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TEMPERATURA AMBIENTE E SEUS EFEITOS NA COMPETITIVIDADE DA INDÚSTRIA DE EMBALAGENS

Santa Cruz do Sul

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LISTA DE ABREVIATURAS

ABIEF	Associação Brasileira da Indústria de Embalagens Plásticas Flexíveis
ABRE	Associação Brasileira de Embalagens
AG	Aquecimento Global
BI	Business Intelligence
CAT	Comunicado de Acidente de Trabalho
CLT	Consolidação das Leis de Trabalho
CNI	Confederação Nacional da Indústria
DT	Delta de Temperatura
ERP	Enterprise Resource Planning
ESG	Environment Social and Governance
ESI	Environmental Stress Index
ET	Enviromental Temperature
ISCP	Global Inclusive and Sustainable Competitive Industrial Performance
KPI	key performance indicator
LM	Lean Manufacture
LSS	Lean Six Sigma
ILO	International Labour Organization
INMET	Instituto Nacional de Meteorologia
ISCP	Global Inclusive and Sustainable Competitive Industrial Performance
OEE	Overall Equipment Effectiveness

ODS	Objetivos de Desenvolvimento Sustentável
PAS	Práticas Ambientais Sustentáveis
PCP	Planejamento e Controle de Produção
PIB	Produto interno bruto
SGQ	Sistema de Gestão da Qualidade
RR	Risco Relativo
RSL	Revisão Sistemática da Literatura
SSO	Saúde e Segurança Ocupacional
TA	Temperatura Ambiente
TAF	Temperatura Ambiente Fabril
TD	Temperature Delta
WBGT	Went-Bulb Globe Temperature

SUMÁRIO

Resumo

Diversos fatores afetam a cadeia global de suprimentos, afetando pessoas e organizações, comprometendo a produtividade e a competitividade. Neste contexto a temperatura ambiente pode ter relações com a perda de competitividade. Com base nesse pressuposto foi definido o objetivo geral que é analisar a influência da temperatura ambiente e seus impactos na Competitividade das Indústrias de Embalagens Flexíveis e os objetivos específicos, que são: Relacionar o histórico de registros climáticos com histórico de indicadores, relacionar os níveis de temperatura interna e externa projetando os níveis de temperatura dos períodos históricos, gerar subsídios para a mitigação de riscos oriundos da temperatura ambiente e avaliar a temperatura ambiente como uma variável que influencia a competitividade. Através de uma Revisão Sistemática da Literatura, utilizado o protocolo *Preferred ReportingItems for Systematic Reviews and Meta-Analyses*, foram identificados os conhecimentos existentes sobre o tema, que por sua vez evidenciaram o papel central do ser Humano como um elemento de produtividade industrial. Posterior a revisão sistemática da literatura, foi estruturado um Estudo de Caso em Indústria de Embalagens Flexíveis. Utilizando uma abordagem e modelagem do pensamento sistêmico, os *key performance indicator* foram selecionados. A leitura de *Went-BulbGlobe Temperature* seguiu de acordo com as determinações legais do Ministério Do Trabalho e Emprego. As análises de correlação foram feitas mediante a equação de Pearson. Os resultados mostraram que a temperatura no ambiente de trabalho se eleva em média 4,21 °C em relação à temperatura registrada na estação meteorológica, 52,17% dos acidentes de trabalho ocorreram em faixas de temperatura não recomendadas pela *International Labour Standards*, 73,27% das mercadorias devolvidas foram produzidos com temperatura ambiente acima de 27 °C. O indicador % Devoluções apresenta correlação de Pearson forte positiva (0,8901). O indicador *Performance* OEE apresenta uma correlação de Pearson forte negativa (-0,8404) para a máquina N° 1. Os resultados evidenciam que a temperatura ambiente influencia na competitividade da indústria de embalagens flexíveis, imputando perda de *performance* dos seus *key performance indicator* e aumento dos riscos de acidentes no ambiente de trabalho. Estes resultados respondem as indagações da pesquisa, evidenciando o papel central do ser Humano na competitividade e que a Temperatura Ambiente TA influência na competitividade das organizações industriais.

Palavras-chave: Competitividade, temperatura ambiente, perdas industriais, ambiente de trabalho, indústria de embalagens, impacto.

Abstract

Several factors affect the global supply chain, affecting people and organizations, compromising productivity and competitiveness. In this context, enviromental temperature can be related to the loss of competitiveness. Based on this assumption, the general objective was defined, which is to analyze the influence of ambient temperature and its impacts on the competitiveness of Flexible Packaging Industries, and the specific objectives, which are: To relate the history of climate records with the history of indicators, to relate the levels of internal and external temperature by projecting the temperature levels of historical periods, to generate subsidies for the mitigation of risks arising from environment temperature and to confirm environment temperature as a variable that reduces competitiveness. Through a Systematic Review of the Literature, using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses protocol, the existing knowledge on the subject was identified, which in turn highlighted the central role of the Human Being as an element of industrial productivity. After the systematic review of the literature, a Case Study in the Flexible Packaging Industry was structured. Using a system thinking approach and modeling, the key performance indicators were selected. The Went-Bulb Globe Temperature reading followed the legal determinations of the MINISTÉRIO DO TRABALHO E EMPREGO. The correlation analyses were performed using the Pearson equation. The temperature in the work environment rises on average 4.21 °C in relation to the temperature recorded at the meteorological station, 52.17% of the work accidents occurred in temperature ranges not recommended by INTERNATIONAL LABOR STANDARDS, 73.27% of the returned goods were produced at room temperature above 27 °C. The % Returns indicator presents a strong positive Pearson correlation (0.8901). The Performance OEE indicator presents a strong negative Pearson correlation (-0.8404) for machine N° 1. The results show that ambient temperature influences the competitiveness of the flexible packaging industry, imputing a loss of performance of its key performance indicators and an increase in the risk of accidents in the work place. These results answer the research questions, highlighting the central role of Human beings in competitiveness and that Ambient Temperature influences the competitiveness of industrial organizations.

Key words: Competitiveness, environment temperature, workplace, industrial waste, packaging industry, impact

1 INTRODUÇÃO

Crises como a pandemia global de COVID-19 impactaram as cadeias globais de produção e suprimentos, gerando inúmeras reflexões nas pessoas e organizações (Nicola *et al.*2020). Além disso, Yousfi *et al.* (2024) acrescentam a estes impactos as tensões geopolíticas. Todos estes eventos impactam os sistemas produtivos e de suprimentos globais. As indústrias por sua vez foram impactadas de diversas formas, desde a falta da matéria prima até a perda da competitividade devido aos efeitos econômicos em relação a variações cambiais e inflação, que atingiram todas as nações, inclusive o Brasil.

O Brasil possui grande relevância nesta cadeia global de suprimentos, sendo um País ativo e fundamental aos sistemas globalizados, pois segundo Gereffi *et al.* (2018) países emergentes como o Brasil estão desempenhando papéis significativos devido a serem grandes exportadores de bens manufaturados intermediários e finais.

Neste contexto é importante que a indústria nacional desenvolva estratégias bem estruturadas que possibilitem um crescimento sustentável aprimorando a competitividade no cenário mundial. Segundo Naeemah *et al*. (2022) os crescentes níveis de globalização, mudanças climáticas, escassez de recursos empurram as organizações a buscarem práticas mais sustentáveis, devido as características de riscos que envolvem os processos de manufatura, como os riscos ecológicos, sociais e econômicos.

Um dos segmentos industriais de suma relevância no contexto nacional é a indústria de embalagens, devido a sua participação econômica (Willy, 2000). Além disso, Sorgho *et al*. (2021) relatam que é necessário considerar que estas organizações estão sujeitas às consequências de fatores políticos, sociais, econômicos e ambientais.

O Brasil é um país de dimensões continentais, sendo o 5° país com maior extensão territorial e com o sentido perpendicular à linha do Equador, pode apresentar diversos climas ambientais nos ambientes industriais. Dependendo da localização da indústria, climas distintos podem ser percebidos em um período de 24 horas, segundo Barcellos *et al.* (2024) todas as regiões do Brasil vêm apresentando anomalias climáticas sendo que a Região Sul apresenta o maior número nos últimos anos de 2014 a 2020, situação típica para indústrias localizadas na região sul do país.

Os fatores ambientais oriundos do clima são onipresentes para todas as organizações industriais. Atualmente as bases da literatura apresentam inúmeros estudos (Leejarkpai *et al*., 2016; Keller *et al*., 2022; Durastanti *et al*., 2024) relacionados ao Aquecimento Global (AG), buscando identificar os impactos das atividades industriais no meio ambiente ou o impacto das temperaturas extremas na saúde dos trabalhadores (Ferrari, 2023). Entretanto, há pouca base de estudos no sentido oposto, ou seja, entender o quanto e como as empresas estão sendo afetadas pelo nível de aquecimento já existente.

Borg *et al.* (2021) relatam que o impacto do aquecimento no âmbito econômico é substancial. Fatima *et al*. (2022) analisaram os efeitos das temperaturas extremas no ambiente de manufatura da indústria Australiana, relacionado aos impactos da Temperatura Ambiente (TA) nas doenças ocupacionais. O estudo sugere que o risco de doenças aumenta substancialmente em temperaturas elevadas, na ordem de 40,2 °C, tendo maior potencial de impacto a temperaturas moderadas, na ordem de 32,3 °C, o estudo buscou associar a leitura da TA em relação aos registros de acidentes no mesmo período, colaborando com Ferrari *et al.* (2023).

Os estudos de Ferrari *et al.* (2023) também investigam a influência dos fatores climáticos no ambiente de trabalho, utilizando base de dados meteorológicos associados aos dados dos registros de acidentes, gerando via cálculo os dados de *Went-Bulb Globe Temperature* (WBGT). Para medir o stress térmico no ambiente de trabalho, com este indicador foi relacionado o índice WBGT aos riscos ocupacionais do ambiente e seus impactos na saúde dos trabalhadores, concluindo que altos índices WBGT possuem influência direta na ocorrência de acidentes de trabalho. Além dos impactos relacionados à redução da força de trabalho em virtude dos acidentes de trabalho, sendo necessário compreender como o ambiente é considerado nos sistemas de gestão.

Normalmente as organizações tratam o meio ambiente junto às ferramentas de gestão de qualidade, que normalmente são utilizados em processos investigativos para solucionar não conformidades no Sistema de Gestão da Qualidade (SGQ), tendo o meio ambiente como uma das potenciais causas para a geração de um efeito não desejado, ferramenta de Causa-Efeito, onde o meio ambiente pode gerar efeitos indesejados no objeto pretendido (Ishikawa, 2012). As ferramentas de SGQ contribuem para padronização e eficiência dos processos, tendo reflexos diretos na competitividade.

A ferramenta de *Lean Six Sigma* (LSS) foi utilizada por Bhat *et al*. (2021) em uma indústria gráfica na Índia para identificar as possíveis causas que impactam a competitividade. O estudo de Bhat *et al.* (2021) mapeou a indústria definindo os pontos de monitoramento e intervenção, aplicando ferramentas de qualidade para a identificação de causas potenciais para baixa competitividade. Os dados obtidos foram tratados com ferramentas estatísticas para medir as *Key Performance Indicators* (KPI). A temperatura do ambiente de trabalho foi considerada como um fator de análise, porém esta variável não foi considerada como causa provável, contrariando outros estudos relacionados aos impactos do clima nos trabalhadores.

Amini *et al*. (2021) concluíram em seus estudos que a TA pode gerar efeitos positivos e negativos na produtividade dos trabalhadores, uma vez que, em regiões frias observa-se aumento da produtividade e por outro lado, em regiões quentes, a perda de produtividade devido ao aquecimento do ambiente de trabalho. Utilizando dados de estações meteorológicas em softwares matemáticos, os referidos autores projetaram cenários de impacto sobre a produtividade dos trabalhadores. Onde a TA de trabalho pode influenciar a força de trabalho das organizações

Sobre esta mesma ótica Sousa *et al*. (2020) também buscaram identificar o impacto das mudanças climáticas na força de trabalho de trabalhadores em ambientes abertos, realizando projeções matemáticas com base no *Environmental Stress Index* (ESI) associadas a modelos climáticos para medir a influência da temperatura ao ambiente de trabalho ao final do século XXI (2071-2100). Os dados apontam que elevados índices geram redução da capacidade de trabalho e temperaturas acima de 30°C contribuem substancialmente para o aumento de erros dos trabalhadores. No cenário mais grave, os efeitos do aquecimento indicam que a capacidade produtiva do trabalhador pode ficar de 0% a 25%, gerando interrupções contínuas na jornada de trabalho, entretanto, o modelo proposto não realiza projeções de trabalhadores em ambientes fechados.

Os efeitos da TA no ambiente de trabalho fechado expõem um universo de desafios para o crescimento, sustentabilidade e competitividade da indústria nacional. De acordo Haguenauer *et al.* (2012) a competitividade pode ser definida como a capacidade de uma organização de produzir mercadorias com padrões de qualidade específicos, requeridos por mercados determinados, utilizando recursos em níveis iguais ou inferiores aos que prevalecem em indústrias semelhantes no resto do mundo, durante certo período de tempo. A competitividade pode ser avaliada tanto pelo desempenho exportador quanto pela eficiência produtiva, considerando aspectos como preços, qualidade, tecnologia, salários e produtividade. Considerando estas temáticas observa-se que há um grande campo de pesquisa quanto ao impacto do ambiente na competitividade das organizações industriais. Por que há poucos estudos que abordam os efeitos da TA na capacidade competitiva das organizações industriais.

1.1 Tema, Problema de Pesquisa e Objetivos

Os efeitos oriundos da TA podem afetar todos os seres e organizações ao redor do mundo, gerando riscos a todas as partes envolvidas. A falta de entendimento quanto à relação destes efeitos no ambiente produtivo industrial e a baixa competitividade da indústria Brasileira expõem a necessidade de buscar conhecimento que possibilite gerenciar, de forma mais eficaz, os riscos oriundos do AG.

Segundo dados da Confederação Nacional da Indústria (CNI), o Brasil ocupa a 16ª posição na análise de competitividade geral da indústria quando comparado com outros 18 países (CNI, 2022). Considerando o eixo da estrutura produtiva, o Brasil ocupa a 13ª posição, conforme pode ser visto na Figura 1. A constatação dos dados apresentados pela CNI,corroboram com a necessidade de melhorar os índices de competitividade das organizações industriais brasileiras, que por sua vez, poderão contribuir para o alcance das metas globais de ODS. A competitividade da indústria pode ser observada por várias óticas e Willy *et al*. (2000) classificam os fatores sistêmicos de competitividade nas categorias infra-estruturais, político-institucionais, internacionais, sociais e legais-regulatórios. Haguenauer *et al.* (2012) propõem que a competitividade poderia ser definida pela capacidade de uma indústria produzir produtos ou serviços com padrões de qualidade específicos, utilizando recursos similares a indústrias internacionais semelhantes, podendo competir em igualdade por um tempo determinado.

