronizing information and material delivery, limiting these chains' ability to operate efficiently and respond adequately to market demands. Implementing information tools and advanced technologies is crucial to improving this situation. According to the USAID Logistics Indicators Study (2014), organizations should focus on process management, technological advancements, chain collaboration, customer relations, and investment optimization to optimize their operations.

Background

Fluidity in supply chains is another essential factor influencing their performance. Increasing fluidity improves the chain's reliability and responsiveness to market changes.

However, research on fluidity in supply chains is limited, leaving ample room for future studies. Implementing a fluidity index, as proposed by Cedillo Campos (2018), can provide a valuable tool for measuring and improving supply chain performance. This index helps identify the level of capacity achieved continuously and safely, which is essential for decision-making and efficient information management.

Fluidity can be defined as the level of capacity to achieve a reliable, safe, and accurate flow of physical, financial, human, and information resources over time, effectively supporting the supply chain's objectives. (Cedillo Campos, Lizarraga, Lizarraga & Martner Peyrelongue, 2019).

The integration of the supply chain and its ability to improve process fluidity can offer numerous benefits, including reducing uncertainty in decision-making, decreasing errors, eliminating non-value-adding activities, and increasing resource flow. (Bueno et al., 2022). Additionally, integration facilitates collaboration among different supply chains, which can lead to the creation of new business opportunities and economic development at regional, state, national, and even global levels.

A significant challenge organization currently face is achieving supply chain integration, where all components' flow is controlled. This integration applies to any industry sector, as they are affected by different variables, such as endogenous and exogenous factors.

Bautista Santos and others (2015) define supply chain integration as "a term that ranges from the interrelation of internal processes and flows of each company to the combination of processes and flows of multiple actors; where these processes are aligned based on the chain's strategy to satisfy the customer."

According to the USAID Logistics Indicators Study (2014), five main areas where organizations should focus to optimize supply chain operations are: process management, technological advancements, chain collaboration, customer relations, and investment optimization.

ISSN: 2414-8849.
RENIECYT-CONAHCYT: 1702902

Bueno-Solano, Alfredo, Hernández-Valdez, Lizeth Danyra, Vega-Telles, Ernesto Alonso and Acosta-Quintana, María Paz Guadalupe. [2024]. Fluidity index for smart farms supply chain. ECORFAN Journal Republic of Guatemala. 10[18]1-9: e31018109.
https://doi.org/10.35429/EJRG.2024.10.18.3.9

The current situation of supply chains in the mentioned study reveals that only 13% of the organizations studied have an integrated system for synchronizing information and material delivery. This low percentage is influenced by the limited use of information tools, with 64% of companies doing so informally and/or in certain areas.

The integrated coordination within supply chains facilitates value creation, especially when demand and supply fluctuate rapidly and unpredictably. Phadnis and Schoemaker (2024).

However, to gain more information about the influence of supply chain integration on the fluidity index of the food sector, this research proposes designing a graphical interface to measure the fluidity level in agri-industrial supply chains by identifying variables and constructing a causal diagram that explains their relationship and the level of integration of each link, all using system dynamics as a tool to understand the relationships among all participants in the supply chain.

Methodology

This section details the procedure or methodological route used in the research project on supply chains in the agri-food sector. Figure 1 below illustrates this.

Box 1

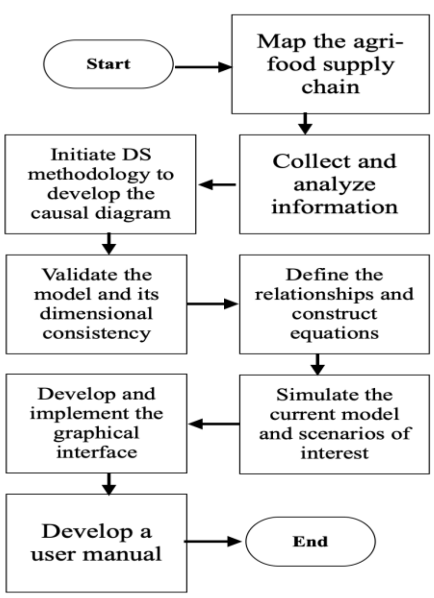


Figure 1
Research Project Procedure Flowchart

The stages of this procedure are explained below:

- **Mapping the Agri-Food Supply Chain**

Bibliographic searches and visits to organizations in northwestern Mexico will be conducted to determine the configuration of the agri-industrial supply chain, specifically identifying the elements involved in tomatoes.

- **Data Collection and Analysis**

For information collection, Google Maps will be used to indicate the departure location and destination of transported resources. This will identify the routes between different locations as well as traffic conditions.

- **Development of the Causal Diagram of the Supply Chain**

In this stage, a causal diagram will be created, a tool used in the early stages of system dynamics to graphically show cause-effect relationships between two or more variables. (Lagarda Leyva, 2019).

In causal diagrams, three types of relationships are presented: direct relationships, where a parameter affects a variable; simple relationships, where one variable affects another and is also influenced by it, possibly affected by a parameter; and complex relationships, where more than two variables affect each other.

Feedback loops occur when a simple or complex relationship arises between variables, which can be of two types: reinforcing or balancing, influenced by the type of polarity. A positive (+) polarity increases the other variable, while a negative (-) polarity decreases it.

- **Construction of the Forrester Diagram**

In this stage, the mathematical model is constructed following the system dynamics methodology with the Forrester diagram, which, according to Morlán Santa Catalina (2010), is "an intermediate step for obtaining the mathematical equations that define the system's behavior."

- Simulation of the Current Model

Model ejection will be conducted using the Stella Architect software simulation based on the data obtained in the research on the current situation of the food sector supply chain.

- Dimensional Consistency Verification

A series of tables will be created to identify and classify the different types of variables in the system dynamics methodology, which are level, flow, and auxiliary variables. The procedure for validating consistency, according to Sterman (2000), involves "carefully reviewing that each equation and parameter in the model have consistency in their units to prevent errors during calculations in the simulation and avoid drawing erroneous conclusions about the system's behavior under study." Additionally, the units of each variable used in the model will be verified with an internal tool in the Stella Architect software.

- Implementation and Communication of the Graphical Interface

In this stage, a graphical interface was designed, consisting of a series of graphical elements that allow the user to communicate with the system. The interface design, according to Luna González (2004), requires "a theoretical foundation to discern each element that composes it and provide its solutions." Consequently, the graphical interface design was based on the Forrester diagram previously developed in the Stella Architect software.

Results

- Mapping the Agri-Food Supply Chain

In this stage, the agri-food sector's supply chain was designed, including the main elements such as links and their relationships. Figure 2 below illustrates this.

Box 2

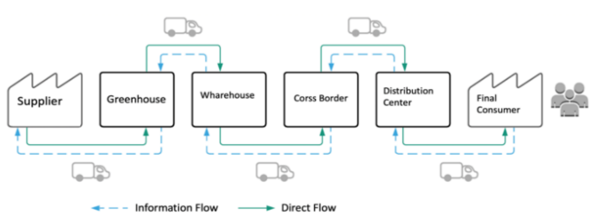


Figure 2
Agri-Food Supply Chain Mapping

The agri-food sector's supply chain starts with a raw material supplier, providing seeds, fertilizers, irrigation materials, etc., for cultivation, required by a greenhouse responsible for planting, growing, harvesting, and manually selecting the product. The product is then moved to an intermediate warehouse near the border for weighing, cleaning, and packaging.

The next step is customs, where the product undergoes inspections to meet standards before entering the country. The product is then transported to a distribution center for further distribution to various points of sale, eventually reaching the final consumer.

The supply chain works as a network where information and material flows. The greenhouse handles planting, growing, harvesting, and selecting the product, then moves it to an intermediate warehouse for weighing, cleaning, and packaging. The next step is customs, followed by distribution to various sales points, eventually reaching the final consumer. Information follows a process starting with product demand, inventory checks, order fulfillment, and customer approval, or ordering from the supplier if inventory is insufficient.

- Data Collection and Analysis

In this stage, Google Maps was used to determine transportation times between supply chain links. Figure 3 below illustrates an example.

Box 3

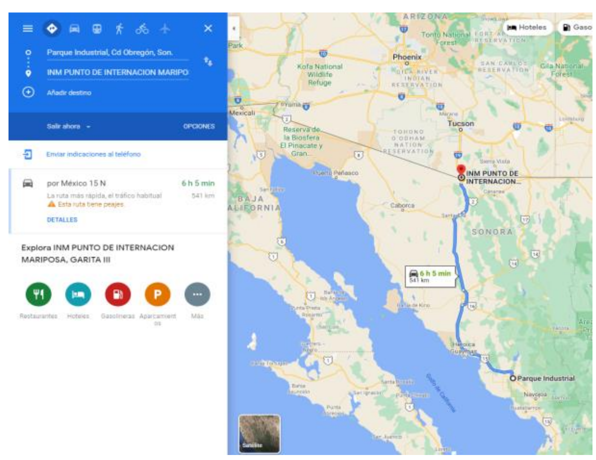


Figure 3
Inventory Transit to Customs Route
Source: Google Maps 2020

ISSN: 2414-8849.
RENIECYT-CONAHCYT: 1702902

The times and routes between different locations were recorded in the corresponding table. Table 1 below shows the routes studied for fluidity.

Box 4

Table 1

Studied Routes

Process/Echalon	Route	Route Considered
Supplies	1	Bácum/Son 105 hacia calle base/128
Cleaning and sorting (preparation to sent)	2	Blvd. Rodolfo Félix Valdez La Loma de Bácum, Son.
Washing and Packaging	3	Calzada Francisco Villanueva y Calle Sufragio Efectivo
In transit Inventory	4	Calzada Francisco Villanueva y Calle Sufragio Efectivo
Preparation to Cross an international Costumes	5	INM Punto de Internación Mariposa, Garita III Col del Rosario, 84020 Nogales, Son
Distribution center	6	Nogales, Arizona 85621, EE. UU.

Box 5

Table 2

Transportation times in minutes for each process, morning shift, afternoon shift, night shift

Route	Mornig	Afternoon	Night
1	18 - 28	18-28	---
2	3	3	3
3	24 - 45	26 - 40	28-50
4	15 – 60	15 – 60	15 – 60
5	340 - 430	340 - 450	380
6	14 – 18	14 - 18	14 - 18
TOTAL	496.5	507.5	465.5

Each table has routes, total distance, and delivery time, will be used to determine each link's fluidity index in the supply chain.

- **Development of the Causal Diagram of the Supply Chain**

The causal diagram was created with the identified variables and their relationships. Figure 4 below illustrates this.

Box 6

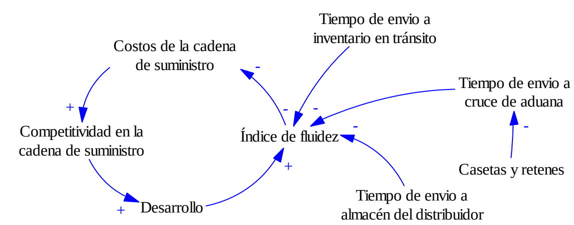


Figure 4

Tomato Supply Chain Causal Diagram

Source: Own elaboration

The causal diagram allows identifying the variables influencing the process and evaluating the relationships between them.

- **Construction of the Forrester Diagram**

The Forrester diagram was created in the Stella Architect software. Figure 5 below illustrates this.

Box 7

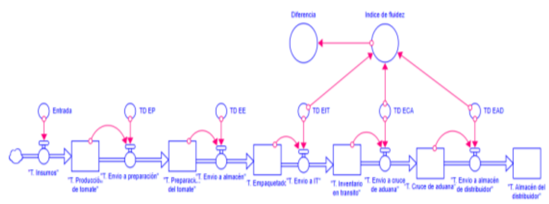


Figure 5

Forrester Diagram of the Tomato Supply Chain

Source: Own elaboration

The Forrester diagram defines each variable's role in the supply chain, from supplies to final delivery.

- **Simulation of the Current Model**

Model runs were conducted to simulate the current situation. Figure 7 shows the simulation run and validation. Also Table 3 below shows the results.

Box 8

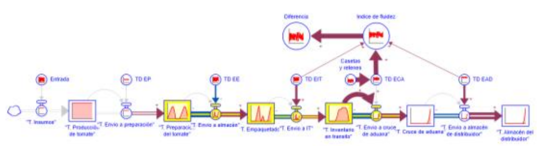


Figure 6

Results of simulation and validation process

Source: Own elaboration

ISSN: 2414-8849.
RENIECYT-CONAHCYT: 1702902

Figure 6 shows the model's behavior throughout the run, and the flow of resources through it can be observed. This verifies that the model's structure produces a result that approximates reality, in this case, the free-flow time.

For the search for inconsistencies, an analysis of extreme conditions and the resulting units of the designed model was carried out. The process began with the use of the software, which is illustrated in Figure 7 below.

Box 9

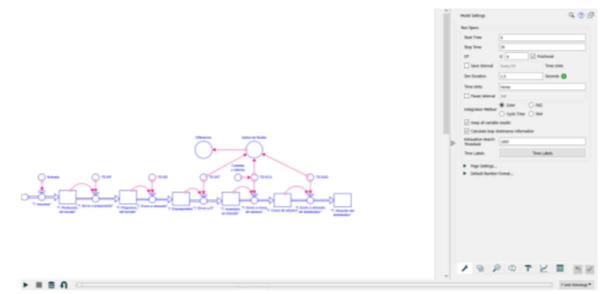


Figure 7
Consistency Validation
Source: Own elaboration

- **Implementation and Communication of the Graphical Interface**

The graphical interface was designed, allowing users to interact with the system. Figure 8 below illustrates this.

Box 10

Figure 8
Graphical Interface of the Tomato Supply Chain
Source: Own elaboration

As shown in Figure 8, the graphical interface menu contains five buttons, which, when clicked, direct you to a tab with the selected scenario or condition. Among these scenarios are three: the development of the model in the morning, afternoon, and night shifts.

The situations include being subject to a specific shift, which means it is a general model, and the scenario where an unplanned delay occurs, such as checkpoints, toll booths, and off-route inspections. This tab also includes two buttons to move forward or backward, similar to those used on previous pages.

For the situation where the process develops normally, without any particular condition, a tab was designed, which is shown in Figure 9 below.

Box 11

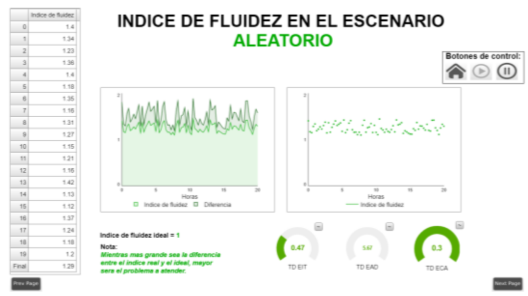


Figure 9
Model in general scenario of graphical interface
Source: Own elaboration

In Figure 9, the model for calculating the fluidity index is shown when no specific scenario is desired to be represented or when it is not subject to any particular situation.

The table inserted in the tab displays the results of the fluidity index calculated randomly twenty times. Additionally, two graphs can be observed: the first one shows two variables that aim to indicate the difference between the ideal value of the fluidity index and the resulting real value, while the second graph shows the distribution of the fluidity index results.

This tab also includes three knobs that function as control levers for the variables determining the fluidity index, specifically the time in hours between the links of packaging, inventory in transit, customs clearance, and distributor warehouse.

Following this, Figure 10 shows another screen of the graphical interface, where the user can analyze the previously discussed scenarios.

ISSN: 2414-8849.
RENIECYT-CONAHCYT: 1702902

Box 12

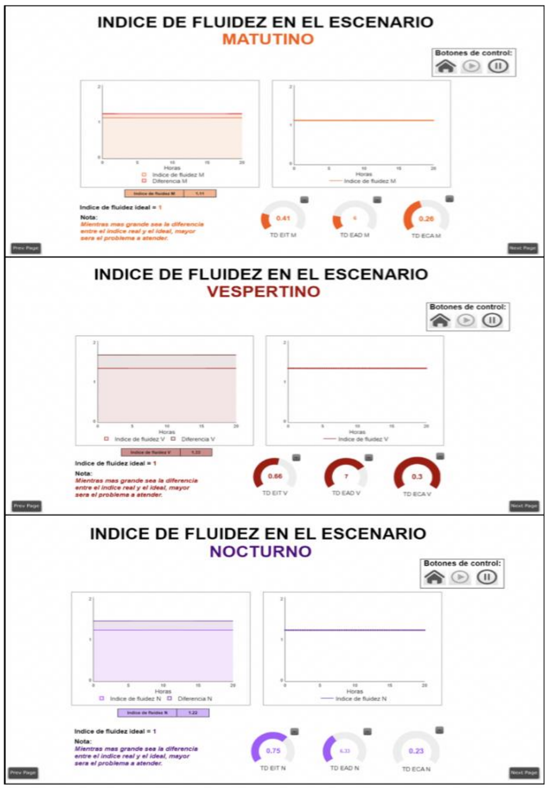


Figure 10

Graphical Interface of scenarios

Source: Own elaboration

In Figure 10, there is a screen where, for each shift under analysis, two graphs can be observed. The one on the top corresponds to the current calculated system fluidity index, while the second graph visually represents the difference between the current index and the ideal value.