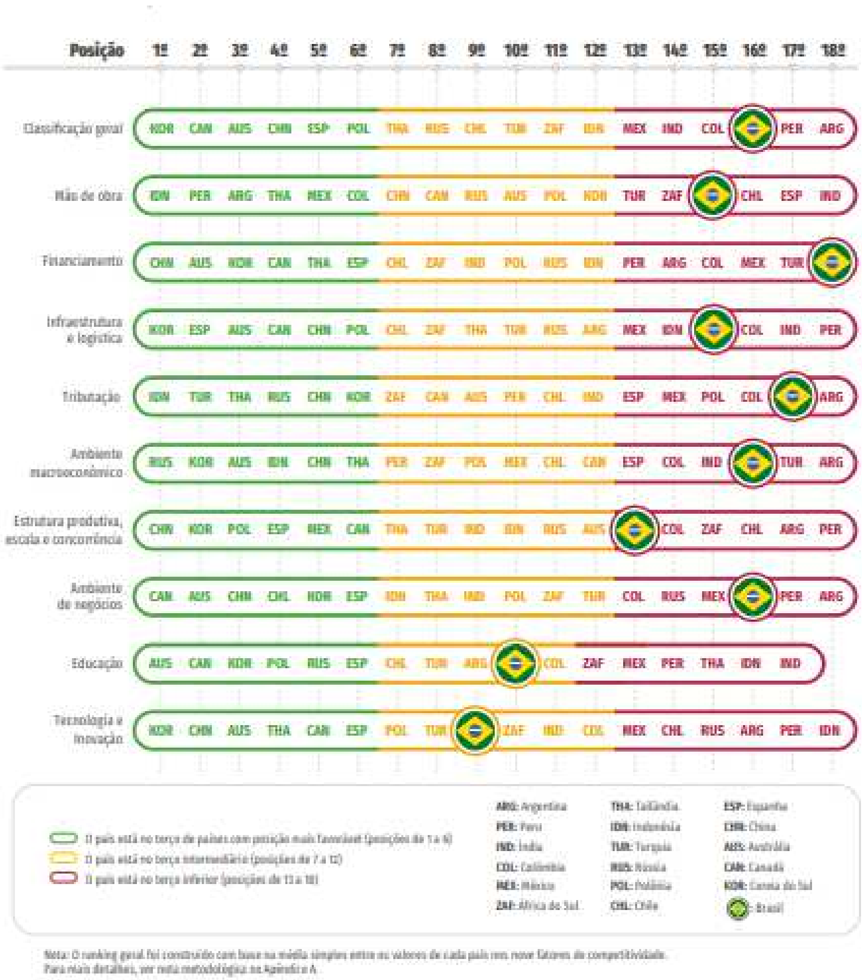
Entretanto esta abordagem atua em conceitos amplos mais voltados a influência dos agentes humanos, que são abordados em outros estudos utilizando o ambiente interno das organizações. Naeemah *et al*. (2022) efetuaram um estudo de revisão bibliográfica para entender quais seriam os efeitos das ferramentas de *Lean Manufacture* (LM) na sustentabilidade das organizações. Segundo os autores, 38% dos efeitos positivos podem ser atribuídos às 10 principais ferramentas de LM, 7S, JIT, Kamban, Kaizen, Celular Manufacturing, Visual Control, VSM, PokaYoke, Six Sigma e SED. Desta forma impactando os fatores econômicos que sustentam a competitividade das organizações. Estes resultados também são confirmados pelos estudos de (Shahriar, 2022) em uma indústria de embalagens plásticas, considerando que a organização no ambiente industrial contribui para a competitividade da indústria de embalagens, devido à redução de perda de matéria prima e de tempo operacional.

O controle das perdas dentro das indústrias de embalagens é ponto chave para a sustentabilidade desta área industrial. De *et al*. (2023) abordam a sustentabilidade como um diferencial apreciado por clientes entre outros *Stakeholders*, gerando posicionamento diferenciado e visibilidade positiva para a marca. Neste contexto, De *et al*. (2023) descrevem a importância do sistema de gerenciamento das perdas na indústria de embalagens plásticas para sustentar a competitividade da organização.

Independente da ótica utilizada para observar a competitividade, todos estes estudos abordam a aplicação de ferramentas que visam aprimorar os resultados das organizações. Entretanto tais ferramentas atuam nos fatores diretos de resultado, ou seja, não atuam na identificação dos fatores precedentes aos fatos redutores de resultado. As condições ambientais somadas aos fatores humanos presentes no ambiente de trabalho industrial, correspondem pela maior parte da subjetividade existente e, portanto, entender a relação destas causas precedentes pode aprimorar os resultados e modificar as técnicas de gerenciamento das organizações industriais.

A inexistência de um processo formal bem como metodologias para tratar os impactos das variáveis climáticas no ambiente produtivo evidencia uma lacuna nas ferramentas de gestão e estratégias organizacionais para elevar a competitividade. O preenchimento desta lacuna deve permitir direcionar ações preditivas para mitigar os impactos negativos do clima, e com isso, aprimorar o nível de qualidade dos produtos, reduzir o consumo de materiais por unidade de produto, aumentar a vida útil das plantas industriais, melhorar a segurança laboral e elevar a lucratividade da indústria.

Figura 1: Comparativo de competitividade Brasil.



Fonte: CNI, 2023.

A busca por competitividade se torna preponderante para o crescimento das organizações industriais e abrange de maneira global a necessidade de estudos que possam identificar e aprimorar os fatores de produção. Estes estudos devem ter como objetivo a busca de conhecimento para o aumento da eficiência da indústria, visando maximizar seus recursos de produção, humanos e financeiros, evitando desperdícios de recursos.

Nesse contexto, a questão de pesquisa é quais são os impactos da TA na competitividade da indústria de embalagens? Desta forma, o objetivo geral deste estudo para responder essa indagação é:

Analisar a influência da Temperatura Ambiente e seus impactos na Competitividade das Indústrias de Embalagens Flexíveis.

Os objetivos específicos são:

- Relacionar o histórico de registros climáticos com histórico de KPI, para avaliar a correlação da TA com as métricas dos KPI.
- Relacionar os níveis de temperatura externa com a temperatura no ambiente de trabalho para projetar os níveis de TA dos períodos históricos elencados no estudo.
- Gerar subsídios para a mitigação de riscos oriundos da TA no ambiente fabril.
- Avaliar se a TA é uma variável que influencia competitividade da indústria de embalagens flexíveis.

1.2 Procedimentos metodológicos

Os procedimentos metodológicos estão organizados na forma de uma Revisão Sistemática de Literatura (RSL) e um estudo de caso que visam responder às questões de pesquisa e aos objetivos deste trabalho, buscando aprofundar o conhecimento técnico científico sobre o tema. Primeiramente foi realizada a RSL, utilizado o modelo proposto porGohr *et al*. (2013), denominado como protocolo *Preferred ReportingItems for Systematic Reviews and Meta-Analyses* (PRISMA), contendo três fases metodológicas, adaptado para ordenar as análises qualitativa e quantitativa dos artigos coletados (Saputra *et al.*, 2024). O período de busca foi inicialmente limitado a artigos de revisão e artigos de pesquisas, publicados nos anos de 2021, 2022 e 2023. A determinação do período elencado no estudo se deve a estratégia de considerar os documentos mais recentes relacionadosà temática de pesquisa. Entretanto as relações da TA com a indústria de embalagens, se fez necessário buscar artigos anteriores ao período estabelecido inicialmente. A busca de trabalhos relacionados se baseou na estratégia adaptada de Varghese *et al.* (2018), combinado as palavras chaves e possíveis sinônimos do estudo referenciado, junto a palavras relacionadas ao tema competitividade das indústrias, obtendo dois eixos de *Strings*, relacionadas às questões de pesquisa da RSL

As questões de pesquisa para a RSL foram:

Q1: Quais são as consequências da exposição dos trabalhadores a níveis elevados de TA?

Q2: Quais são as relações destes trabalhadores afetados pela TA na competitividade das organizações industriais?

Para fazer a busca nas bases de dados foram construídas as seguintes relações entre as palavras-chave:

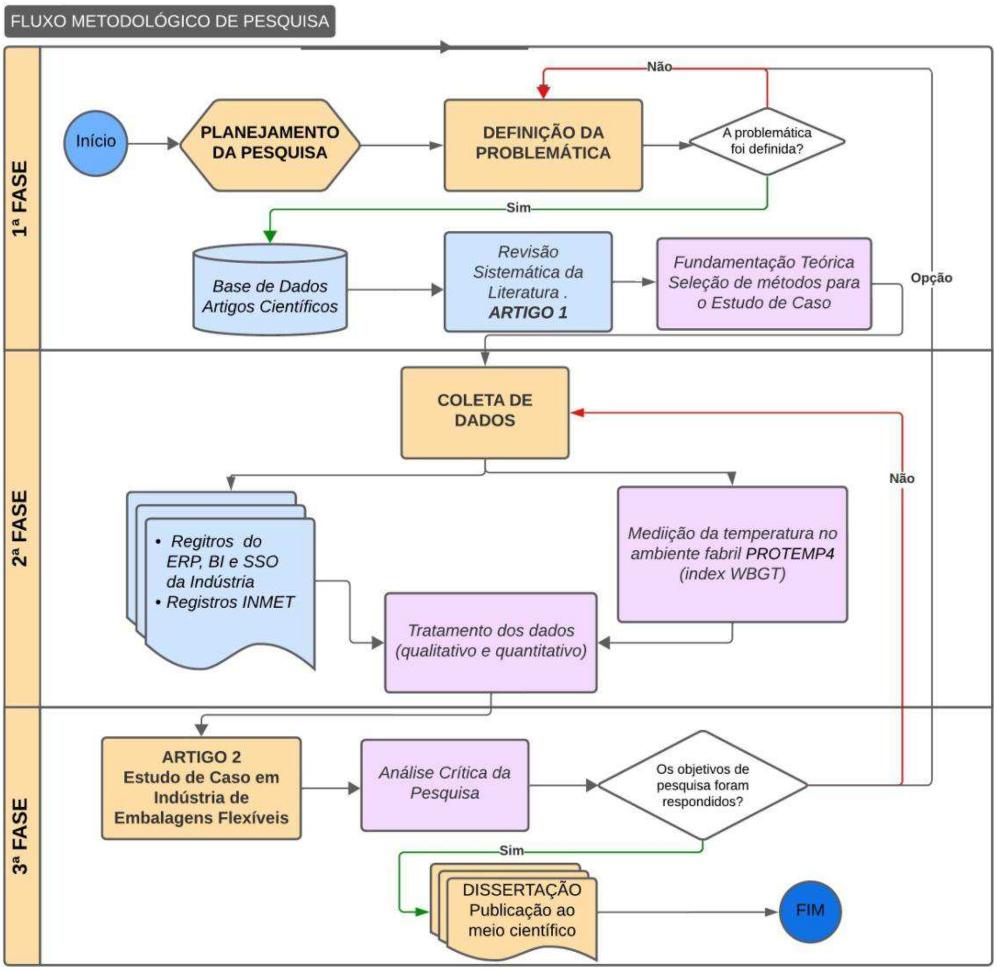
String 1: “environmentaltemperature” OR “environmenttemperature” AND “occupational injuries” AND “heat stress” AND “workplaceheatexposure” OR “workplace hot temperature” AND “healthandsafety”

String 2: “competitiveness of industry” AND “workplace" AND “worker” OR “workers”

Posterior a execução da RSL foi efetuado um estudo de caso em uma indústria de embalagens (Miguel, 2007; Shahriar *et al*., 2022). Com base na abordagem de modelagem do pensamento sistêmico sugerido por De *et al*. (2023) auxilia no entendimento dos problemas complexos. Desta forma o presente estudo de caso foi com base na modelagem de Shahriar*et al.* (2022) utilizando a metodologia do pensamento sistêmico abordada por De *et al.* (2023) em uma indústria de cosméticos.

Desta forma, as atividades de pesquisa foram divididas em três fases conforme pode ser visto na Figura 2, a primeira fase consiste na definição da problemática de pesquisa e execução de uma RSL para identificar as lacunas de conhecimento sobre o tema. A segunda fase trata do estudo de caso em uma indústria de embalagens flexíveis para responder às questões de pesquisa. A terceira fase trata dos resultados e conclusões da presente pesquisa.

Figura 2: Fluxo metodológico de pesquisa



Fonte: Autores.

1.3 Delimitação do Estudo

A tendência global das organizações por aperfeiçoamento da governança corporativa nos faz refletir a respeito do posicionamento das mesmas em relação a suas condições de competitividade (Nicola, 2020). Neste contexto, países emergentes como o Brasil possuem destaque nos interesses globais (Gereffi, 2018), e para atingir níveis globais alinhados ao ODS é necessário estudar com profundidade os fatores redutores da competitividade.

Considerando esta ótica, precisamos ir além dos pilares técnicos e econômicos das organizações nacionais, para atingir níveis globais alinhados às ODS. Pois segundo Cheng *et* *al.* (2023) o Brasil quando comparado com outros 139 países através do *Global Inclusive and Sustainable Competitive Industrial Performance* (ISCIP), está na sexagésima posição para a economia total quando avaliada pelas dimensões de competitividade industrial, inclusão social e sustentabilidade ambiental, que são os pilares do ESG. Os dados da Associação Brasileira de Embalagens (ABRE) corroboram com o contexto da competitividade da indústria nacional, pois o mercado de embalagens obteve queda de 4,5% no montante produzido em 2022 (ABRE, 2023).

Com base neste contexto as delimitações da presente pesquisa, foram definidas em: Uma revisão da literatura científica através de uma RSL. Um estudo de caso em uma Indústria de Embalagens Flexíveis do Sul do País, utilizando dados históricos dos anos de 2021 a 2024 da indústria elencada para o estudo de caso e dados meteorológicos do Instituto Nacional de Meteorologia (INMET) da cidade de Rio Pardo no Estado do Rio Grande do Sul, Brasil.

1.4 Estrutura da Dissertação

Esta dissertação é disposta em formato de artigos científicos sendo que a mesma está subdividida em quatro capítulos. O primeiro capítulo aborda introdução, no qual trata os seguintes tópicos: Tema, problema de pesquisa e objetivos (gerais e específicos), procedimentos metodológicos e limitações do estudo. No segundo capítulo, apresenta-se o primeiro artigo da dissertação. Este artigo, buscou identificar os conhecimentos existentes na literatura sobre o impacto da temperatura ambiente nos trabalhadores industriais e a capacidade competitiva das organizações industriais, por meio de uma RSL. A elaboração da RSL teve como objetivo elucidar os conhecimentos existentes sobre o tema. O artigo foi publicado no periódico RGSA – Revista de Gestão Social e Ambiental, ISSN: 1981-982X, Qualis A3, DOI: https://doi.org/10.24857/rgsa.v18n9-179. O artigo publicado encontra-se no Anexo A.

O terceiro capítulo é composto pelo segundo artigo que teve por objetivo identificar as correlações da TA com os KPI de uma indústria de embalagens. O quarto capítulo é composto pelas considerações finais assim como pelas sugestões para trabalhos futuros.

As referências são apresentadas no final de cada capítulo. Os apêndices foram organizados no final da dissertação e contém os trabalhos realizados durante o mestrado.

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2 ARTIGO 1 – THERMAL STRESS AND ITS RELATIONSHIP WITH INDUSTRY: A SISTEMATIC REVIEW OF THE LITERATURE

ABSTRACT

Objective: This study systematically reviews the literature on the impact of environment temperature on industrial workers and the competitive capacity of industrial organizations.

Theoretical Framework: Research such as that by Ferrari et al. (2023) and Varghese (2018) indicates that the relationship between heat and occupational health is predominant, influencing productivity and economic costs. Borg *et al.* (2021) highlight the need to explore the economic impacts of heat in the workplace to develop effective management policies. Hariyani *et al.* (2022) emphasize the importance of integrating sustainability and technology into organizational strategies to increase competitiveness.

Method: Using the PRISMA protocol and the Science Direct, Web of Science, PubMed and Scopus databases, the research analyzed 329 documents from 31 journals.

Results and Discussion: The results indicate that high environmental temperatures affect the physical and mental health of workers, reducing productivity. Organizations implement strategic actions and mitigation measures when they perceive competitive advantages. However, industries do not see environmental temperature as a direct factor in reducing competitiveness, addressing it as secondary to the economic axis, which creates a knowledge gap.

Research Implications: This research allows organizations to create new strategies to mitigate risks that may reduce their competitive capabilities. In addition, it allows for the creation of direct actions for the thermal comfort of workers, due to the central role of human beings in the competitive capacity of industrial organizations.

Originality/Value: This work highlights a gap in the scientific literature and in organizational strategies in the search for competitiveness, since the main actors in the manufacturing process, the workers, who are the most affected by exposure to AT, are not seen as elements sensitive to environmental risk .

Keywords: Environment temperature, heat stress, competitiveness, industry, workplace, workers.

2.1 Introduction

Global events, such as the COVID-19 pandemic, have generated profound reflections in organizations around the world, impacting production and global supply systems, causing advances in primary materials and loss of competitiveness in several sectors, aggravating exchange rate variations and generating inflation resulting from these impacts.

According to El Khatib *et al.* (2022) modern organizations are more impacted by external factors, as they are more dependent on globalized systems. In this context, it is important that they develop well-structured strategies that enable them to be competitive.

However, it is also necessary to consider that these organizations are subject to the consequences of political, social, economic, and environmental factors. In relation to environmental factors such as temperature and relative humidity, these become extremely important, as Borg *et al.* (2021) report that the impact of warming on the economic level is substantial.

Fatima *et al.* (2022) analyzed the effects of extreme temperatures, relating the impacts of Environmental Temperature (ET) on occupational diseases, suggesting that the risk of diseases increases substantially at high temperatures, in the order of 40.2 °C, with greater potential impact at moderate temperatures, in the order of 32.3 °C, the study sought to associate ET with accident records in the same period, collaborating with (Ferrari, 2023). In this same context Varghese *et al.* (2018) carried out a systematic review of the literature, to look for structured relationships between heat exposure and worker injuries.According to the authors, there is a need for interventions aimed at incorporating preventive actions, as on hotter days an increase in injuries and loss of productivity can be expected.

Interventions in work environments may become an imminent need due to the predictions of temperature rise due to climate change, studies by Dorado *et al.* (2023) mention that the temperature may increase by 4 °C in the future; therefore, understanding the effects of ET in industrial environments could become a strategic axis for these organizations.

It is believed that the effects of ET in the closed workplace can directly impact the competitiveness of industrial organizations, as Amini *et al.* (2021) concluded in their studies that ET can generate positive and negative effects on workers' productivity, since, in cold regions, there is an increase in productivity and, on the other hand, in hot regions, there is loss of productivity due to the heating of the workplace. Using data from weather stations and mathematical software, the aforementioned authors designed scenarios of impact on worker productivity. About this same perspective Souza *et al.* (2020) also seek to identify the impact of climate change on the workforce of workers in open environments, carrying out mathematical projections based on the Environmental Stress Index (ESI) associated with climate models to measure the influence of temperature on the workplace at the end of the 21st century (2071-2100). The data shows that high temperatures generate a reduction in work capacity and when exceeding 30°C it contributes substantially to an increase in worker errors. In the most serious scenario, the effects of warming indicate that the worker's productive capacity can range from 0% to 25%, generating continuous interruptions in the working day, however the proposed model does not make projections of workers in closed workplace.

When looking at indoor environments it is necessary to consider the influence of construction characteristics, which according to Hidalgo *et al.* (2023), urbanized environments have a greater thermal absorption capacity due to the nature of the construction materials used, such as bricks and concrete, which make it difficult to cool urbanized areas.

In view of the above, in order to better understand the relationship between ambient temperature and workers and industrial organizations, a Systematic Literature Review (SLR) was carried out.

2.2 Theoretical reference

One of the ways to identify knowledge on a given topic is the SLR, according to Gohr *et al.* (2013) this model presents consistent and reliable results for the scientific community. To achieve this objective, it is essential that researchers determine a recognized protocol for collecting and processing data, the object of research (Thompson, 2023).

The analysis of pre-existing knowledge provides support for the research spectrum and foundations for the preparation of the work. Through systematic mapping Ferrari *et al.* (2023) sought to identify the impacts of climate change on workers, at the end of the research they identified that the most common relationship in articles related to the topic is the association of heat with occupational health and work accidents, which in turn were confirmed by studies carried out by (Varghese, 2018). Contributing to the discussion, studies of Borg *et al.* (2021) who identified considerable knowledge regarding the effects of ET on workers' health and its consequences on productivity, the economic costs of these losses are substantial and poorly understood. According to the authors, future research that explores the relationship between ET and costs is important for creating new management policies to minimize the economic impacts arising from ET (Borg, 2021).

Considering the economic spectrum Hariyani *et al.* (2022) sought to identify knowledge regarding the agile manufacturing context of integrated green and sustainable six sigma, to create high-performance and competitive organizations. The authors identified that the context of the planet, the context of the organization, and the context of technology need to be pillars of the organization's strategic plan.

Competitiveness is a relevant topic of research due to the importance of this context for the survival of organizations. Hallioui *et al.* (2022) sought to understand these relationships and identified that there continues to be a gap in the literature so that organizations can become more contemporary and competitive.

The state of the art highlights a gap in knowledge regarding the direct relation between ET and the context of organizational competitiveness. In addition, it suggests that new studies that directly address and investigate these factors will be explored.

2.3 Methodology

The structure of the present study is based on the analysis and review of scientific literature, using five databases, initially limited to studies published in 2021, 2022 and 2023, as researchers are interested in the state of the art of the study topic. The model proposed by Gohr *et al.* (2013) was used which contains three methodological phases for structuring this research: research question, selection of previous works and classification of works suitable for study. Also, the protocol considered was Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), adapted from Saputra *et al.* (2024) to order the qualitative and quantitative analyzes.

The search for related works was based on the adapted strategy of Varghese *et al.* (2018), which combined the keywords and possible synonyms of the referenced study, along with words related to the theme of industrial competitiveness, obtaining two axes of Strings, the first search being related to research Q1 and the second search related to research Q2.

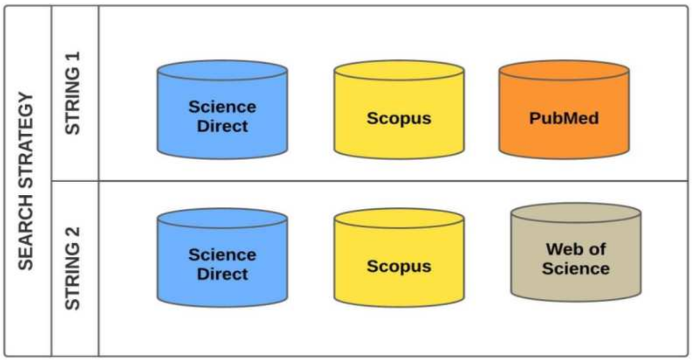
String 1: “environmental temperature” OR “environment temperature” AND “occupational injuries” AND “heat stress” AND “workplace heat exposure” OR “workplace hot temperature” AND “health and safety”.

String 2: “competitiveness of industry” AND “workplace" AND “worker” OR “workers”.

The present study used the databases Science Direct, Scopus, PubMed, and Web of Science. Limited to review and research articles, the bases and strings were organized as shown in Figure 3.

Figure 3

Bases used in studies.



The base PubMed was chosen to search for articles related to string 1 due to the nature of the literature published in the journal, which focuses on the areas of biomedicine, human health, life sciences, behavioral sciences, chemical sciences, and bioengineering. On the other hand, the Web of Science database was chosen for string 2, due to its breadth of coverage, containing a wide range of academic books, journals, and conference proceedings.This separation of the bases contributed to the organization of the present study, generating an alignment of the search areas with the established review method and the research questions.

The synthesis of research results is presented in two topics, the first addresses the consequences of worker exposure to high levels of ET. The second topic deals with the relations of workers affected by ET in the competitiveness of industrial organizations. In the end, the relationships found are presented in the form of a conceptual map.

2.3.1 Method of systematic literature review

This theoretical study started from the identification of a problem that requires answers to direct and substantiate the research spectrum. The problem was: How are the relationships between reduced worker productive capacity resulting from exposure to heat and the competitiveness of industrial organizations described in the literature? In this way, we seek to understand pre-existing knowledge regarding the effects of heat exposure on productive capacity and the influence of these consequences on the competitiveness of industrial organizations.

Research questions:

Q1: What are the consequences of worker exposure to high ET levels?

Q2: What are the relationships of these workers affected by ET in the competitiveness of industrial organizations?

Based on the adaptation of the PRISMA protocol associated with the model proposed by Gohr *et al.* (2013) the methodological steps for implementing this SLR were determined. The steps are described below.

2.3.2 Inclusion and exclusion criteria

Inclusion:

a) scientific articles published in the English language from January 1, 2021 to December 15, 2023 in the databases listed in Figure 1;
b) studies that address worker exposure relationships to high levels of ET;
c) studies that address the relationships between ET and workers, with the competitiveness of industrial organizations.

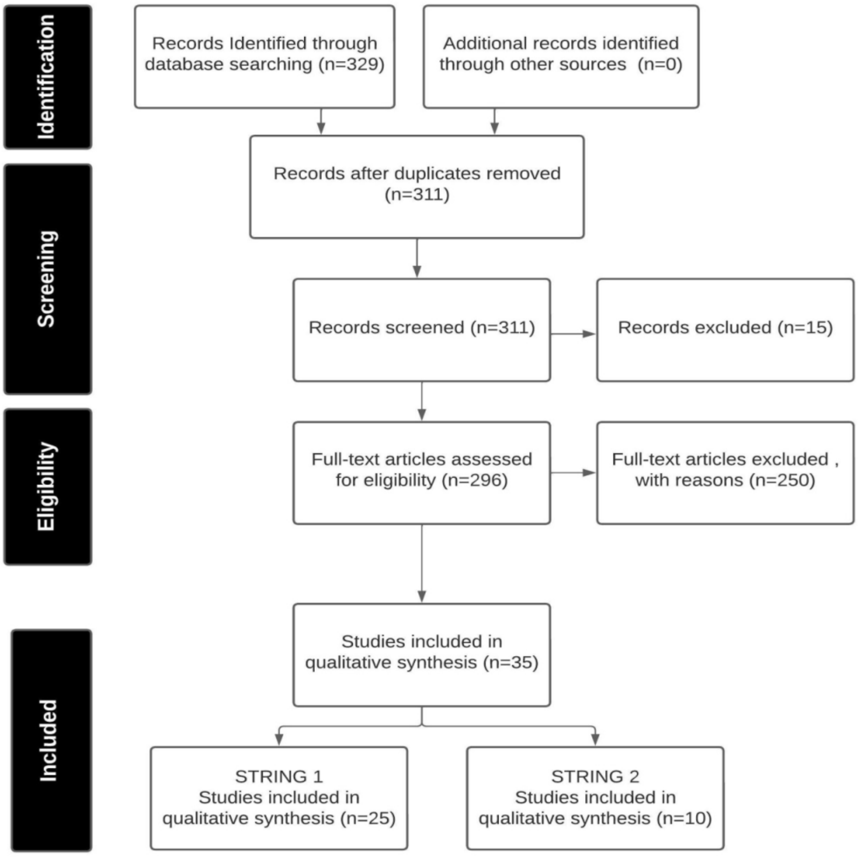
Exclusion:

a) duplicate articles in the databases;
b) articles with titles where the keywords are isolated or not contextualized to the research topic;
c) studies that do not address the relationships between ET exposure in the population outside the industrial workplace;
d) studies that address competitiveness in non-industrial organizations.

A total of 329 articles published from 2021 to 2023 were identified. After completing the steps described in Figure 4, the selected articles were divided into two string categorizations. Figure 4 illustrates the selection protocol applied.

Figure 4

PRISMA protocol for selecting studies for subsequent analysis.



Fonte: Adapted from SAPUTRA,Bibliometric Analysis of Research Publication Trends on Job Rotation Satisfaction. Revista de Gestão Social e Ambiental, 18, n. 9, p. e05312, 04/26 2024.

String 1 is related to Q1, while string 2 refers to Q2. The present SLR study identified a total of 35 documents suitable for extraction, categorizing their typology and methods used, there are 18 theoretical studies and 17 practical studies, being: 11 SLR or meta-analysis studies, 10 case studies, 5 statistical data analysis, 4 interview research, 2 experimental research, 2 longitudinal empirical research, 1 expert panel, and 1 empirical analysis.

2.4 Results and discussion

2.4.1 Consequences of worker exposure to high levels of ET

Currently, researchers are concerned (Borg *et al*., 2023; Fatima *et al*., 2023) regarding the topic of heat, the effects of ET on workers' health and occupational risks related to ET dominate the research objectives. Furthermore, there are projections that point to a tendency for the impact of ET on working conditions to increase in the future (Kim& Lee, 2020).

The study of Varghese *et al.* (2018) indicates that the prospect of increased heat will represent a significant growth in accidents and injuries at work, generating losses associated with workers' productive capacity. In a later case study Varghese *et al.* (2019) mapped temperature levels related to injury types. The 33.3° C Relative Risk (RR) range is classified as moderate temperatures, and the 40.6° C RR range is classified as extremely hot temperatures, however, Fatima *et al*. (2023) consider 38° C as an extreme temperature, and considering obese people or people with comorbidities, a temperature of 37.6° C is considered hyperthermia according to Flouris *et al.* (2018).

The main injuries identified are: Trauma, joint injuries, muscle injuries, burns, dermatitis, lacerations, amputations, organ injuries, symptoms of exhaustion, cramps, skin rashes, dehydration, and death (Bendak *et al.*, 2022; Samaniego-Rascón *et al.*, 2019; BENSON *et al.,* 2021; Lan *et al.,* 2022). Furthermore, there are intrinsic factors that aggravate injury levels. Varghese *et al.* (2020) and Hansen *et al.* (2018) report that some workers are unaware that heat can be related to health problems, however, studies by Carter *et al.* (2020) pointed out that 79% of workers interviewed present chronic symptoms of Heat Stress (HS), which tends to worsen when associated with other factors.

Socioeconomic condition is considered a factor that worsens the effects of HS, because Lucas *et al.* (2014) report that workers with lower socioeconomic status exceed physiological limits for heat exposure due to fear of being fired from their jobs and Fatima *et al.* (2021) point out that more experienced workers have an increased RR to injuries due to self-confidence. On the other hand, self-control can be an important tool in reducing the RR on workers' health (Lao *et al*., 2016).

The literature shows that there is no distinction between groups among workers who may be affected by exposure to high levels of heat, according to Ansah *et al.* (2021) young, old, men or women workers suffer adverse symptoms arising from inadequate exposure to heat. What can change between groups are the type of injury and its level of intensity. Furthermore, the authors cite the existence of geographic factors in the increase in RR, as workers from tropical, subtropical regions, regions with high levels of air pollution, low and middle-income countries have a higher RR of occupational diseases arising from exposure to heat.