This is influenced by three parameters corresponding to the time elapsed between the links, which, in this case, remain fixed since these values were obtained during the research for the morning shift.

The fluidity index given by the system should be equal to or as close as possible to the ideal; otherwise, there is an issue present. The screen also includes control buttons for managing the graphical interface.

Since only free flow is considered, the fluidity index is 100% in all cases as the programmed time is met.

In the following Figure 11, there is a screen of the graphical interface where two additional parameters were included to analyze the behavior when a series of exogenous events occur.

Box 13

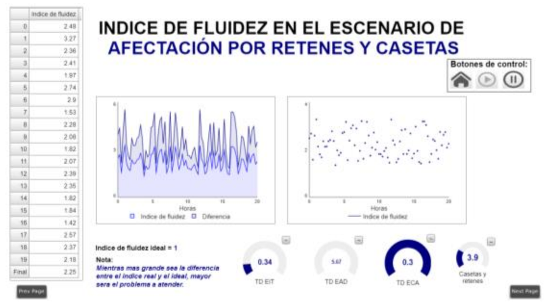


Figure 11

Graphical Interface of scenarios that present disruptions in the trip

Source: Own elaboration

In Figure 11, there is a screen of the graphical interface that includes the logic of the first model plus the inclusion of two variables: the time spent at toll booths and military or inspection checkpoints.

These have an influence when the shipment is sent for customs clearance. On the left side of the figure, there is a table with the times in minutes that it takes to cross all the stopping points along the route and, as a consequence, a significant decrease in the fluidity level measurement due to these variables.

This type of graph allows the user to observe the highest possible values of the difference between the fluidity index. It shows a decrease from 100% during free-flow conditions to 87% when considering toll booths and sanitary inspections.

- **Documentation and Continuous Improvement**

The final phase of the proposed methodology involves the documentation of the system's usage and the implementation of continuous improvement.

As mentioned earlier, this part is carried out by the model designers and the stakeholders, through the identification of areas of opportunity or the inclusion of new variables that may intervene in the future. It is always important to conduct an analysis process that allows for the updating of the model's variables and parameters, as well as the graphical interface, so that the user can access relevant information. This work should be done cyclically and repeated, as there is always room for improvement.

Conclusions

In this research project, a proposal was developed for a tool that allows the measurement of the fluidity index in the agri-food supply chain focused on the tomato export process with the objective of answering the question: How does the integration of the supply chain influence the fluidity index of the food sector?

As a result of applying the system dynamics methodology, a graphical interface was obtained for the user, allowing the analysis of different scenarios to which the fluidity index measurement is exposed and making decisions based on the index analysis. The graphical interface was developed with the help of Stella Architect software.

Analyzing the proposed scenarios of the fluidity index calculation model in the food sector supply chain, it was determined that although none of these scenarios meet an ideal fluidity index equal to one, some are close to achieving it. Conversely, others are significantly far from the ideal due to the impact of exogenous variables beyond the control of the members of this supply chain.

One recommendation arising from the scenario analysis is the use of morning hours for product shipments, as the fluidity index values are closer to the ideal, with a difference of only 11% below it.

Another recommendation is to continue studying time reduction due to the nature of the product being handled and its shelf life after harvest to maintain the quality and safety of the tomatoes.

Finally, it is also recommended to use the Stella Architect software as it allows for various types of analyses in the supply chain links that aid in decision-making.

Declarations

Conflict of interest

The authors declare that they have no conflicts of interest. They have no known competing financial interests or personal relationships that might have appeared to influence the article reported in this paper.

Authors' Contribution

Bueno-Solano Alfredo: Contributed to the project idea, research method and technique.

Acosta-Quintana Maria Paz: Contributed to developed the background and methodology

Vega-Telles Erneto A.: Contribuite to the developed of the model and its validation

Hernande- Valdez, Lizeth.: Contibuite with the field work and developed de reach.

Availability of data and materials

Research data are available at alfredo.buenos@gmail.com, as well as can be estimated using google maps databases.

Funding

The present project was financed by the program of teaching strengthening of the INSTITUTO TECNOLÓGICO DE SONORA, number PROFAPI- 2024-0562.

Acknowledgments

The researchers are grateful for the support of the Instituto Tecnológico de Sonora through the PROFAPI- 2024-0562 program. Also, the collaboration of the student Karla Angélica Rodríguez Beltrán and the National Laboratory of Transportation and Logistics Systems of CONAHCYT is gratefully acknowledged.

Referencias

[1] Roldán., P.N. (2021). Cadena de suministro. Economipedia.com recupedo el 29 de enero de 2023

[2] Bautista Santos , H., Martínes Flores , J. L., Fernandéz Lambert , G., Bernabé Loranca, M. B., Sánchez Galván, F., & Sablón Cossio, N. (2015). Modelo de integración de cadenas de suministro colaborativas. *Dyna vol. 82*, 145 - 154.

[3] USAID MEXICO. (2014). Estudio de indicadores del desempeño logístico de las cadenas de suministro en México. México: Secretaría de Economía.

[4] CamBioTec. (2018). *Sector agroalimentario en el estado de México.* Ciudad de México: FECYT

[5] Cedillo-Campos, M. (2018). El “valor Logístico” de la infraestructura. NOTAS IMT, No. 174, septiembre-octubre,

[6] Cedillo Campos, M. G., Lizarraga Lizarraga, G., & Martner Peyrelongue, C. D. (2019). Medición de la fluidez en corredores de transporte de carga intermodal. Sanfandilla: IMT.

[7] Bueno-Solano, A., Lagarda-Leyva, E.A., Miranda- Ackerman, M.A, Velarde-Cantú, J.M. & Pérez, K.G. (2022). Conceptual fluidity model for resilient agroindustry supply chains, *Production & Manufacturing Research*, 10(1), 281-293

[8] Lagarda Leyva, E. A. (2019). Introducción a la dinámica de sistemas . Ciudad de México: Pearson.

[9] Morlán Santa Catalina, I. (2010). Modelo de dinámica de sistemas para la implantación de tecnologías de la información en la gestión estratégica universitaria. Donostia: Universidad del país Vasco.

[10] Sterman, J. D. (2000). Business dynamics: systems thinking and modeling for a complex world. Boston: McGraw Hill.

[11] Phadnis, S. S., & Schoemaker, P. J. Strategic (2024) Agility in Supply Chains: A Conceptual Research Review.

[12] Luna González, L. (2004). EL DISEÑO DE INTERFAZ GRÁFICA DE USUARIO PARA PUBLICACIONES DIGITALES. *Revista digital universitaria*, 2 - 12.

ISSN: 2414-8849.
RENIECYT-CONAHCYT: 1702902

ECORFAN Journal Republic of Guatemala 10[18]1-10: e41018110

Article

Exploring the Food Quality System (SQF) in Plastic Cap Manufacturing: A Scientific and Practical Approach

Exploración del Sistema de Calidad de Alimentos (SQF) en la fabricación de tapas plásticas: enfoque científico y práctico

Campos-Villegas, Cesar Antonio *[a] & Pecina-Rivas Erika María [b]

[a] ROR Tecnológico Nacional de México - Tecnológico de Estudios Superiores de Cuautitlán Izcalli • KMX-3952-2024 • 0009-0005-2880-2245 • 2047058

[b] ROR Tecnológico Nacional de México - Tecnológico de Estudios Superiores de Cuautitlán Izcalli • KHE-1673-2024 • 0000-0001-6723-6139 • 1027569

CONAHCYT classification:

Area: Engineering
Field: Engineering
Discipline: Industrial engineer
Subdiscipline: Quality control

https://doi.org/10.35429/EJRG.2024.10.18.1.10

History of the article:
Received: August 16, 2024
Accepted: December 30, 2024

* ✉ [cesacovi94@gmail.com]

Abstract

The Food Safety Quality System. (SQF) is a critical tool for ensuring the safety and quality of food products. However, its application goes beyond the food industry. The Food Quality System (SQF) is a necessary tool to ensure the safety and quality of food products. Therefore, this study focuses on the investigation of SQF in the specific context of plastic cap manufacturing. The unique challenges faced by this sector in terms of food safety, product quality, and regulatory compliance are examined, and a practical framework for implementing SQF in plastic cap manufacturing operations is proposed, with the goal of improving product safety and customer satisfaction. It is concluded that the Food Quality System (SQF) is essential to guarantee food safety and quality in the manufacture of plastic lids, helping to mitigate contamination risks, improve processes and meet consumer expectations. However, there is variability in SQF compliance among companies, with some showing high compliance and others requiring improvements, a clear correlation between SQF compliance and product quality indicates that rigorous standards result in higher quality products and customer satisfaction; The choice of rigorous, standardized criteria to assess compliance and quality is essential. Despite the good performance in implementing the SQF, there are always opportunities for continuous improvement through the identification of critical areas and the adoption of corrective actions.