One of the main methods used to identify the level of ET that the worker is exposed to is mediation through the Wet Bulb Globe Temperature (WBGT) (Oliveira *et al.,* 2018). The accuracy of measurement results can be improved when combined with other measurement models such as Predicted Heat Strain (PHS), and ESI. WBGT was used by Chong *et al.* (2020) in experimental studies with controlled ET levels, with the aim of evaluating the capacity of Human Adaptation (HA) to certain temperature levels, the study suggests that HA training can reduce levels of human error and reduce the negative impacts of thermal stress. Error levels are directly linked to the worker's cognitive capacity; because Zhang *et al.* (2019) show that there is a consensus among researchers that complex tasks, such as conflict resolution, are directly affected by high levels of ET.

According to Borg *et al.* (2023) occupational injuries and illnesses have great relevance in the economic burden of treating workers' health. Mathematical projections for the future prepared by the authors indicate an increase in related costs by 2030 and 2050. In the same context Kim *et al.* (2020) project a significant reduction in production capacity in 2030 in the Republic of Korea. These economic impacts are confirmed in China by Ma *et al.* (2019), and in Australia by Ireland *et al*. (2023) and Borg *et al.* (2021). The study by Fahed *et al.* (2018) in a steel industry, in which they quantified the loss of productivity in environments with high rates of ET, arising from the radiant heat of the manufacturing process, in heavy activities the loss of productivity is between 20% and 30%. Additionally, when classifying the exposure time the authors report losses between 61% and 76%.

The articles analyzed show that workers suffer harmful effects on their health when exposed to high levels of ET (Lucas *et al.*, 2014; Hansen *et al.*, 2018; Flouris *et al*., 2018; Varghese *et al*., 2018; Varghese *et al*., 2019; Varghese *et al*., 2020; Chong *et al*., 2020; Fatima *et al*., 2023; Ansah *et al*., 2021). The effects are diverse, ranging from mild symptoms such as dehydration to severe ones such as organ damage. These consequences depend on the ET levels and the physical and physiological characteristics of the individual (Samaniego-Rascón *et al*., 2019; Carter *et al*., 2020; Benson *et al*., 2021; Lan *et al*., 2022; Bendak *et al*., 2022). These effects on worker health are reflected in the reduction of the worker's productive capacity, directly impacting their work capacity, generating loss of productivity, increased operational errors, increased costs related to workers' health treatment and a higher rate of workplace accidents (Fahed *et al*., 2018; Zhang *et al*., 2019; Ma *et al*., 2019; Kim *et al*., 2020; Borg *et al*., 2021; Borg *et al*., 2023; Ireland *et al*., 2023).

2.4.2 Relations of workers affected by ET in the competitiveness of industrial organizations

According Henao *et al.* (2019) one of the ways to improve the results of industrial organizations is the application of LM methods. The authors point out that LM improves the performance of organizations, generating an organizational virtuous circle. Still according to Henao *et al* (2019) human factors play a fundamental role in the stability of economic, social and environmental factors in organizations. In an unsafe work environment, the factor's economic and performance organizational can is affected. Furthermore, the effects compromise the productivity and competitiveness of the workers themselves Khahro *et al*. (2020) report that actions applied to improve the worker environment now play a key role in these organizations. On the other hand Leong *et al.* (2020) report that companies often invest in social outcomes when these actions provide competitive advantages, although social relations with workers receive little attention in organizational management. This indicates a failure in corporate strategies, as Zhu *et al.* (2021) project a potential reduction in worker productivity due to future HS levels.

According to Ciccarelli *et al.* (2022) there is a great use of LM tools in the search for competitiveness in manufacturing industries. In addition, the authors report the existence of several studies that address ergonomics and the design of worker-centered workplaces. The studies by Ciccarelli *et al.* (2022) sought to evaluate, through a case study, the influence of 4.0 technologies in supporting the development of more ergonomic equipment.

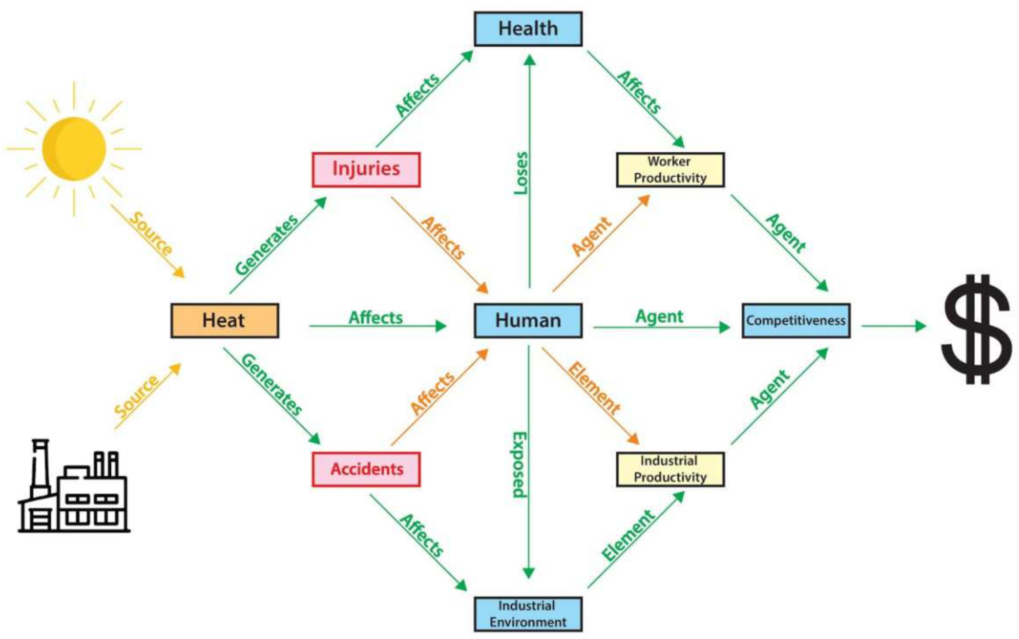
The literature shows that workers are constant actors in the competitiveness relations of industries, which is why Rumsey *et al.* (2019) address in their studies the importance of preparing and educating future professionals focused on the manufacturing industry. Investigating Georgia's educational models Rumsey *et al.* (2019) concluded that to develop labor preparation systems aimed at industry, it is essential to have partnerships between industries, government and educational institutions. Concern for workers is a sensitive topic that requires broad debate to improve organizational processes, Czornyj *et al.* (2018) record analyzes and conclusions of several experts from industrial and educational laboratories that involve greater safety in the operations carried out.

The articles analyzed show that the human being plays a key role in industrial organizations, as the human being is directly affected by environmental conditions and at the same time is an agent of environmental transformation (Czornyj *et al.*, 2018; Henao *et al.*, 2019; Rumsey *et al*., 2019; Leong *et al*., 2020; Ciccarelli *et al*., 2022). Furthermore, the workplace and workers' health impact the economic axes of these organizations, as the worker's capacity has a direct relationship with the level of quality of the workplace (Khahro *et al*., 2020; Zhu *et al*., 2021). In this way, industrial companies adopt strategies and tools to minimize these effects, such as the standardization of processes, qualification and education of workers, LM tools and adoption of 4.0 technologies in ergonomics, especially when these actions generate a competitive advantage when compared to the competition (Henao et al., 2019; Rumsey *et al*., 2019; Leong *et al*., 2020; Bhat *et al*., 2021; Ciccarelli *et al*., 2022).

As can be seen in Figure 5, the human being is at the center of the relations between ET and competitiveness, ET directly affects the human being, reducing their work capacity, the human being is the central element of the industrial environment, having a direct influence on competitiveness levels.

Figure 5

ET relations with humans and competitiveness



The research results show, through the relations of AT with humans and competitiveness, that ET is the result of the heat generated by manufacturing processes (Fahed *et al*., 2018; Oliveira *et al*., 2018) and external heat arising from the climate (Varghese *et al*., 2018; Varghese *et al*., 2019; Varghese *et al*., 2020; Fatima *et al*., 2021; Fatima *et al*., 2023). Heat becomes an element that causes injuries and accidents in the workplace, directly affecting human beings (Bendak *et al*., 2022; Samaniego-Rascón *et al*., 2019; Benson *et al*., 2021; Lan *et al*., 2022; Borg *et al*., 2023; Fatima *et al*., 2023).

Injuries in turn directly affect human health, causing humans to lose their health levels (Lucas *et al*., 2014; Hansen *et al*., 2018; Flouris *et al*., 2018; Varghese *et al*., 2018; Varghese *et al*., 2019; Varghese *et al*., 2020; Chong *et al*., 2020; Fatima *et al*., 2023; Ansah *et al*., 2021). In the same direction, accidents affect the industrial environment, where human beings are exposed (Fahed *et al*., 2018; Zhang *et al*., 2019; Ma *et al*., 2019; Kim *et al*., 2020; Borg *et al*., 2021; Borg *et al*., 2023; Ireland *et al*., 2023).

The industrial environment and the human being make up the main elements of industrial productivity, where the human being becomes an agent of productivity (Henao *et al*., 2019; Khahro *et al*., 2020; Bhat *et al*., 2021). Worker productivity is the result of the productive capacity of the human being, which in turn is affected by the loss of health (Zhu *et al*., 2021; Rumsey *et al*., 2019; Ciccarelli *et al*., 2022), generated by exposure to high levels of AT (Bendak *et al*., 2022; Samaniego-Rascón *et al*., 2019; Benson *et al*., 2021; Lan *et al*., 2022; Borg *et al*., 2023; Fatima *et al*., 2023).

In this context, the human being becomes the key point in the relations between ET and competitiveness, as the human being as an agent of worker productivity and an element of industrial productivity also becomes an agent of competitiveness (Czornyj *et al*., 2018; Henao *et al*., 2019; Rumsey *et al*., 2019; Leong *et al*., 2020; Ciccarelli *et al*., 2022; Bhat *et al*., 2021).

The competitiveness of industrial organizations is dependent on all agents: Human beings, worker productivity and industrial productivity. These agents are the central elements of the competitiveness of industrial organizations (Henao *et al*., 2019; Khahro *et al*., 2020; Leong *et al*., 2020; Zhu *et al*., 2021; Ciccarelli *et al*., 2022; Bhat *et al*., 2021; Rumsey *et al*., 2019; Czornyj *et al*., 2018).

2.5 Conclusions

There are works related to the effects of ET on working conditions, worker's productive capacity, work accidents, injuries and occupational diseases (Bendak *et al*., 2022; Samaniego-Rascón *et al*., 2019; Benson *et al*., 2021; Lan *et al*., 2022; Borg *et al*., 2023; Fatima *et al*., 2023). Given this, we conclude that there is full knowledge of the impacts of heat on workers' health, but there is no work that point to a direct relation between ET and competitiveness. However, evidence indicates that exposure factors are partly neglected; the affected population lacks awareness of the risks and public and private risk mitigation policies.

When looking at the topic of competitiveness, it is clear that ET is not seen by industrial organizations as a factor that reduces competitiveness, as no studies were found in the literature that directly address the influence of ET on the competitive capacity of industrial organizations. On the other hand, there is robust information on how workers are affected by ET. The costs related to injuries and occupational health are high, in addition, there is clear evidence of the reduction in workers' productive capacity due to the effects on their health.

This work highlights a gap in the scientific literature and organizational strategies in the search for competitiveness. As the main actors in the manufacturing process, workers, who are mostly affected by exposure to ET, are not seen as elements sensitive to environmental risk. Studies related to the theme of competitiveness aim to improve processes through the application of quality tools, insertion of 4.0 technologies and LM concepts (Henao *et al*., 2019; Rumsey *et al*., 2019; Leong *et al*., 2020; Bhat *et al*., 2021; Ciccarelli *et al*., 2022). Not considering the thermal influences of the environment as a possible root cause for low competitive capacity.

The study suggests further research to directly address the impact of heat exposure (TE) on the ability of industrial organizations to achieve high levels of competitiveness. Furthermore, it is recommended that these organizations treat the impacts of heat on workers as a public health problem and include a response to heat stress as a point of analysis in their strategic planning.

The documents analyzed fulfill the objective of understanding how the relationship between the reduction in the productive capacity of workers due to heat exposure and the competitiveness of industrial organizations is described in the literature. The study also highlights the central role of human beings in the competitiveness of industries.The relationships revealed indicate that TE has indirect impacts on competitiveness. TE affects both humans and the industrial environment, which in turn have direct relationships with competitiveness, as the latter depends on environmental conditions and human capabilities.

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3

4 CONSIDERAÇÕES FINAIS

Analisar a influência da TA e seus impactos na competitividade das indústrias de embalagens flexíveis é o tema central da presente pesquisa. A RSL apresentada no Artigo 1 traz a este estudo o papel central do ser humano na competitividade das organizações industriais (Czornyj *et al*., 2018; Rumsey *et al*., 2019; Henao *et al*., 2019; Khahro *et al*., 2020; Leong *et al*., 2020; Zhu *et al*., 2021;Bhat *et al*., 2021; Ciccarelli *et al*., 2022). O ser humano tem redução em sua capacidade produtiva devido aos efeitos da exposição a altos níveis de TA na saúde dos seres humanos (Rumsey *et al*., 2019; Zhu *et al*., 2021; Ciccarelli *et al*., 2022). Desta forma a TA afeta o ser Humano e altera as condições do ambiente (Phanprasit, 2021). Os achados científicos de Santos *et al.* (2024) evidenciam que o ser humano ao ser afetado pela TA, onde o próprio passa a ter redução de suas capacidades produtivas se tornando um gerador de impactos negativos na produtividade das organizações industriais, tendo como consequência reflexos financeiros a estas organizações.

Os resultados da SRL, responde a um dos objetivos específicos de pesquisa desta dissertação, que é gerar subsídios para a mitigação de riscos oriundos da TA no ambiente fabril. O ser Humano é diretamente afetado pela TA, desta forma considerar esta variável na estratégia de gestão permite a mitigação dos riscos associados a TA na produtividade e saúde dos trabalhadores.

A partir destas evidências apresentadas da SRL, foi estruturado o estudo de caso, apresentado no Artigo 2. Que por sua vez evidenciou a ocorrência de altos níveis de TA nos ambientes analisados, através da medição WBGT. Além disso, evidenciou-se que há um incremento médio de DT *inside* na ordem de 4,21 °C na TA do local de trabalho, em relação às medições oficiais do INMET. A identificação destes níveis de TA e o DT *inside*, respondem a outro objetivo específico de pesquisa, que é relacionar os níveis de temperatura externa com a temperatura no ambiente de trabalho para projetar níveis de TA dos períodos históricos. Esta projeção evidenciou que elevados índices de TA são corriqueiros no ambiente fabril ao longo do período estudado, reforçando a necessidade de considerar os riscos relacionados esta variável no gerenciamento do ambiente industrial.

De posse das relações da temperatura externa com a temperatura do ambiente de trabalho obteve-se o atendimento do próximo objetivo específico, que é relacionar o histórico de registros climáticos com o histórico dos KPI. Onde os indicadores analisados, KPI de

Acidente de Trabalho, KPI % Devoluções e KPI *Performance* OEE evidenciam a influência da TA no resultado dos referidos KPI.

Para o KPI Acidentes de Trabalho, evidenciou-se que mais da metade dos acidentes (51,09%) ocorreram em condições de TA acima de 24,7 °C. O KPI % Devoluções Produtos evidencia que produtos fabricados em dias com TA superior a 27 °C representam 73,27% das mercadorias devolvidas obtendo uma correlação de Pearson forte positiva na ordem de 0,890, ou seja, conforme os níveis de TA se elevam o percentual de mercadorias devolvidas também se eleva. O KPI *Performance* OEE das máquinas impressoras (N° 1 e N° 2) atingem seu melhor desempenho de OEE em condições de TA abaixo de 18 °C e evidencia-se uma correlação de Pearson forte negativa na ordem de -0,8404 para a máquina N° 1. Desta forma conforme se elevam os níveis de TA o OEE da máquina N° 1 decai.