Objectives	Methodology	Conclusions
To implement the SQF in plastic caps manufacturing operations, with the aim of improving product safety and customer satisfaction.	Variables play a key role in understanding and evaluating the implementation of such a system.	Companies that implement SQF standards more rigorously tend to produce higher quality plastic closures, which translates into higher customer satisfaction.

Quality, Food, Application

Resumen

El Sistema de Calidad en seguridad de Alimentos con las siglas en ingles. (SQF) es una herramienta fundamental para garantizar la seguridad y la calidad de los productos alimenticios. Sin embargo, su aplicación va más allá de la industria alimenticia. El Sistema de Calidad de Alimentos (SQF) es una herramienta necesaria para garantizar la seguridad y la calidad de los productos alimenticios. Por lo que este estudio se centra en la investigación del SQF en el contexto específico de la fabricación de tapas plásticas. Se examinan los desafíos únicos que enfrenta este sector en términos de seguridad alimentaria, calidad del producto y cumplimiento normativo, por lo que se propone un marco práctico para implementar el SQF en las operaciones de fabricación de tapas plásticas, con el objetivo de mejorar la seguridad del producto y la satisfacción del cliente. Se concluye que el Sistema de Calidad de Alimentos (SQF) es imprescindible para garantizar la seguridad alimentaria y la calidad en la fabricación de tapas plásticas, ayudando a mitigar riesgos de contaminación, mejorar procesos y satisfacer las expectativas de los consumidores. Sin embargo, existe variabilidad en el cumplimiento del SQF entre las empresas, con algunas mostrando alto cumplimiento y otras requiriendo mejoras, una clara correlación entre el cumplimiento del SQF y la calidad del producto indica que estándares rigurosos resultan en productos de mayor calidad y satisfacción del cliente; la elección de criterios rigurosos y estandarizados para evaluar el cumplimiento y la calidad es esencial. A pesar del buen desempeño en la implementación del SQF, siempre hay oportunidades de mejora continua a través de la identificación de áreas críticas y la adopción de acciones correctivas.

Objetivos	Metodología	Conclusiones
Implementar el SQF en las operaciones de fabricación de tapas plásticas, con el mejorar la seguridad del producto y la satisfacción del cliente.	Las variables desempeñan un papel fundamental en la comprensión y evaluación de la implementación de dicho sistema.	Las empresas que implementan de manera más rigurosa los estándares SQF tienden a producir tapas plásticas de mayor calidad, lo que se traduce en una mayor satisfacción del cliente.

Calidad, alimentos, aplicación

Citation: Campos-Villegas, Cesar Antonio & Pecina-Rivas Erika María. [2024]. Exploring the Food Quality System (SQF) in Plastic Cap Manufacturing: A Scientific and Practical Approach. ECORFAN Journal Republic of Guatemala. 10[18]1-10: e41018110.

Introduction

Food safety and product quality are paramount concerns at all stages of the food supply chain; that is why in this sense, the Food Quality System (SQF) is an internationally recognized standard to ensure the integrity and safety of food; but its application beyond the food industry, As is the case with the manufacture of plastic caps, it has received less attention.

This study seeks to address this gap by investigating how SQF adapts to and benefits the manufacture of plastic caps.

Challenges in Plastic Cap Manufacturing

The manufacture of plastic lids presents unique challenges in terms of food safety and product quality, with reference to cross-contamination, chemical migration and improper handling which are just some of the potential risks that need to be addressed; additionally, government regulations and consumer expectations demand a proactive approach to ensure regulatory compliance and customer satisfaction. (González Peña, 2023).

Box 1

Figure 1

Plastic Cap Making Process

Source [Authors' own creation by Canva 2024]

Box 2

Table 1

Challenges in the production of plastic lids

Challenges in Plastic Cap Manufacturing	Preventive Measures
Cross-contamination	- Implementation of cleaning and disinfection protocols to prevent cross-contamination between materials.
Migration of chemicals	- Regular training of staff in hygiene practices and safe handling of materials and products. - Implementation of quality controls at every stage of the manufacturing process to detect and prevent improper handling.
Improper handling	- Regular training of staff in hygiene practices and safe handling of materials and products. - Implementation of quality controls at every stage of the manufacturing process to detect and prevent improper handling.
Government Regulations and Consumer Expectations	- Detailed record keeping demonstrating compliance with regulations and quality standards. - Constant monitoring of market trends and consumer demand to adapt and meet their expectations.

Source: [Authors' own creation]

During the process of producing, storing, or handling the materials used in the manufacture of the lids, there is a risk of cross-contamination with materials not suitable for food contact, because plastic materials contain additives and chemical compounds that have the potential to migrate into the food in contact with the plastic lids. which is accelerated by factors such as the temperature and acidity of food (González Peña, 2023). In addition, improper handling of plastic materials and caps can introduce physical, chemical, or biological contaminants into the final product, hence government regulations and meeting consumer expectations for product safety and quality is necessary to maintain consumer confidence and competitiveness in the industry. (Acuña Vélez, 2021)

ISSN: 2414-8849.
RENIECYT-CONAHCYT: 1702902

The role of the Food Quality System (SQF)

The Food Quality System (SQF) plays an essential role in the manufacture of plastic lids by providing a comprehensive framework to ensure product safety and quality, in this context, the SQF is presented as an internationally recognized standard that addresses the specific challenges related to food safety in this area of production.

The implementation of SQF in the manufacture of plastic caps implies the adoption of its principles and best practices, which allows companies to establish quality management systems that cover all stages of the process, from the selection of raw materials to the delivery of the final product; in this sense, SQF acts as a precise approach that seeks to ensure safety, Quality, and compliance in all areas of production. (Acuña Vélez, 2021)

One of the key aspects of SQF is the implementation of strict hygiene controls, including the implementation of proper cleaning and disinfection procedures to prevent cross-contamination and ensure product safety. (Palacios Bautista, 2014).

In addition, SQF promotes the traceability of the materials used, which means that companies must be able to trace and document the origin of each component used in the manufacturing process.

Another critical aspect of SQF is the training of personnel in safe manufacturing practices. This ensures that the work team is well prepared to handle materials safely and prevent contamination hazards. (González Peña, 2023).

Ultimately, the implementation of SQF in the manufacture of plastic caps not only ensures compliance with regulations and consumer expectations, but also improves the competitiveness of companies in the global market by promoting consumer confidence and operational efficiency (Palacios Bautista, 2014).

Box 3

Table 2

Comparison between Plastic Cap Manufacturing Challenges and Food Quality System (SQF) Preventive Measures.

Challenges in Plastic Cap Manufacturing	Preventive Measures according to SQF
Cross-contamination	Implementation of cleaning and disinfection protocols.
Migration of chemicals	Implementation of cleaning and disinfection protocols.
Improper handling	Training staff in safe manufacturing practices.
Government Regulations and Consumer Expectations	Record keeping and adapting to market trends.

Source: [Authors' own creation]

Technical Aspects of SQF's Exploration in Plastic Cap Manufacturing

From the perspective of administrative engineering, the exploration of the Food Quality System (SQF) in the manufacture of plastic lids involves a combination of technical and practical aspects to ensure efficiency and effectiveness in the implementation of quality and food safety standards. (Palacios Bautista, 2014). Here are some key technical aspects:

- **Efficient process design**: A detailed analysis of plastic cap manufacturing processes is carried out to identify opportunities for improvement and optimization, which involves the application of process engineering methods to design and develop efficient workflows that minimize contamination risks and maximize the quality of the final product.

- **Implementation of advanced technologies**: It is necessary to consider the adoption of advanced technologies in the manufacture of plastic caps to improve the accuracy, consistency, and safety of the process, which brings with it the automation of certain tasks, the use of sensors to monitor production conditions, and the implementation of in-line quality control systems (Méndez-Barrón, 2018).

ISSN: 2414-8849.
RENIECYT-CONAHCYT: 1702902

- **Resource optimization**: To do this, an analysis of the supply chain and the resources used in the manufacture of plastic lids must be carried out, with the aim of identifying areas of waste and opportunities for optimization, which includes the application of value engineering techniques to reduce costs, improve energy efficiency and minimize the use of raw materials. (Méndez-Barrón, 2018).

- **Quality Management and Regulatory Compliance**: The establishment of quality management systems based on the SQF to ensure compliance with food safety regulations and standards, including the implementation of quality control procedures, the conduct of internal and external audits, and the management of records and documentation, is a priority.

- **Risk Analysis and Decision Making**: Risk analysis techniques are not to be forgotten to identify, assess, and mitigate the risks associated with the manufacture of plastic caps, which involves conducting root cause analysis, risk analysis, and critical control points (HACCP), and implementing preventive and corrective measures based on scientific data and analysis.

That is why, from the perspective of administrative engineering, the exploration of SQF in the manufacture of plastic caps focuses on process optimization, the implementation of advanced technologies, efficient resource management, and quality assurance and regulatory compliance (González Peña, 2023).

This allows companies to improve their operational performance, reduce risks, and ensure the safety and quality of the final product (Méndez-Barrón, 2018).

Box 4

Table 3

Technical aspects of the exploration of the Food Quality System (SQF) in the manufacture of plastic lids.

Aspect	Strategies
Efficient Process Design	Process Analysis Workflow Design.
Implementation of Advanced Technologies	Task automation. Use of sensors for monitoring. Inline Quality Control Systems.
Resource optimization	Supply chain analysis. Reduced costs and waste. Improved energy efficiency.
Quality management and regulatory compliance	Implementation of quality control procedures. Conducting internal and external audits. Records and documentation management.
Risk Analysis and Decision Making	Risk Identification and Assessment Application of Risk Analysis Techniques. Implementation of preventive and corrective measures.

Source: [Authors' own creation]

The application of SQF in the context of plastic cap manufacturing

The principles and standards of the Food Quality System (SQF) and their specific adaptation to the context of the manufacture of plastic lids are elements that must be properly understood and harmonized, the SQF is a comprehensive quality management and food safety system internationally recognized that is based on the identification, evaluation, and control of risks to ensure the integrity of food products (Gambaudo, 2014). In the context of plastic cap manufacturing, the application of SQF involves the consideration of the following key elements:

1. **Quality Management and Food Safety:** The SQF provides a structured framework for establishing quality management systems spanning from raw material to final product in the manufacture of plastic lids, including the implementation of preventive controls to ensure food safety and product quality, as well as the training of personnel in safe manufacturing practices (Bravo, et al., 2021).

ISSN: 2414-8849.
RENIECYT-CONAHCYT: 1702902

2. **Regulatory Compliance:** SQF helps companies comply with government regulations and food safety regulations applicable to plastic lid manufacturing, along with that comes accurate record keeping and adapting to ever-evolving market trends to ensure regulatory compliance and customer satisfaction (Gambaudo, 2014).

3. **Risk-based approach:** SQF is based on a risk management approach to identify, assess, and control the risks associated with the manufacture of plastic caps, considering the performance of comprehensive risk assessments at all stages of the manufacturing process and the implementation of preventive controls to mitigate the identified risks (Huerta-Dueñas, 2018).

Hence, the application of the Food Quality System (SQF) in the manufacture of plastic lids highlights the importance of ensuring food safety, product quality and regulatory compliance in this specific sector (Bravo, et al., 2021).

Box 5

Table 4

Application of SQF in the Manufacture of Plastic Caps

Aspect	Strategies
Quality Management & Food Safety	The SQF provides a structured framework for establishing quality management systems from raw material to final product in the manufacture of plastic caps, including the implementation of preventive controls to ensure food and product safety, as well as the training of the Personnel in Safe Manufacturing Practices.
Compliance	SQF helps companies meet the government regulations and Food Safety Applicable to Manufacturing of plastic caps, including maintenance accurate records and adaptation to the to ensure regulatory compliance and Customer Satisfaction.
Risk-based approach	SQF is based on a risk management approach. to identify, assess, and control the risks associated with the manufacture of plastic caps, in addition to conducting. Comprehensive risks at all stages of the process and the implementation of controls preventive measures to mitigate identified risks.

Specific SQF standard requirements for the plastic cap industry

The Food Quality System (SQF) is an internationally recognized standard designed to ensure food safety and product quality throughout the food supply chain. (Méndez-Barrón, 2018). Although originally developed for the food industry, its application has been extended to related sectors, such as the manufacture of plastic lids, which are in direct contact with food products. (Huerta-Dueñas, 2018).

Below are the specific requirements of the SQF standard applicable to the plastic cap industry, covering aspects such as food safety, product quality, hygiene, sanitation, and more.

Food safety

- **Risk Assessment and Hazard Analysis:** The implementation of SQF requires a comprehensive risk assessment and hazard analysis (HACCP) specific to the manufacture of plastic lids, which must identify all potential contamination points that may compromise food safety, such as chemical, physical, and biological contaminants; for which preventive measures and critical controls must be established to mitigate these risks. (Méndez-Barrón, 2018).

- **Raw material control:** Raw materials used in the manufacture of plastic lids, such as resins and additives, must meet food safety standards. It is essential that suppliers are evaluated and approved through audits that verify their compliance with SQF requirements. (Huerta-Dueñas, 2018). In addition, receiving and storage procedures must be implemented to ensure the integrity of raw materials.

- **Traceability:** Traceability is a necessary component of the SQF standard. Each batch of plastic caps must be traceable from the raw material to the final product, which entails a documentation and registration system that allows any batch of products to be traced in the event that a food safety issue is detected, facilitating quick and efficient recalls. (Bravo, et al., 2021).

ISSN: 2414-8849.
RENIECYT-CONAHCYT: 1702902

Campos-Villegas, Cesar Antonio & Pecina-Rivas Erika María. [2024]. Exploring the Food Quality System (SQF) in Plastic Cap Manufacturing: A Scientific and Practical Approach. ECORFAN Journal Republic of Guatemala. 10[18]1-10: e41018110.
https://doi.org/10.35429/EJRG.2024.10.18.1.10

Product Quality

- **Product Specifications:** Plastic lids must comply with detailed technical specifications that ensure their suitability for their intended use, especially when in contact with food, which must include precise dimensions, strength, tolerances, and compatibility with the food packaging that will use these lids.

- **Quality testing:** Quality testing should be performed on each production batch to ensure that plastic caps meet set specifications. These tests contain physical and chemical analyses, strength and durability tests, and compatibility tests with specific food products. (Huerta-Dueñas, 2018). The results of these tests should be documented and maintained as quality records.

- The SQF standard requires companies to conduct regular internal audits to assess the effectiveness of their quality management systems. (Bravo, et al., 2021). These audits should review all aspects of the manufacturing process, from the receipt of raw materials to the shipment of the final product, ensuring that quality requirements are met.

Hygiene and sanitation

1. **Cleaning and disinfecting programs:** Hygiene and sanitation are essential to the manufacture of food-safe plastic lids. Detailed cleaning and disinfection programs should be developed and maintained for all areas of production, storage, and handling; specifying the methods, frequencies and cleaning agents used. (Bravo, et al., 2021).

2. **Pest Control:** Pest control is a critical requirement for maintaining a hygienic production environment. Pest control programs should be implemented that include regular inspections, traps, and preventative measures to minimize the risk of infestations. (González Peña, 2023). In addition, all pest control-related activities need to be documented.

3. **Good Manufacturing Practices (GMP):** GMPs are essential to ensure hygiene and safety in the manufacture of plastic lids, which requires the use of appropriate equipment and utensils, the maintenance of clean and tidy facilities, and the continuous training of personnel in hygienic and food safety practices. (González Peña, 2023).