As relações evidenciadas no comportamento dos KPI respondem ao último objetivo específico de pesquisa, que é avaliar a variável TA como uma variável que influencia competitividade da indústria de embalagens. Além disso, os resultados encontrados trazem subsídios para a mitigação dos riscos oriundos da TA no ambiente fabril.

Desta forma, estes resultados evidenciados no estudo de caso descrito no Artigo 2 e os resultados encontrados na RSL descrito no Artigo 1, respondem a indagação da presente pesquisa, que busca entender quais os impactos da TA na competitividade da indústria de embalagens.

Por fim, a presente pesquisa evidencia que a TA influência na competitividade da indústria de embalagens flexíveis, imputando perda de produtividade, aumento de custos, perda de qualidade e *performance* dos seus KPI. Além disso, há o aumento dos riscos de acidentes no ambiente de trabalho, que elucida a importância do tema no âmbito empresarial e acadêmico, permitindo um novo olhar para a variável TA.

4.1 Implicações acadêmicas e empresariais

Os resultados de pesquisa destacam algumas implicações as entidades industriais e ao meio científico:

- O mapeamento da TA associado aos modelos de previsão do tempo, as organizações industriais através de seus gestores possuem a condição de estimar os futuros níveis de TA no processo de manufatura e classificar o nível de risco para a capacidade produtiva dos trabalhadores, qualificando as possíveis consequências à saúde dos trabalhadores expostos a TA.

- A importância de monitorar e controlar as condições térmicas no ambiente de produção para garantir o cumprimento das metas estabelecidas por KPI, e consequentemente manter a competitividade e o desempenho operacional da organização.
- A importância de investigar a influência da TA na competitividade das organizações indústrias
- A identificação do ser humano como elemento central da produtividade industrial, conforme evidenciado na RSL.

Com base nestes resultados fica evidenciado que as organizações não consideram a TA como um fator de risco para atingir a plena competitividade perante a sua concorrência e há uma necessidade imediata de inserir em seus planejamentos estratégicos a TA como fator de risco e com isso gerar estratégias para mitigação destes riscos.

4.2 Limitações de pesquisa

As limitações de pesquisa da presente dissertação estão no âmbito de sua amplitude, pois os resultados deste estudo se limitam a uma única amostra de organização industrial. Além disso, os KPI selecionados representam uma fração dos indicadores existentes na organização. Desta forma não é garantido que os resultados encontrados se repitam em outras organizações com as mesmas relações e intensidade.

Mediante a isso, recomenda-se a realização de novas pesquisas explorando de forma mais representativa o quantitativo e a diversidade das indústrias nacionais. Além disso, recomenda-se novos estudos que possam relacionar a influência da TA em outros tipos de KPI que não foram abordados neste trabalho.

4.3 Sugestões para trabalhos futuros

Os resultados consistentes desta dissertação trazem uma nova perspectiva ao tema, possibilitando que novas pesquisas sejam elaboradas abordando o tema com maior profundidade. Desta forma, sugere-se que sejam elaboradas futuras pesquisas que tratem a influência da TA em outros tipos de KPI, pesquisas com maior capilaridade de organizações industriais que não foram abordados neste trabalho.

Além disso, sugere-se futuras pesquisas na temática gestão de riscos. Buscando analisar o emprego de ferramentas de análise de riscos relacionadas ao ambiente industrial e a competitividade.

ANEXO A – Artigo publicado na revista RGSA

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THERMAL STRESS AND ITS RELATIONSHIP WITH INDUSTRY: A SYSTEMATIC REVIEW OF THE LITERATURE

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ABSTRACT

Objective: This study systematically reviews the literature on the impact of environment temperature on industrial workers and the competitive capacity of industrial organizations.

Theoretical Framework: Research such as that by Ferrari et al. (2023) and Varghese (2018) indicates that the relationship between heat and occupational health is predominant, influencing productivity and economic costs. Borg et al. (2021) highlight the need to explore the economic impacts of heat in the workplace to develop effective management policies. Hariyani et al. (2022) emphasize the importance of integrating sustainability and technology into organizational strategies to increase competitiveness.

Method: Using the PRISMA protocol and the Science Direct, Web of Science, PubMed and Scopus databases, the research analyzed 329 documents from 31 journals.

Results and Discussion: The results indicate that high environment temperatures affect the physical and mental health of workers, reducing productivity. Organizations implement strategic actions and mitigation measures when they perceive competitive advantages. However, industries do not see environment temperature as a direct factor in reducing competitiveness, addressing it as secondary to the economic axis, which creates a knowledge gap.

Research Implications: This research allows organizations to create new strategies to mitigate risks that may reduce their competitive capabilities. In addition, it allows for the creation of direct actions for the thermal comfort of workers, due to the central role of human beings in the competitive capacity of industrial organizations.

Originality/Value: This work highlights a gap in the scientific literature and in organizational strategies in the search for competitiveness, since the main actors in the manufacturing process, the workers, who are the most affected by exposure to AT, are not seen as elements sensitive to environmental risk .

Keywords: Environment Temperature, Heat Stress, Competitiveness, Industry, Workplace, Workers.

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ESTRESSE TÉRMICO E SUA RELAÇÃO COM A INDÚSTRIA: REVISÃO SISTEMÁTICA DA LITERATURA

RESUMO

Objetivo: Este estudo analisa sistematicamente a literatura sobre o impacto da temperatura ambiental nos trabalhadores industriais e a capacidade competitiva das organizações industriais.

Quadro Teórico: Pesquisas como as de Ferrari et al. (2023) e Varghese (2018) indicam que a relação entre calor e saúde ocupacional é predominante, influenciando a produtividade e os custos econômicos. Borg et al. (2021) destacam a necessidade de explorar os impactos econômicos do calor no local de trabalho para desenvolver políticas de gestão eficazes. Hariyani et al. (2022) enfatizam a importância de integrar sustentabilidade e tecnologia em estratégias organizacionais para aumentar a competitividade.

Método: Utilizando o protocolo PRISMA e as bases de dados Science Direct, Web of Science, PubMed e Scopus, a pesquisa analisou 329 documentos de 31 revistas.

Resultados e Discussão: Os resultados indicam que as altas temperaturas ambientais afetam a saúde física e mental dos trabalhadores, reduzindo a produtividade. As organizações implementam ações estratégicas e medidas de mitigação quando percebem vantagens competitivas. No entanto, as indústrias não veem a temperatura ambiente como um fator direto na redução da competitividade, abordando-a como secundária em relação ao eixo econômico, o que cria uma lacuna de conhecimento.

Implicações da pesquisa: Esta pesquisa permite que as organizações criem novas estratégias para mitigar riscos que podem reduzir suas capacidades competitivas. Além disso, permite a criação de ações diretas de conforto térmico dos trabalhadores, devido ao papel central dos seres humanos na capacidade competitiva das organizações industriais.

Originalidade/valor: Este trabalho evidencia uma lacuna na literatura científica e nas estratégias organizacionais na busca de competitividade, uma vez que os principais atores do processo de fabricação, os trabalhadores, que são os mais afetados pela exposição à TA, não são vistos como elementos sensíveis ao risco ambiental.

Palavras-chave: Temperatura Ambiental, Estresse Térmico, Competitividade, Indústria, Local de Trabalho, Trabalhadores.

ESTRÉS TÉRMICO Y SU RELACIÓN CON LA INDUSTRIA: UNA REVISIÓN SISTEMÁTICA DE LA LITERATURA

RESUMEN

Objetivo: Este estudio analiza sistemáticamente la literatura sobre el impacto de la temperatura ambiental en los trabajadores industriales y la capacidad competitiva de las organizaciones industriales.

Marco Teórico: Investigaciones como la de Ferrari et al. (2023) y Varghese (2018) indican que la relación entre calor y salud ocupacional es predominante, influyendo en la productividad y los costos económicos. Borg et al. (2021) destacan la necesidad de explorar los impactos económicos del calor en el lugar de trabajo para desarrollar políticas de gestión eficaces. Hariyani et al. (2022) enfatizan la importancia de integrar la sostenibilidad y la tecnología en las estrategias organizacionales para aumentar la competitividad.

Método: Utilizando el protocolo PRISMA y las bases de datos Science Direct, Web of Science, PubMed y Scopus, la investigación analizó 329 documentos de 31 revistas.

Resultados y Discusión: Los resultados indican que las altas temperaturas ambientales afectan la salud física y mental de los trabajadores, reduciendo la productividad. Las organizaciones implementan acciones estratégicas y medidas de mitigación cuando perciben ventajas competitivas. Sin embargo, las industrias no ven la temperatura ambiente como un factor directo de reducción de la competitividad, considerándola secundaria en relación al eje económico, lo que genera una brecha de conocimiento.

Implicaciones de la investigación: esta investigación permite a las organizaciones crear nuevas estrategias para mitigar los riesgos que pueden reducir sus capacidades competitivas. Además, permite crear acciones directas para el confort térmico de los trabajadores, debido al papel central del ser humano en la capacidad competitiva de las organizaciones industriales.

Originalidad/valor: Este trabajo destaca un vacío en la literatura científica y en las estrategias organizacionales en la búsqueda de la competitividad, ya que los principales actores del proceso de fabricación, los trabajadores, que son los más afectados por la exposición a las AT, no son vistos como elementos sensibles. al riesgo ambiental.

Palabras clave: Temperatura Ambiental, Estrés Térmico, Competitividad, Industria, Lugar de Trabajo, Trabajadores.

1 INTRODUCTION

Global events, such as the COVID-19 pandemic, have generated profound reflections in organizations around the world, impacting production and global supply systems, causing advances in primary materials and loss of competitiveness in several sectors, aggravating exchange rate variations and generating inflation resulting from these impacts.

According to El KhatIb *et al.* (2022) modern organizations are more impacted by external factors, as they are more dependent on globalized systems. In this context, it is important that they develop well-structured strategies that enable them to be competitive.

However, it is also necessary to consider that these organizations are subject to the consequences of political, social, economic, and environmental factors. In relation to environmental factors such as temperature and relative humidity, these become extremely important, as Borg *et al.* (2021) report that the impact of warming on the economic level is substantial.

Fatima et al. (2022) analyzed the effects of extreme temperatures , relating the impacts of Environmental Temperature (ET) on occupational diseases, suggesting that the risk of diseases increases substantially at high temperatures, in the order of 40.2 °C , with greater potential impact at moderate temperatures, in the order of 32.3 °C, the study sought to associate ET with accident records in the same period, collaborating with (Ferrari, 2023). In this same context Varghese et al. (2018) carried out a systematic review of the literature, to look for structured relationships between heat exposure and worker injuries.According to the authors, there is a need for interventions aimed at incorporating preventive actions, as on hotter days an increase in injuries and loss of productivity can be expected.

Interventions in work environments may become an imminent need due to the predictions of temperature rise due to climate change, studies by Dorado et al. (2023) mention that the temperature may increase by 4 °C in the future; therefore understanding the effects of ET in industrial environments could become a strategic axis for these organizations.

It is believed that the effects of ET in the closed workplace can directly impact the competitiveness of industrial organizations, as Amini *et al.* (2021) concluded in their studies that ET can generate positive and negative effects on workers' productivity, since, in cold regions, there is an increase in productivity and, on the other hand, in hot regions, there is loss of productivity due to the heating of the workplace. Using data from weather stations and mathematical software, the aforementioned authors designed scenarios of impact on worker productivity. About this same perspective Souza *et al.* (2020) also seek to identify the impact of climate change on the workforce of workers in open environments, carrying out mathematical projections based on the Environmental Stress Index (ESI) associated with climate models to measure the influence of temperature on the workplace at the end of the 21st century (2071-2100). The data shows that high temperature generate a reduction in work capacity and when exceeding 30°C it contributes substantially to an increase in worker errors. In the most serious scenario, the effects of warming indicate that the worker's productive capacity can range from 0% to 25%, generating continuous interruptions in the working day, however the proposed model does not make projections of workers in closed workplace.

When looking at indoor environments it is necessary to consider the influence of construction characteristics, which according to Hidalgo *et al.* (2023), urbanized environments have a greater thermal absorption capacity due to the nature of the construction materials used, such as bricks and concrete, which make it difficult to cool urbanized areas.

In view of the above, in order to better understand the relationship between ambient temperature and workers and industrial organizations, a Systematic Literature Review (SLR) was carried out.

2 THEORETICAL REFERENCE

One of the ways to identify knowledge on a given topic is the SLR, according to Gohr *et al.* (2013) this model presents consistent and reliable results for the scientific community. To achieve this objective, it is essential that researchers determine a recognized protocol for collecting and processing data, the object of research (Thompson, 2023).

The analysis of pre-existing knowledge provides support for the research spectrum and foundations for the preparation of the work. Through systematic mapping Ferrari *et al.* (2023) sought to identify the impacts of climate change on workers, at the end of the research they identified that the most common relationship in articles related to the topic is the association of heat with occupational health and work accidents, which in turn were confirmed by studies carried out by (Varghese, 2018). Contributing to the discussion, studies of Borg *et al.* (2021) who identified considerable knowledge regarding the effects of ET on workers' health and its consequences on productivity, the economic costs of these losses are substantial and poorly understood. According to the authors, future research that explores the relationship between ET and costs is important for creating new management policies to minimize the economic impacts arising from ET (Borg, 2021).

Considering the economic spectrum Hariyani *et al.* (2022) sought to identify knowledge regarding the agile manufacturing context of integrated green and sustainable six sigma, to create high-performance and competitive organizations. The authors identified that the context of the planet, the context of the organization, and the context of technology need to be pillars of the organization's strategic plan.

Competitiveness is a relevant topic of research due to the importance of this context for the survival of organizations. Hallioui *et al.* (2022) sought to understand these relationships and identified that there continues to be a gap in the literature so that organizations can become more contemporary and competitive.

The state of the art highlights a gap in knowledge regarding the direct relation between ET and the context of organizational competitiveness. In addition, it suggests that new studies that directly address and investigate these factors will be explored.

3 METHODOLOGY

The structure of the present study is based on the analysis and review of scientific literature, using five databases, initially limited to studies published in 2021, 2022 and 2023, as researchers are interested in the state of the art of the study topic. The model proposed by Gohr *et al.* (2013) was used which contains three methodological phases for structuring this research: research question, selection of previous works and classification of works suitable for study. Also, the protocol considered was Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), adapted from Saputra *et al.* (2024) to order the qualitative and quantitative analyzes.

The search for related works was based on the adapted strategy of Varghese *et al.* (2018), which combined the keywords and possible synonyms of the referenced study, along with words related to the theme of industrial competitiveness, obtaining two axes of Strings, the first search being related to research Q1 and the second search related to research Q2.

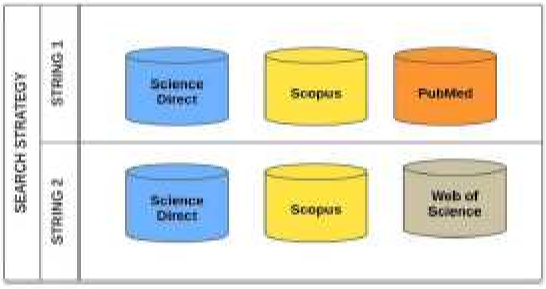
String 1: "environmental temperature" OR "environment temperature" AND "occupational injuries" AND "heat stress" AND "workplace heat exposure" OR "workplace hot temperature" AND "health and safety".