Quality System Management

1. **Documentation and Records:** The SQF standard requires extensive documentation of all procedures and activities related to food safety and product quality, including procedure manuals, production records, audit reports, and traceability documents. (González Peña, 2023). Proper management of this documentation is essential for the effective implementation and maintenance of the SQF system.

2. **Staff training: Staff** training is a key component of the SQF standard. All employees should receive ongoing training on food safety, product quality, hygiene, and sanitation issues, so training should be documented and updated regularly to reflect changes in procedures or regulatory requirements (Huerta-Dueñas, 2018).

3. **Communication and accountability:** Effective communication and clear assignment of responsibilities are critical to the management of the SQF system, all levels of the organization must be informed about food safety and quality objectives and procedures, clear communication channels must be established to report problems and take corrective actions. (Bravo, et al., 2021).

Continuous review and improvement

1. **Management Reviews:** Management reviews are a requirement of the SQF standard to evaluate the effectiveness of the food safety and quality system, which must be conducted by senior management and must include evaluation of audit results, food safety incidents, and the overall performance of the SQF system. (Huerta-Dueñas, 2018).

ISSN: 2414-8849.
RENIECYT-CONAHCYT: 1702902

2. **Corrective and preventive actions:** Procedures must be established for the identification and correction of non-conformities, corrective actions must be implemented in a timely manner and properly documented. In addition, preventive measures must be taken to prevent the recurrence of problems. (González Peña, 2023).

3. **Innovation and technological improvements**: The plastic lid industry must be open to innovation and the adoption of new technologies that improve food safety and product quality, including the implementation of real-time monitoring technologies, process automation, and the use of advanced materials that reduce the risk of contamination. (González Peña, 2023).

Implementing the SQF standard in plastic lid manufacturing requires a comprehensive approach that encompasses food safety, product quality, hygiene and sanitation, quality system management, and continuous improvement, so meeting these requirements not only ensures compliance with international regulations, it also improves customer confidence and competitiveness in the market. (Bravo, et al., 2021).

Companies that adopt and maintain these rigorous standards are sure to succeed in producing plastic caps that meet the highest levels of safety and quality, thus ensuring consumer protection and long-term success in the industry. (Huerta-Dueñas, 2018).

Box 6

Table 5

SQF Standard Requirements for Plastic Caps

Criteria	Requirements
Food safety	- Risk Assessment & Hazard Analysis - Raw material control - Traceability
Product Quality	- Product Specifications - Quality Testing - Internal Audits
Hygiene and sanitation	- Cleaning & Disinfection Programs - Pest Control - Good Manufacturing Practices (GMP)
Quality System Management	- Product Specifications - Quality Testing - Internal Audits
Continuous Improvement Review	- Management Reviews - Corrective and Preventive Actions - Innovation and technological improvements

Methodology

In the context of the research methodology of the SQF System in the manufacture of plastic lids, the variables are key in the understanding and evaluation of the implementation of this system.

Variables in SQF System Research

In this study, the variables are of different types and represent different aspects related to the implementation of the Food Quality System (SQF) in the manufacture of plastic lids, some of these variables are:

Independent variables:

1. Type of company: Medium
2. Geographic location: Cuautitlan Izcalli, Mexico.
3. Experience in implementing SQF: (New implementations versus companies with previous experience.)

Dependent Variables:

4. SQF Compliance Level: Measured through internal and external audits.
5. Product quality: Evaluated using specific quality and food safety criteria.
6. Customer satisfaction: Based on customers' perception and feedback on the quality and safety of plastic caps.

Importance of comparing the criteria used

Comparing the criteria used in this study is essential for several reasons:

1. **Validity of the conclusions:** Comparing the criteria used in different companies ensures that the conclusions of the study are valid and generalizable. If each company uses different criteria to assess SQF compliance or product quality, comparisons between them will be difficult and conclusions may be questionable.

2. **Reliability of measurements:** Using comparable criteria ensures the reliability of the measurements made. If the criteria used are consistent and standardized, the measurements are more likely to be accurate and reliable, increasing the credibility of the study results.

3. **Identification of best practices:** Comparing the criteria used in different companies allows you to identify best practices in the implementation of SQF and the manufacture of plastic caps.

By knowing which criteria lead to better results in terms of SQF compliance and product quality, companies learn from each other and improve their own practices.

Research results of the SQF system in the manufacture of plastic caps for company Bericap Mexico

1. SQF Compliance Level:

The Bericap Mexico Company achieves an SQF compliance level of 96% internal audit, which indicates a solid commitment to the quality and food safety standards established by the SQF.

The level of compliance of the Food Quality System (SQF) of the Bericap Mexico Company is compared with the standards and requirements established by the SQF itself, as well as with the levels of compliance of other similar companies in the industry, in a recertification audit 99% was obtained in this area.

Box 7

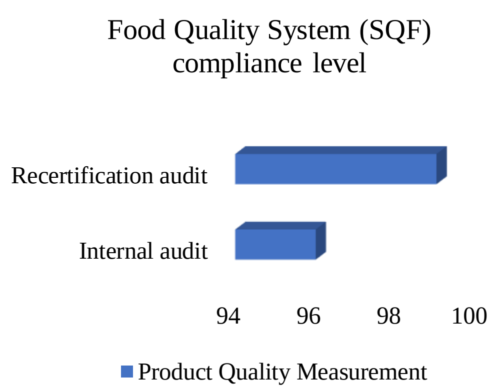


Figure 2
Food Quality System (SQF) compliance level

2. Product Quality:

95% of the plastic caps manufactured by Company Bericap Mexico meet the established quality standards, highlighting its focus on producing high-quality and safe products.

The percentage of plastic lids manufactured by Company Bericap Mexico that meet the established quality standards is compared with the quality criteria defined by the company and the customer's expectations.

Box 8

Figure 3
Product Quality

3. Customer Satisfaction:

1. 90% of Company Bericap Mexico 's customers are satisfied with the quality and safety of the plastic caps, reflecting the customer's trust and satisfaction in the company's products.

2. Company Bericap Mexico's level of customer satisfaction with the quality and safety of plastic caps is compared to customer expectations, as well as customer satisfaction levels of other companies in the same industry.

4. Comparison of criteria used:

1. Company Bericap Mexico uses rigorous and consistent criteria to assess SQF compliance and product quality, which correlates with its high levels of SQF compliance and customer satisfaction.

The rigor and consistency of the criteria used by Company Bericap Mexico to assess SQF compliance and product quality with the standards and guidelines set forth by the SQF and with the practices of other companies in the industry is compared.

Data collection

The data presented here were obtained from internal audits and pre-certification.

ISSN: 2414-8849.
RENIECYT-CONAHCYT: 1702902

Conclusions

After the investigation of the Food Quality System (SQF) in the manufacture of plastic lids, the following conclusions have been obtained:

1. **Importance of SQF in the Plastic Cap Industry:**

SQF is instrumental in ensuring food safety and product quality in the manufacture of plastic lids. Its effective implementation helps mitigate contamination risks, improve processes, and meet consumer expectations.

2. **Variety in SQF compliance:**

Variability in the levels of compliance with the SQF is observed among the companies studied. While some companies show a high degree of compliance, others have areas for improvement that require immediate attention and action.

3. **Relationship between SQF compliance and product quality:**

There is a clear correlation between the level of SQF compliance and product quality. Companies that more rigorously implement SQF standards tend to produce higher-quality plastic caps, which translates to higher customer satisfaction.

4. **Importance of the criteria used:**

The choice and application of rigorous and consistent criteria to assess SQF compliance and product quality are critical. Companies that use clear and standardized criteria tend to achieve stronger and more consistent results in terms of food safety and product quality.

5. **Opportunities for continuous improvement:**

While good performance has been demonstrated in the implementation of SQF, there are always opportunities for improvement.

Identifying areas for improvement and implementing corrective actions are necessary to strengthen food safety and improve product quality.

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Author contribution

Campos-Villegas, Cesar Antonio: Main idea of the research, design, development and implementation of the SQF.

Pecina-Rivas, Erika María: Monitoring, control and evaluation of the Quality system.

Availability of data and materials

The data was collected directly from sources provided by the company.

Funding

This research work, called an article, received financial support in two parts for its publication, the first from the Tecnológico Nacional de México campus Tecnológico de Estudios Superiores de Cuautitlán Izcalli, the second from the author and co-author.

Acknowledgements

The Tecnologico de Estudios Superiores de Cuautitlán Izcalli is thanked for the general support they provide to students committed to their mission in the context of research.