String 2: "competitiveness of industry" AND "workplace" AND "worker" OR "workers".

The present study used the databases Science Direct, Scopus, PubMed, and Web of Science. Limited to review and research articles, the bases and strings were organized as shown in Figure 1.

Figure 1

Bases used in studies.



The base PubMed was chosen to search for articles related to string 1 due to the nature of the literature published in the journal, which focuses on the areas of biomedicine, human health, life sciences, behavioral sciences, chemical sciences, and bioengineering. On the other hand, the Web of Science database was chosen for string 2, due to its breadth of coverage, containing a wide range of academic books, journals, and conference proceedings.This separation of the bases contributed to the organization of the present study, generating an alignment of the search areas with the established review method and the research questions.

The synthesis of research results is presented in two topics, the first addresses the consequences of worker exposure to high levels of ET. The second topic deals with the relations of workers affected by ET in the competitiveness of industrial organizations. In the end, the relationships found are presented in the form of a conceptual map.

3.1 METHOD OF SYSTEMATICLITERATURE REVIEW

This theoretical study started from the identification of a problem that requires answers to direct and substantiate the research spectrum. The problem was: How are the relationships between reduced worker productive capacity resulting from exposure to heat and the competitiveness of industrial organizations described in the literature? In this way, we seek to understand pre-existing knowledge regarding the effects of heat exposure on productive capacity and the influence of these consequences on the competitiveness of industrial organizations.

Research questions:

Q1: What are the consequences of worker exposure to high ET levels?

Q2: What are the relationships of these workers affected by ET in the competitiveness of industrial organizations?

Based on the adaptation of the PRISMA protocol associated with the model proposed by Gohr *et al.* (2013) the methodological steps for implementing this SLR were determined. The steps are described below.

3.2 INCLUSION AND EXCLUSION CRITERIA

Inclusion:

a) scientific articles published in the English language from January 1, 2021 to December 15, 2023 in the databases listed in Figure 1;
b) studies that address worker exposure relationships to high levels of ET;
c) studies that address the relationships between ET and workers, with the competitiveness of industrial organizations.

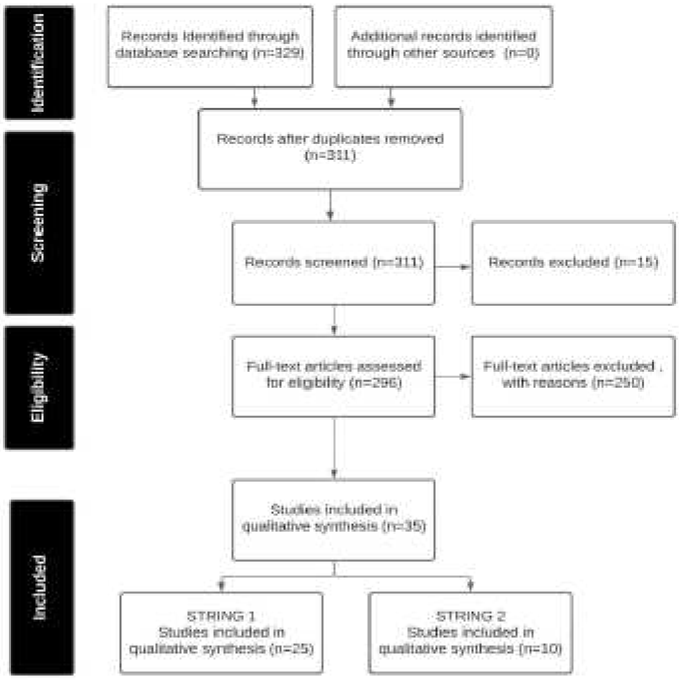
Exclusion:

a) duplicate articles in the databases;
b) articles with titles where the keywords are isolated or not contextualized to the research topic;
c) studies that do not address the relationships between ET exposure in the population outside the industrial workplace;
d) studies that address competitiveness in non-industrial organizations.

A total of 329 articles published from 2021 to 2023 were identified. After completing the steps described in Figure 2, the selected articles were divided into two string categorizations. Figure 2 illustrates the selection protocol applied.

Figure 2

PRISMA protocol for selecting studies for subsequent analysis.



Fonte: Adapted from SAPUTRA,Bibliometric Analysis of Research Publication Trends on Job Rotation Satisfaction. Revista de Gestão Social e Ambiental, 18, n. 9, p. e05312, 04/26 2024.

String 1 is related to Q1, while string 2 refers to Q2. The present SLR study identified a total of 35 documents suitable for extraction, categorizing their typology and methods used, there are 18 theoretical studies and 17 practical studies, being: 11 SLR or meta-analysis studies, 10 case studies, 5 statistical data analysis, 4 interview research, 2 experimental research, 2 longitudinal empirical research, 1 expert panel, and 1 empirical analysis.

4 RESULTS AND DISCUSSION

4.1 CONSEQUENCES OF WORKER EXPOSURE TO HIGH LEVELS OF ET

Currently, researchers are concerned (Borg *et al.*, 2023; Fatima *et al.*, 2023) regarding the topic of heat, the effects of ET on workers' health and occupational risks related to ET dominate the research objectives. Furthermore, there are projections that point to a tendency for the impact of ET on working conditions to increase in the future (Kim& Lee, 2020).

The study of Varghese *et al.* (2018) indicates that the prospect of increased heat will represent a significant growth in accidents and injuries at work, generating losses associated with workers' productive capacity. In a later case study Varghese *et al.* (2019) mapped temperature levels related to injury types. The 33.3° C Relative Risk (RR) range is classified as moderate temperatures, and the 40.6° C RR range is classified as extremely hot temperatures, however, Fatima *et al.* (2023) consider 38° C as an extreme temperature, and considering obese people or people with comorbidities, a temperature of 37.6° C is considered hyperthermia according to Flouris *et al.* (2018).

The main injuries identified are: Trauma, joint injuries, muscle injuries, burns, dermatitis, lacerations, amputations, organ injuries, symptoms of exhaustion, cramps, skin rashes, dehydration, and death (Bendak *et al.*, 2022; Samaniego-Rascón *et al.*, 2019; BENSON *et al.*, 2021; Lan *et al.*, 2022). Furthermore, there are intrinsic factors that aggravate injury levels. Varghese *et al.* (2020) and Hansen *et al.* (2018) report that some workers are unaware that heat can be related to health problems, however, studies by Carter *et al.* (2020) pointed out that 79% of workers interviewed present chronic symptoms of Heat Stress (HS), which tends to worsen when associated with other factors.

Socioeconomic condition is considered a factor that worsens the effects of HS, because Lucas *et al.* (2014) report that workers with lower socioeconomic status exceed physiological limits for heat exposure due to fear of being fired from their jobs and Fatima *et al.* (2021) point out that more experienced workers have an increased RR to injuries due to self-confidence. On the other hand, self-control can be an important tool in reducing the RR on workers' health (Lao *et al.*, 2016).

The literature shows that there is no distinction between groups among workers who may be affected by exposure to high levels of heat, according to Ansah *et al.* (2021) young, old, men or women workers suffer adverse symptoms arising from inadequate exposure to heat. What can change between groups are the type of injury and its level of intensity. Furthermore, the authors cite the existence of geographic factors in the increase in RR, as workers from tropical, subtropical regions, regions with high levels of air pollution, low and middle-income countries have a higher RR of occupational diseases arising from exposure to heat.

One of the main methods used to identify the level of ET that the worker is exposed to is mediation through the Wet Bulb Globe Temperature (WBGT) (Oliveira *et al.,* 2018). The accuracy of measurement results can be improved when combined with other measurement models such as Predicted Heat Strain (PHS), and ESI. WBGT was used by Chong *et al.* (2020) in experimental studies with controlled ET levels, with the aim of evaluating the capacity of Human Adaptation (HA) to certain temperature levels, the study suggests that HA training can reduce levels of human error and reduce the negative impacts of thermal stress. Error levels are directly linked to the worker's cognitive capacity; because Zhang *et al.* (2019) show that there is a consensus among researchers that complex tasks, such as conflict resolution, are directly affected by high levels of ET.

According to Borg *et al.* (2023) occupational injuries and illnesses have great relevance in the economic burden of treating workers' health. Mathematical projections for the future prepared by the authors indicate an increase in related costs by 2030 and 2050. In the same context Kim *et al.* (2020) project a significant reduction in production capacity in 2030 in the Republic of Korea. These economic impacts are confirmed in China by Ma *et al.* (2019), and in Australia by Ireland *et al.* (2023) and Borg *et al.* (2021). The study by Fahed *et al.* (2018) in a steel industry, in which they quantified the loss of productivity in environments with high rates of ET, arising from the radiant heat of the manufacturing process, in heavy activities the loss of productivity is between 20% and 30%. Additionally, when classifying the exposure time the authors report losses between 61% and 76%.

The articles analyzed show that workers suffer harmful effects on their health when exposed to high levels of ET (Lucas *et al.*, 2014; Hansen *et al.*, 2018; Flouris *et al.*, 2018; Varghese *et al.*, 2018; Varghese *et al.*, 2019; Varghese *et al.*, 2020; Chong *et al.*, 2020; Fatima *et al.*, 2023; Ansah *et al.*, 2021). The effects are diverse, ranging from mild symptoms such as dehydration to severe ones such as organ damage. These consequences depend on the ET levels and the physical and physiological characteristics of the individual (Samaniego-Rascón *et al.*, 2019; Carter *et al.*, 2020; Benson *et al.*, 2021; Lan *et al.*, 2022; Bendak *et al.*, 2022). These effects on worker health are reflected in the reduction of the worker's productive capacity, directly impacting their work capacity, generating loss of productivity, increased operational errors, increased costs related to workers' health treatment and a higher rate of workplace accidents (Fahed *et al*., 2018; Zhang *et al*., 2019; Ma *et al*., 2019; Kim *et al*., 2020; Borg *et al*., 2021; Borg *et al*., 2023; Ireland *et al*., 2023).

4.2 RELATIONS OF WORKERS AFFECTED BY ET IN THE COPETITIVENESS OF INDUSTRIAL ORGANIZATIONS

Acording Henao et al. (2019) one of the ways to improve the results of industrial organizations is the application of LM methods. The authors point out that LM improves the performance of organizations, generating an organizational virtuous circle. Still according to Henao et al (2019) human factors play a fundamental role in the stability of economic, social and environmental factors in organizations. In an unsafe work environment, the factor's economic and performance organizational can is afected. Furthermore, the effects compromise the productivity and competitiveness of the workers themselves Khahro *et al*. (2020) report that actions applied to improve the worker environment now play a key role in these organizations. On the other hand Leong et al. (2020) report that companies often invest in social outcomes when these actions provide competitive advantages, although social relations with workers receive little attention in organizational management. This indicates a failure in corporate strategies, as Zhu et al. (2021) project a potential reduction in worker productivity due to future HS levels.

According to Ciccarelli *et al*. (2022) there is a great use of LM tools in the search for competitiveness in manufacturing industries. In addition, the authors report the existence of several studies that address ergonomics and the design of worker-centered workplace. The studies by Ciccarelli *et al*. (2022) sought to evaluate, through a case study, the influence of 4.0 technologies in supporting the development of more ergonomic equipment.

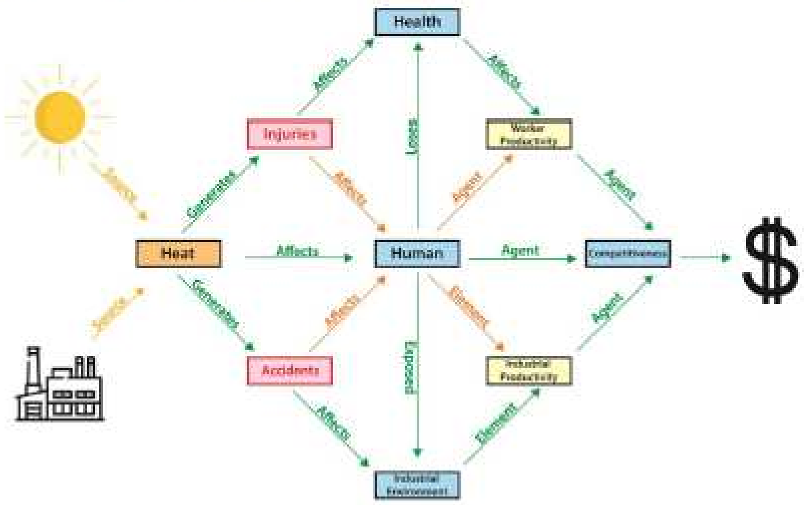
The literature shows that workers are constant actors in the competitiveness relations of industries, which is why Rumsey *et al*. (2019) address in their studies the importance of preparing and educating future professionals focused on the manufacturing industry. Investigating Georgia's educational models Rumsey *et al*. (2019) concluded that to develop labor preparation systems aimed at industry, it is essential to have partnerships between industries, government and educational institutions. Concern for workers is a sensitive topic that requires broad debate to improve organizational processes, Czornyj *et al*. (2018) record analyzes and conclusions of several experts from industrial and educational laboratories that involve greater safety in the operations carried out.

The articles analyzed show that the human being plays a key role in industrial organizations, as the human being is directly affected by environmental conditions and at the same time is an agent of environmental transformation (Czornyj*et al.*, 2018; Henao*et al.*, 2019; Rumsey *et al.*, 2019; Leong *et al.*, 2020; Ciccarelli *et al.*, 2022). Furthermore, the workplace and workers' health impact the economic axes of these organizations, as the worker's capacity has a direct relationship with the level of quality of the workplace (Khahro *et al.*, 2020; Zhu *et al.*, 2021). In this way, industrial companies adopt strategies and tools to minimize these effects, such as the standardization of processes, qualification and education of workers, LM tools and adoption of 4.0 technologies in ergonomics, especially when these actions generate a competitive advantage when compared to the competition (Henao *et al.*, 2019; Rumsey *et al.*, 2019; Leong *et al.*, 2020; Bhat *et al.*, 2021; Ciccarelli *et al.*, 2022).

As can be seen in Figure 3, the human being is at the center of the relations between ET and competitiveness, ET directly affects the human being, reducing their work capacity, the human being is the central element of the industrial environment, having a direct influence on competitiveness levels.

Figure 3

ET relations with humans and competitiveness



The research results show, through the relations of AT with humans and competitiveness, that ET is the result of the heat generated by manufacturing processes (Fahed*et al.*, 2018; Oliveira*et al.*, 2018) and external heat arising from the climate (Varghese*et al.*, 2018;

Vargheseet *al.*, 2019; Varghese *et al.*, 2020; Fatima *et al.*, 2021; Fatima *et al.*, 2023). Heat becomes an element that causes injuries and accidents in the workplace, directly affecting human beings (Bendak *et al.*, 2022; Samaniego-Rascón *et al.*, 2019; Benson *et al.*, 2021; Lan *et al.*, 2022; Borg *et al.*, 2023; Fatima *et al.*, 2023).

Injuries in turn directly affect human health, causing humans to lose their health levels (Lucas *et al.*, 2014; Hansen *et al.*, 2018; Flouris *et al.*, 2018; Varghese *et al.*, 2018; Varghese *et al.*, 2019; Varghese *et al.*, 2020; Chong et al., 2020; Fatima *et al.*, 2023; Ansah *et al.*, 2021). In the same direction, accidents affect the industrial environment, where human beings are exposed (Fahed *et al.*, 2018; Zhang *et al.*, 2019; Ma *et al.*, 2019; Kim *et al.*, 2020; Borg *et al.*, 2021; Borg *et al.*, 2023; Ireland *et al.*, 2023).