Abbreviations

GMP	Good Manufacturing Practices
HACCP	Hazard Analysis and Critical Control Points.
SQF	The Food Safety Quality System
TECNM	Tecnologico Nacional de Mexico
TESCI	Tecnológico de Estudios Superiores de Cuautitlan Izcalli

References

Acuña Vélez, L. L. (2021). *Diseño de sistema de gestión para la aprobación y seguimiento a proveedores bajo estándares de la norma mundial de seguridad alimentaria BRC V8 en la empresa Ideal, ubicada en Montecristi* (Doctoral dissertation).

Campos-Villegas, Cesar Antonio & Pecina-Rivas Erika María. [2024]. Exploring the Food Quality System (SQF) in Plastic Cap Manufacturing: A Scientific and Practical Approach. ECORFAN Journal Republic of Guatemala. 10[18]1-10: e41018110.
https://doi.org/10.35429/EJRG.2024.10.18.1.10

Bravo, V. P. B., Espinosa, W. E. C., & Romero, H. B. (2021). Gestión de la calidad alimentaria. *Journal of Science and Research*, *6*(4), 190-214. Gestión de la calidad alimentaria | Journal of Science and Research (utb.edu.ec)

Gambaudo, S. (2014). *Diseño, implementación y certificación de sistema de gestión de inocuidad alimentaria en planta de alimentos balanceados para la nutrición animal* (Doctoral dissertation, Universidad Catolica de Cordoba (Argentina)). Diseño, Implementación y Certificación de Sistema de Gestión de Inocuidad Alimentaria en Planta de Alimentos Balanceados para la Nutrición Animal – ProQuest

Gonzalez Peña, E. (2023). Tecnología para producción de tapas plásticas en Ingrup.Galileo DSpace: "Tecnología para producción de tapas plásticas en Ingrup"

Huerta-Dueñas, Michaelene, & Sandoval-Godoy, S. Alfonso. (2018). Sistemas de calidad como estrategia de ventaja competitiva en la agroindustria alimentaria. *Agricultura, sociedad y desarrollo*, *15*(1), 19-28. Recuperado de

Méndez-Barrón, Rosana. (2021). Inocuidad, normatividad y calidad como estrategia competitiva: experiencias en el sector porcícola de México y Sonora. *Estudios sociales. Revista de alimentación contemporánea y desarrollo regional*, *31*(58), e211155. Epub 22 de agosto de 2022.

Palacios Bautista, E. (2014). *La certificación de la calidad del producto, una alternativa de competitividad y negociación para el sector agroalimentario* (Master's thesis). La certificación de la calidad del producto, una alternativa de competitividad y negociación para el sector agroalimentario (colpos.mx)

Article

[[Title in TNRoman and Bold No. 14 in English and Spanish]

Surname, Name 1st Author*[a], Surname, Name 1st Co-author[b], Surname, Name 2nd Co-author[c] and Surname, Name 3rd Co-author[d] [No.12 TNRoman]

[a] Affiliation institution, Researcher ID, ORC ID, SNI-CONAHCYT ID or CVU PNPC [No.10 TNRoman]
[b] Affiliation institution, Researcher ID, ORC ID, SNI-CONAHCYT ID or CVU PNPC [No.10 TNRoman]
[c] Affiliation institution, Researcher ID, ORC ID, SNI-CONAHCYT ID or CVU PNPC [No.10 TNRoman]
[d] Affiliation institution, Researcher ID, ORC ID, SNI-CONAHCYT ID or CVU PNPC [No.10 TNRoman]

All ROR-Clarivate-ORCID and CONAHCYT profiles must be hyperlinked to your website.
Prot- University of South Australia • 7038-2013• 0000-0001-6442-4409 • 416112

CONAHCYT classification:
https://marvid.org/research_areas.php [No.10 TNRoman]
Area:
Field:
Discipline:
Subdiscipline:

DOI: https://doi.org/
Article History:
Received: [Use Only ECORFAN]
Accepted: [Use Only ECORFAN]
Contact e-mail address:
* ✉ [example@example.org]

Abstract [In English]
Must contain up to 150 words
Graphical abstract [In English]

Authors must provide an original image that clearly represents the article described in the article. Graphical abstracts should be submitted as a separate file. Please note that, as well as each article must be unique. File type: the file types are MS Office files.No additional text, outline or synopsis should be included. Any text or captions must be part of the image file. Do not use unnecessary white space or a "graphic abstract" header within the image file.

Keywords [In English]
Indicate 3 keywords in TNRoman and Bold No. 10

Abstract [In Spanish]
Must contain up to 150 words
Graphical abstract [In Spanish]

Authors must provide an original image that clearly represents the article described in the article. Graphical abstracts should be submitted as a separate file. Please note that, as well as each article must be unique. File type: the file types are MS Office files.No additional text, outline or synopsis should be included. Any text or captions must be part of the image file. Do not use unnecessary white space or a "graphic abstract" header within the image file.

Keywords [In Spanish]
Indicate 3 keywords in TNRoman and Bold No. 10

Citation: Surname, Name 1st Author, Surname, Name 1st Co-author, Surname, Name 2nd Co-author and Surname, Name 3rd Co-author. Article Title. ECORFAN Journal-Republic of Guatemala. Year. V-N: Pages [TN Roman No.10].

Introduction

Text in TNRoman No.12, single space.

General explanation of the subject and explain why it is important.

What is your added value with respect to other techniques?

Clearly focus each of its features.

Clearly explain the problem to be solved and the central hypothesis.

Explanation of sections Article.

Development of headings and subheadings of the article with subsequent numbers

[Title No.12 in TNRoman, single spaced and bold]

Products in development No.12 TNRoman, single spaced.

Including figures and tables-Editable

In the article content any table and figure should be editable formats that can change size, type and number of letter, for the purposes of edition, these must be high quality, not pixelated and should be noticeable even reducing image scale.

[Indicating the title at the bottom with No.10 and Times New Roman Bold]

Box

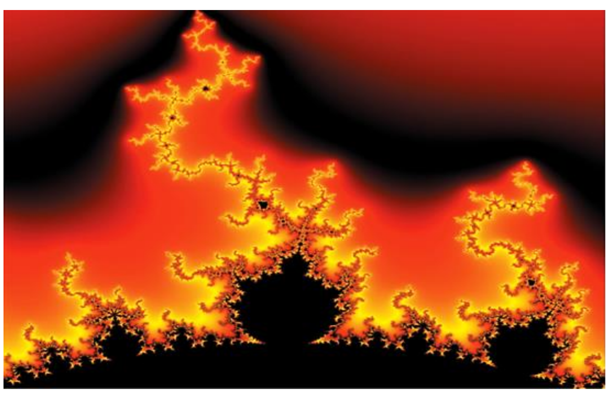


Figure 1
Title [Should not be images-everything must be editable]
Source [in italic]

Box
Table 1
Title [Should not be images-everything must be editable]

Source [in italic]

<u>The maximum number of Boxes is 10 items</u>

For the use of equations, noted as follows:

$$Y_{ij} = \alpha + \sum_{h=1}^{r} \beta_h X_{hij} + u_j + e_{ij} \qquad [1]$$

Must be editable and number aligned on the right side.

Methodology

Develop give the meaning of the variables in linear writing and important is the comparison of the used criteria.

Results

The results shall be by section of the article.

Conclusions

Clearly explain the results and possibilities of improvement.

Annexes

Tables and adequate sources.

<u>The international standard is 7 pages minimum and 14 pages maximum.</u>

Declarations

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

ISSN: 2414-8849
RENIECYT-CONAHCYT: 1702902

Author contribution

Specify the contribution of each researcher in each of the points developed in this research.

Prot-
Benoit-Pauleter, Gerard: Contributed to the project idea, research method and technique.

Availability of data and materials

Indicate the availability of the data obtained in this research.

Funding

Indicate if the research received some financing.

Acknowledgements

Indicate if they were financed by any institution, University or company.

Abbreviations

List abbreviations in alphabetical order.

Prot-
ANN Artificial Neural Network

References

Use APA system. Should not be numbered, nor with bullets, however if necessary numbering will be because reference or mention is made somewhere in the Article.

Use the Roman alphabet, all references you have used should be in Roman alphabet, even if you have cited an article, book in any of the official languages of the United Nations [English, French, German, Chinese, Russian, Portuguese, Italian, Spanish, Arabic], you should write the reference in Roman alphabet and not in any of the official languages.

Citations are classified the following categories:

Antecedents. The citation is due to previously published research and orients the citing document within a particular scholarly area.

Basics. The citation is intended to report data sets, methods, concepts and ideas on which the authors of the citing document base their work.

Supports. The citing article reports similar results. It may also refer to similarities in methodology or, in some cases, to the reproduction of results.

Differences. The citing document reports by means of a citation that it has obtained different results to those obtained in the cited document. This may also refer to differences in methodology or differences in sample sizes that affect the results.

Discussions. The citing article cites another study because it is providing a more detailed discussion of the subject matter.

The URL of the resource is activated in the DOI or in the title of the resource.

Prot-
Mandelbrot, B. B. [2020]. Negative dimensions and Hölders, multifractals and their Hölder spectra, and the role of lateral preasymptotics in science. Journal of Fourier Analysis and Applications Special. 409-432.

Intellectual Property Requirements for editing:

- Authentic Signature in Color of Originality Format Author and Coauthors.
- Authentic Signature in Color of the Acceptance Format of Author and Coauthors.
- Authentic Signature in blue color of the Conflict of Interest Format of Author and Co-authors.

Reservation to Editorial Policy

ECORFAN Journal Republic of Guatemala reserves the right to make editorial changes required to adapt the Articles to the Editorial Policy of the Journal. Once the Article is accepted in its final version, the Journal will send the author the proofs for review. ECORFAN® will only accept the correction of errata and errors or omissions arising from the editing process of the Journal, reserving in full the copyrights and content dissemination. No deletions, substitutions or additions that alter the formation of the Article will be accepted.

Code of Ethics - Good Practices and Declaration of Solution to Editorial Conflicts

Declaration of Originality and unpublished character of the Article, of Authors, on the obtaining of data and interpretation of results, Acknowledgments, Conflict of interests, Assignment of rights and Distribution.

The ECORFAN-Mexico, S.C Management claims to Authors of Articles that its content must be original, unpublished and of Scientific, Technological and Innovation content to be submitted for evaluation.

The Authors signing the Article must be the same that have contributed to its conception, realization and development, as well as obtaining the data, interpreting the results, drafting and reviewing it. The Corresponding Author of the proposed Article will request the form that follows.

Article title:

– The sending of an Article to ECORFAN Journal Republic of Guatemala emanates the commitment of the author not to submit it simultaneously to the consideration of other series publications for it must complement the Format of Originality for its Article, unless it is rejected by the Arbitration Committee, it may be withdrawn.

– None of the data presented in this article has been plagiarized or invented. The original data are clearly distinguished from those already published. And it is known of the test in PLAGSCAN if a level of plagiarism is detected Positive will not proceed to arbitrate.

– References are cited on which the information contained in the Article is based, as well as theories and data from other previously published Articles.

– The authors sign the Format of Authorization for their Article to be disseminated by means that ECORFAN-Mexico, S.C. In its Republic of Guatemala considers pertinent for disclosure and diffusion of its Article its Rights of Work.

– Consent has been obtained from those who have contributed unpublished data obtained through verbal or written communication, and such communication and Authorship are adequately identified.

– The Author and Co-Authors who sign this work have participated in its planning, design and execution, as well as in the interpretation of the results. They also critically reviewed the paper, approved its final version and agreed with its publication.

– No signature responsible for the work has been omitted and the criteria of Scientific Authorization are satisfied.

– The results of this Article have been interpreted objectively. Any results contrary to the point of view of those who sign are exposed and discussed in the Article.

Copyright and Access

The publication of this Article supposes the transfer of the copyright to ECORFAN-Mexico, SC in its Holding Mexico for its ECORFAN Journal Republic of Guatemala, which reserves the right to distribute on the Web the published version of the Article and the making available of the Article in This format supposes for its Authors the fulfilment of what is established in the Law of Science and Technology of the United Mexican States, regarding the obligation to allow access to the results of Scientific Research.

Article Title:

Name and Surnames of the Contact Author and the Co-authors	Signature
1.	
2.	
3.	
4.	

Principles of Ethics and Declaration of Solution to Editorial Conflicts

Editor Responsibilities

The Publisher undertakes to guarantee the confidentiality of the evaluation process, it may not disclose to the Arbitrators the identity of the Authors, nor may it reveal the identity of the Arbitrators at any time.

The Editor assumes the responsibility to properly inform the Author of the stage of the editorial process in which the text is sent, as well as the resolutions of Double-Blind Review.

The Editor should evaluate manuscripts and their intellectual content without distinction of race, gender, sexual orientation, religious beliefs, ethnicity, nationality, or the political philosophy of the Authors.

The Editor and his editing team of ECORFAN® Holdings will not disclose any information about Articles submitted to anyone other than the corresponding Author.

The Editor should make fair and impartial decisions and ensure a fair Double-Blind Review.

Responsibilities of the Editorial Board

The description of the peer review processes is made known by the Editorial Board in order that the Authors know what the evaluation criteria are and will always be willing to justify any controversy in the evaluation process. In case of Plagiarism Detection to the Article the Committee notifies the Authors for Violation to the Right of Scientific, Technological and Innovation Authorization.

Responsibilities of the Arbitration Committee

The Arbitrators undertake to notify about any unethical conduct by the Authors and to indicate all the information that may be reason to reject the publication of the Articles. In addition, they must undertake to keep confidential information related to the Articles they evaluate.

Any manuscript received for your arbitration must be treated as confidential, should not be displayed or discussed with other experts, except with the permission of the Editor.

The Arbitrators must be conducted objectively, any personal criticism of the Author is inappropriate.

The Arbitrators must express their points of view with clarity and with valid arguments that contribute to the Scientific, Technological and Innovation of the Author.

The Arbitrators should not evaluate manuscripts in which they have conflicts of interest and have been notified to the Editor before submitting the Article for Double-Blind Review.

Responsibilities of the Authors

Authors must guarantee that their articles are the product of their original work and that the data has been obtained ethically.

Authors must ensure that they have not been previously published or that they are not considered in another serial publication.

Authors must strictly follow the rules for the publication of Defined Articles by the Editorial Board.

The authors have requested that the text in all its forms be an unethical editorial behavior and is unacceptable, consequently, any manuscript that incurs in plagiarism is eliminated and not considered for publication.

Authors should cite publications that have been influential in the nature of the Article submitted to arbitration.

Information services

Indexation - Bases and Repositories

RESEARCH GATE (Germany)
GOOGLE SCHOLAR (Citation indices-Google)
REDIB (Ibero-American Network of Innovation and Scientific Knowledge- CSIC)
MENDELEY (Bibliographic References Manager)-ROAD (Directory of Open Access scholarly Resources)-REBUIN (Network of Spanish University and Scientific Libraries)-SUDOC (University Documentation System, France)

Publishing Services:

Citation and Index Identification H.
Management of Originality Format and Authorization.
Testing Article with PLAGSCAN.
Article Evaluation.
Certificate of Double-Blind Review.
Article Edition.
Web layout.
Indexing and Repository
ArticleTranslation.
Article Publication.
Certificate of Article.
Service Billing.

Editorial Policy and Management

16 Kilometro, American Highway, House Terra Alta, D7 Mixco Zona 1-Guatemala. Phones: +52 1 55 6159 2296, +52 1 55 1260 0355, +52 1 55 6034 9181; Email: contact@ecorfan.org www.ecorfan.org

Site Licences

03-2010-032610094200-01-For printed material ,03-2010-031613323600-01-For Electronic material,03-2010-032610105200-01-For Photographic material,03-2010-032610115700-14-For the facts Compilation,04-2010-031613323600-01-For its Web page,19502-For the Iberoamerican and Caribbean Indexation,20-281 HB9-For its indexation in Latin-American in Social Sciences and Humanities,671-For its indexing in Electronic Scientific Journals Spanish and Latin-America,7045008-For its divulgation and edition in the Ministry of Education and Culture-Spain,25409-For its repository in the Biblioteca Universitaria-Madrid,16258-For its indexing in the Dialnet,20589-For its indexing in the edited Journals in the countries of Iberian-America and the Caribbean, 15048-For the international registration of Congress and Colloquiums. financingprograms@ecorfan.org

Management Offices

16 Kilometro, American Highway, House Terra Alta, D7 Mixco Zona 1 - Guatemala.

ECORFAN Journal-Republic of Guatemala

2414 8849
ISSN 2414 - 8849