The industrial environment and the human being make up the main elements of industrial productivity, where the human being becomes an agent of productivity (Henao *et al.*, 2019; Khahro *et al.*, 2020; Bhat *et al.*, 2021). Worker productivity is the result of the productive capacity of the human being, which in turn is affected by the loss of health (Zhu *et al.*, 2021; Rumsey *et al.*, 2019; Ciccarelli *et al.*, 2022), generated by exposure to high levels of AT (Bendak *et al.*, 2022; Samaniego-Rascón *et al.*, 2019; Benson *et al.*, 2021; Lan *et al.*, 2022; Borg *et al.*, 2023; Fatima *et al.*, 2023).

In this context, the human being becomes the key point in the relations between ET and competitiveness, as the human being as an agent of worker productivity and an element of industrial productivity also becomes an agent of competitiveness (Czornyj *et al.*, 2018; Henao *et al.*, 2019; Rumsey *et al.*, 2019; Leong *et al.*, 2020; Ciccarelli *et al.*, 2022; Bhat *et al.*, 2021).

The competitiveness of industrial organizations is dependent on all agents: Human beings, worker productivity and industrial productivity. These agents are the central elements of the competitiveness of industrial organizations (Henao *et al.*, 2019; Khahro *et al.*, 2020; Leong *et al.*, 2020; Zhu *et al.*, 2021; Ciccarelli *et al.*, 2022; Bhat *et al.*, 2021; Rumsey *et al.*, 2019; Czornyj *et al.*, 2018).

5 CONCLUSIONS

There are works related to the effects of ET on working conditions, worker's productive capacity, work accidents, injuries and occupational diseases Bendak *et al.*, 2022; Samaniego-Rascón *et al.*, 2019; Benson *et al.*, 2021; Lan *et al.*, 2022; Borg *et al.*, 2023; Fatima *et al.*, 2023). Given this, we conclude that there is full knowledge of the impacts of heat on workers' health, but there is no work that point to a direct relations between ET and competitiveness. However, evidence indicates that exposure factors are partly neglected; the affected population lacks awareness of the risks and public and private risk mitigation policies.

When looking at the topic of competitiveness, it is clear that ET is not seen by industrial organizations as a factor that reduces competitiveness, as no studies were found in the literature that directly address the influence of ET on the competitive capacity of industrial organizations. On the other hand, there is robust information on how workers are affected by ET. The costs related to injuries and occupational health are high, in addition, there is clear evidence of the reduction in workers' productive capacity due to the effects on their health.

This work highlights a gap in the scientific literature and organizational strategies in the search for competitiveness. As the main actors in the manufacturing process, workers, who are mostly affected by exposure to ET, are not seen as elements sensitive to environmental risk. Studies related to the theme of competitiveness aim to improve processes through the application of quality tools, insertion of 4.0 technologies and LM concepts (Henao *et al*., 2019; Rumsey *et al*., 2019; Leong *et al*., 2020; Bhat *et al*., 2021; Ciccarelli *et al*., 2022). Not considering the thermal influences of the environment as a possible root cause for low competitive capacity.

The study suggests further research to directly address the impact of heat exposure (TE) on the ability of industrial organizations to achieve high levels of competitiveness. Furthermore, it is recommended that these organizations treat the impacts of heat on workers as a public health problem and include a response to heat stress as a point of analysis in their strategic planning.

The documents analyzed fulfill the objective of understanding how the relationship between the reduction in the productive capacity of workers due to heat exposure and the competitiveness of industrial organizations is described in the literature. The study also highlights the central role of human beings in the competitiveness of industries.

The relationships revealed indicate that TE has indirect impacts on competitiveness. TE affects both humans and the industrial environment, which in turn have direct relationships with competitiveness, as the latter depends on environmental conditions and human capabilities.

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APÊNDICE A - Relatórios de medição WBGT

Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

Empresa avaliada: Indústria Embalagens Setor: Impressão	Empresa avaliadora: Realizado por: André Santos

Ensaio

Data: 07/02/2024 Duração: 06:07:43 Início: 11:00:32	Tempo em pausa: 00:00:00 Fim: 17:00:32

Resultado da avaliação

Índice do instrumento	Modelo do instrumento	IBUTGi	IBUTGe
1	PROTEMP 4	35,00	34,90

Observações

André Santos
Registro: Day11

Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

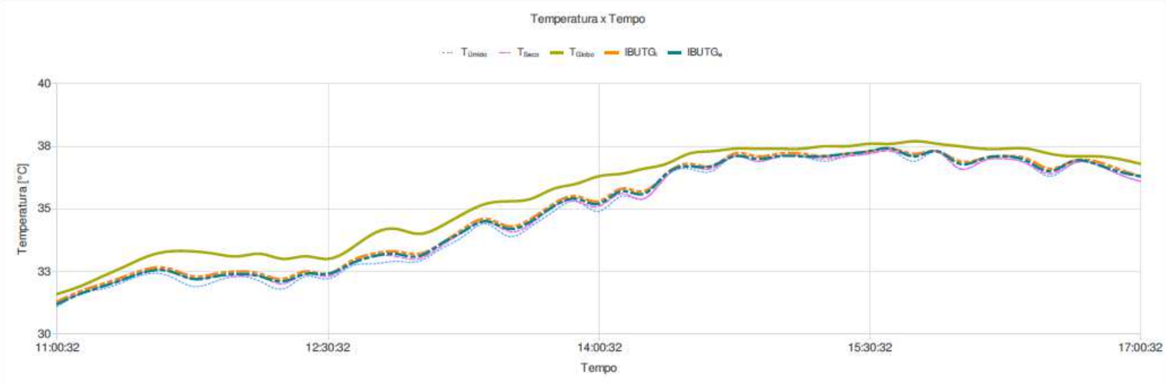
Informações do instrumento

PROTEMP 4(019050073)
Cert. cal.: CRL0860/2023 16/05/2023

Resultados parciais

Bulbo seco [°C]	Bulbo úmido [°C]	Globo [°C]	IBUTGi [°C]	IBUTGe [°C]
Máx: 37,40	Máx: 37,40	Máx: 37,70	Média: 35,00	Média: 34,90
Min: 31,30	Min: 31,10	Min: 31,30		

Gráfico



Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

Empresa avaliada: Indústria Embalagens Setor: Impressão	Empresa avaliadora: Realizado por: André Santos

Ensaio

Data: 15/02/2024 Duração: 06:02:50 Início: 10:31:37	Tempo em pausa: 00:00:00 Fim: 16:24:07

Resultado da avaliação

Índice do instrumento	Modelo do instrumento	IBUTGi	IBUTGe
1	PROTEMP 4	30,40	30,40

Observações

André Santos
Registro: Day16

Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

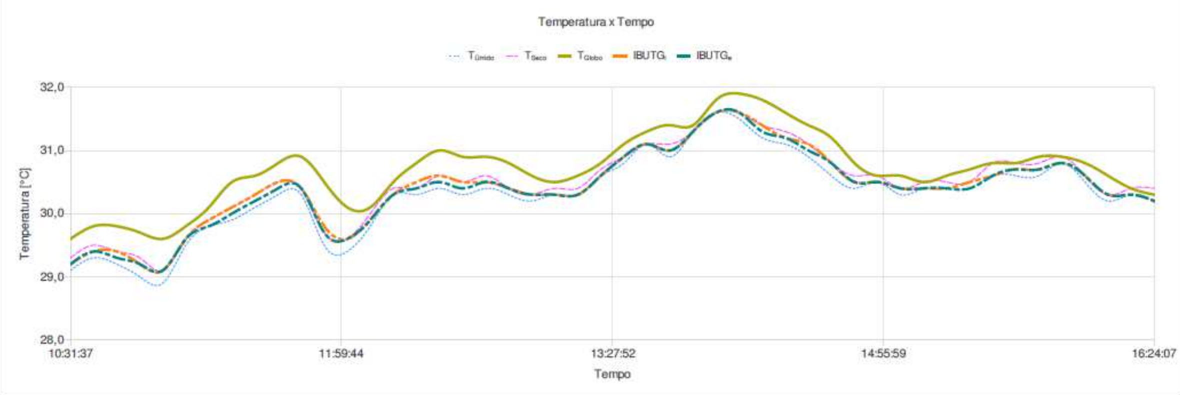
Informações do instrumento

PROTEMP 4(019050073)
Cert. cal.: CRL0860/2023 16/05/2023

Resultados parciais

Bulbo seco [°C]	Bulbo úmido [°C]	Globo [°C]	IBUTGi [°C]	IBUTGe [°C]
Máx: 31,80	Máx: 31,60	Máx: 31,90	Média: 30,40	Média: 30,40
Mín: 29,10	Mín: 28,90	Mín: 29,30		

Gráfico



Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

Empresa avaliada: Indútria Embalagens	Empresa avaliadora:
Setor: Impressão	Realizado por: André Santos

Ensaio

Data: 16/02/2024	
Duração: 06:14:31	Tempo em pausa: 00:00:00
Início: 10:09:05	Fim: 16:09:04

Resultado da avaliação

Índice do instrumento	Modelo do instrumento	IBUTGi	IBUTGe
1	PROTEMP 4	27,00	27,00

Observações

André Santos
Registro: Day17

Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

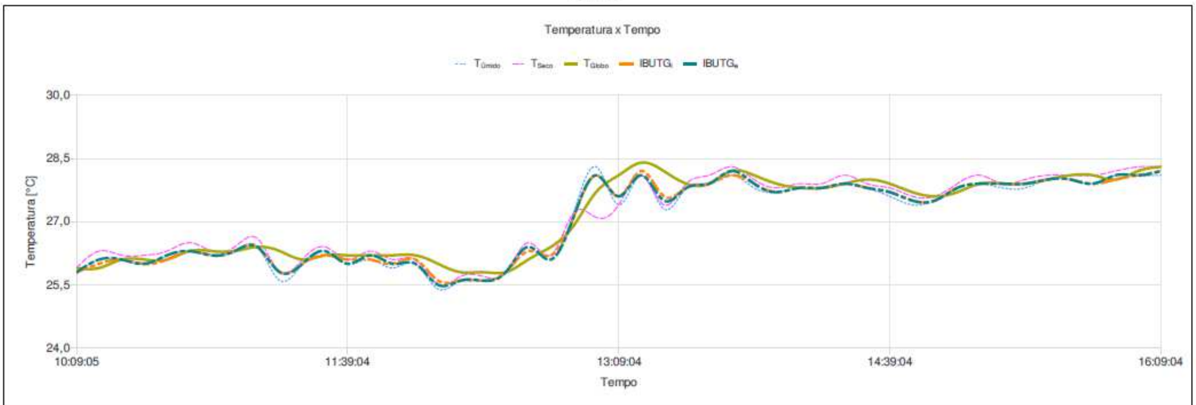
Informações do instrumento

PROTEMP 4(019050073)
Cert. cal.: CRL0860/2023 16/05/2023

Resultados parciais

Bulbo seco [°C]	Bulbo úmido [°C]	Globo [°C]	IBUTGi [°C]	IBUTGe [°C]
Máx: 28,30	Máx: 31,80	Máx: 28,50	Média: 27,00	Média: 27,00
Mín: 25,40	Mín: 25,30	Mín: 25,70		

Gráfico



Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

Empresa avaliada: Indústria de Embalagens Setor: Impressão	Empresa avaliadora: Realizado por: Cassius Xavier

Ensaio

Data: 24/01/2024 Duração: 06:44:02 Início: 09:30:04	Tempo em pausa: 00:00:00 Fim: 16:09:04

Resultado da avaliação

Índice do instrumento	Modelo do instrumento	IBUTGi	IBUTGe
1	PROTEMP 4	29,90	29,90

Observações

Dia parcialmente nublado com pancadas de chuva no início da tarde.

André Luiz dos Santos
Registro: Day 1

Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

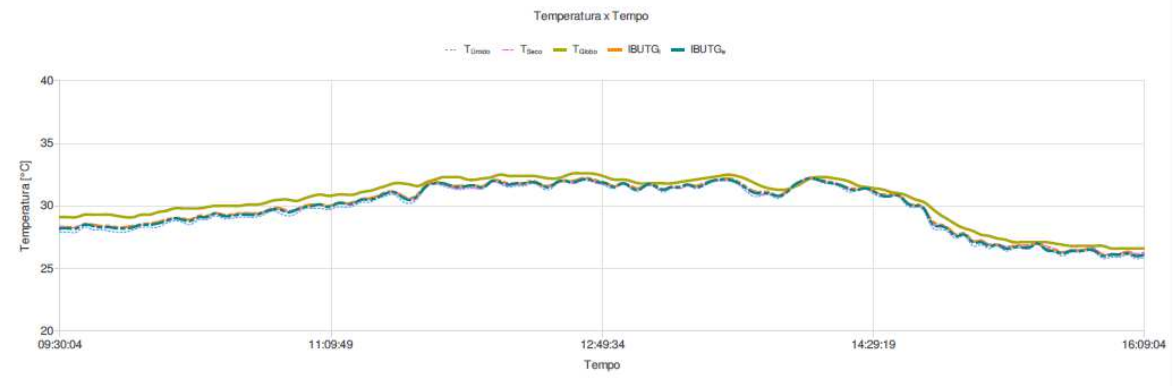
Informações do instrumento

PROTEMP 4(019050073)
Cert. cal.: CRL0860/2023 16/05/2023

Resultados parciais

Bulbo seco [°C]	Bulbo úmido [°C]	Globo [°C]	IBUTGi [°C]	IBUTGe [°C]
Máx: 32,30	Máx: 32,30	Máx: 32,70	Média: 29,90	Média: 29,90
Mín: 25,90	Mín: 25,60	Mín: 26,50		

Gráfico



Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

Empresa avaliada: Indústria de Embalagens Setor: Impressão	Empresa avaliadora: Realizado por: Cassius Xavier

Ensaio

Data: 25/01/2024 Duração: 07:00:35 Início: 09:50:13	Tempo em pausa: 00:00:00 Fim: 16:47:13

Resultado da avaliação

Índice do instrumento	Modelo do instrumento	IBUTGi	IBUTGe
1	PROTEMP 4	31,10	31,10

Observações

Dia ensolarado sem presença de nuvens

André Luiz dos Santos
Registro: Day2

Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

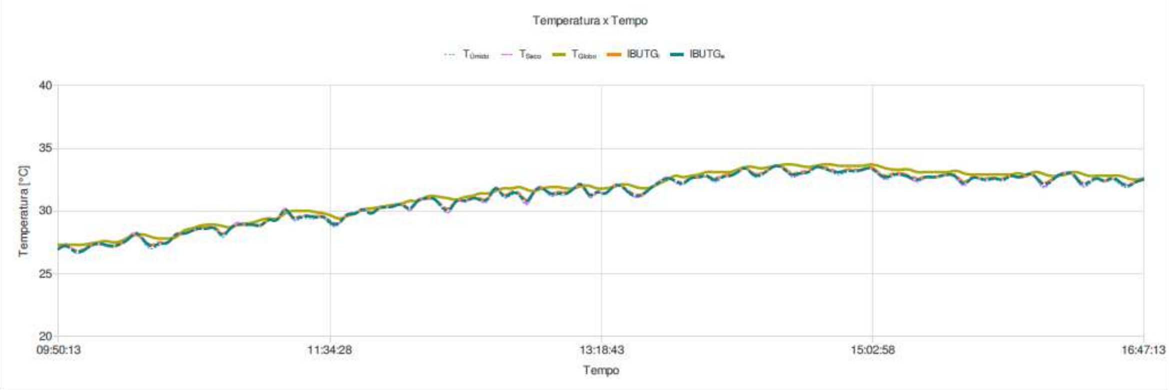
Informações do instrumento

PROTEMP 4(019050073)
Cert. cal.: CRL0860/2023 16/05/2023

Resultados parciais

Bulbo seco [°C]	Bulbo úmido [°C]	Globo [°C]	IBUTGi [°C]	IBUTGe [°C]
Máx: 33,80	Máx: 33,70	Máx: 33,80	Média: 31,10	Média: 31,10
Min: 26,80	Min: 26,60	Min: 27,20		

Gráfico



Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

Empresa avaliada: Indústria de Embalgens
Setor: Impressão

Empresa avaliadora:
Realizado por: André Santos

Ensaio

Data: 26/01/2024
Duração: 06:56:08
Início: 10:00:07

Tempo em pausa: 00:00:00
Fim: 16:51:07

Resultado da avaliação

Índice do instrumento	Modelo do instrumento	IBUTGi	IBUTGe
1	PROTEMP 4	30,80	30,80

Observações

André Santos
Registro: Day3

Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

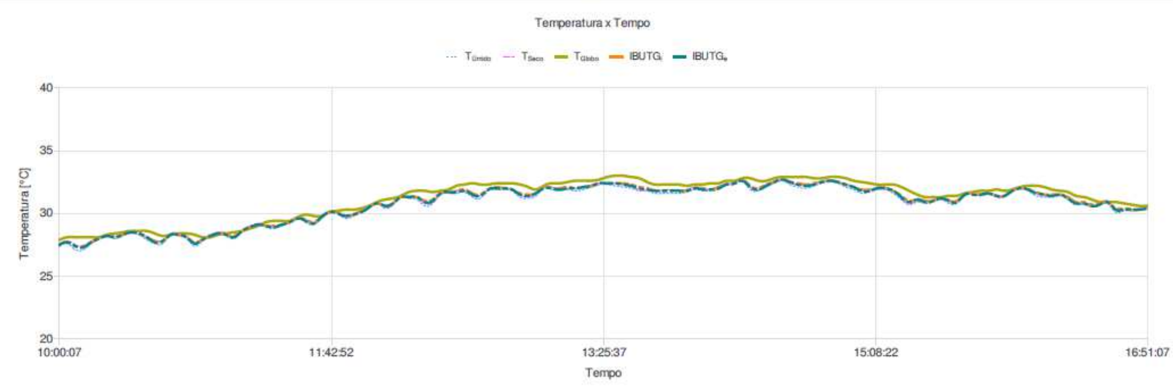
Informações do instrumento

PROTEMP 4(019050073)
Cert. cal.: CRL0860/2023 16/05/2023

Resultados parciais

Bulbo seco [°C]	Bulbo úmido [°C]	Globo [°C]	IBUTGi [°C]	IBUTGe [°C]
Máx: 32,80	Máx: 32,60	Máx: 33,10	Média: 30,80	Média: 30,80
Min: 27,30	Min: 26,90	Min: 27,60		

Gráfico



Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

Empresa avaliada: Indústria de Embalagens Setor: Impressão	Empresa avaliadora: Realizado por: André Santos

Ensaio

Data: 29/01/2024 Duração: 06:23:43 Início: 10:02:15	Tempo em pausa: 00:00:00 Fim: 16:20:15

Resultado da avaliação

Índice do instrumento	Modelo do instrumento	IBUTGi	IBUTGe
1	PROTEMP 4	33,30	33,30

Observações

André Santos
Registro: Day4

Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

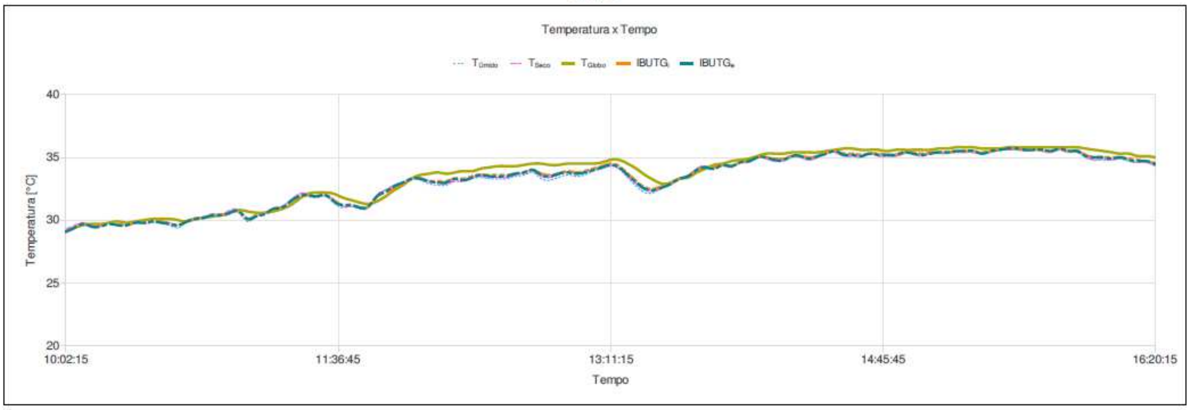
Informações do instrumento

PROTEMP 4(019050073)
Cert. cal.: CRL0860/2023 16/05/2023

Resultados parciais

Bulbo seco [°C]	Bulbo úmido [°C]	Globo [°C]	IBUTGi [°C]	IBUTGe [°C]
Máx: 35,80	Máx: 35,70	Máx: 35,80	Média: 33,30	Média: 33,30
Mín: 28,90	Mín: 28,90	Mín: 29,00		

Gráfico



Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

Empresa avaliada: industria Plástica Setor: Impressão	Empresa avaliadora: Realizado por: André Santos

Ensaio

Data: 30/01/2024 Duração: 06:40:18 Início: 10:06:14	Tempo em pausa: 00:00:00 Fim: 16:42:14

Resultado da avaliação

Índice do instrumento	Modelo do instrumento	IBUTGi	IBUTGe
1	PROTEMP 4	34,40	34,30

Observações

André Santos
Registro: Day5

Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

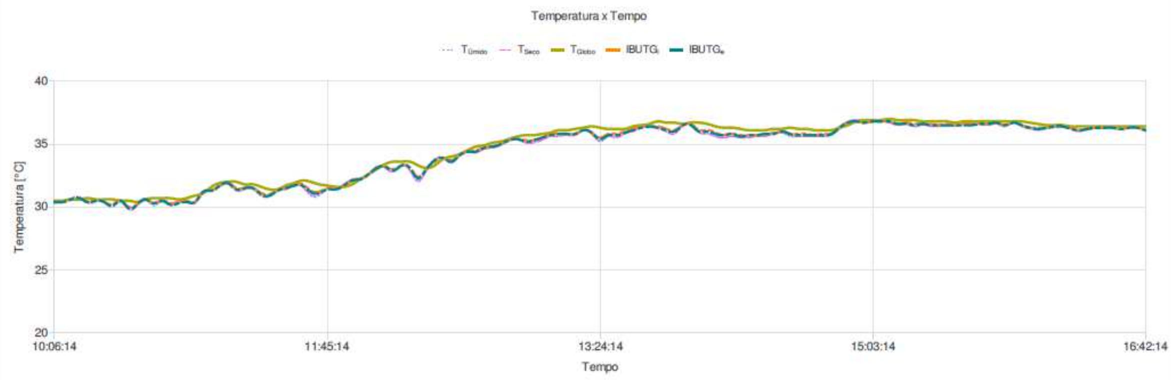
Informações do instrumento

PROTEMP 4(019050073)
Cert. cal.: CRL0860/2023 16/05/2023

Resultados parciais

Bulbo seco [°C]	Bulbo úmido [°C]	Globo [°C]	IBUTGi [°C]	IBUTGe [°C]
Máx: 36,90	Máx: 37,00	Máx: 37,00	Média: 34,40	Média: 34,30
Mín: 29,80	Mín: 29,60	Mín: 30,40		

Gráfico



Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

Empresa avaliada: Indústria Embalagens	Empresa avaliadora:
Setor: Laminação	Realizado por: André Santos

Ensaio

Data: 01/02/2024	
Duração: 07:06:13	Tempo em pausa: 00:00:00
Início: 10:02:08	Fim: 17:05:08

Resultado da avaliação

Índice do instrumento	Modelo do instrumento	IBUTGi	IBUTGe
1	PROTEMP 4	34,30	34,30

Observações

André Santos
Registro: Day7

Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

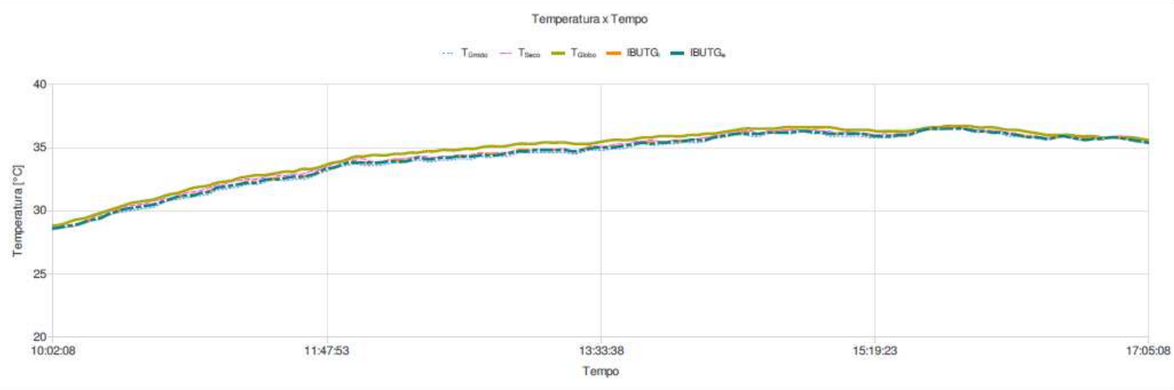
Informações do instrumento

PROTEMP 4(019050073)
Cert. cal.: CRL0860/2023 16/05/2023

Resultados parciais

Bulbo seco [°C]	Bulbo úmido [°C]	Globo [°C]	IBUTGi [°C]	IBUTGe [°C]
Máx: 36,70	Máx: 36,50	Máx: 36,80	Média: 34,30	Média: 34,30
Mín: 28,70	Mín: 28,40	Mín: 28,60		

Gráfico



Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

Empresa avaliada: Indústria Embalagens Setor: Laminação	Empresa avaliadora: Realizado por: André Santos

Ensaio

Data: 02/02/2024 Duração: 06:56:42 Início: 10:07:39	Tempo em pausa: 00:00:00 Fim: 16:52:39

Resultado da avaliação

Índice do instrumento	Modelo do instrumento	IBUTGi	IBUTGe
1	PROTEMP 4	34,60	34,50

Observações

André Santos
Registro: Day8

Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

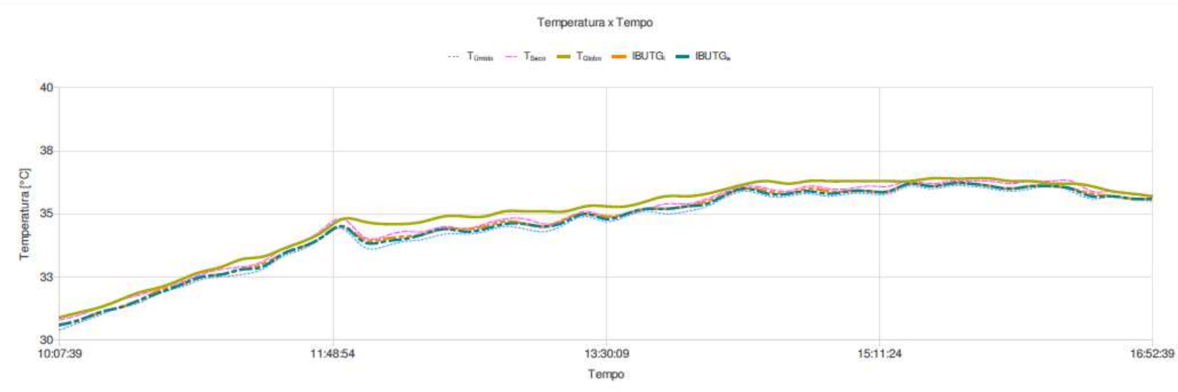
Informações do instrumento

PROTEMP 4(019050073)
Cert. cal.: CRL0860/2023 16/05/2023

Resultados parciais

Bulbo seco [°C]	Bulbo úmido [°C]	Globo [°C]	IBUTGi [°C]	IBUTGe [°C]
Máx: 36,40 Mín: 30,60	Máx: 36,20 Mín: 30,20	Máx: 36,40 Mín: 30,60	Média: 34,60	Média: 34,50

Gráfico



Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

Empresa avaliada: Indústria Embalagens Setor: Laminação	Empresa avaliadora: Realizado por: André Santos

Ensaio

Data: 05/02/2024 Duração: 06:39:04 Início: 10:25:08	Tempo em pausa: 00:00:00 Fim: 16:55:08

Resultado da avaliação

Índice do instrumento	Modelo do instrumento	IBUTGi	IBUTGe
1	PROTEMP 4	34,20	34,20

Observações

André Santos
Registro: Day9

Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

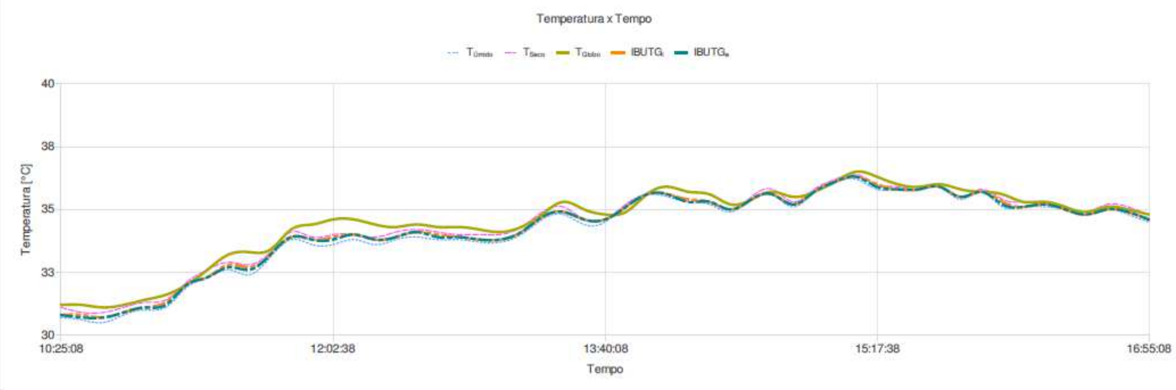
Informações do instrumento

PROTEMP 4(019050073)
Cert. cal.: CRL0860/2023 16/05/2023

Resultados parciais

Bulbo seco [°C]	Bulbo úmido [°C]	Globo [°C]	IBUTGi [°C]	IBUTGe [°C]
Máx: 36,50	Máx: 36,30	Máx: 36,50	Média: 34,20	Média: 34,20
Min: 30,80	Min: 30,50	Min: 30,80		

Gráfico



Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

Empresa avaliada: Indústria Embalagens	Empresa avaliadora:
Setor: Laminação	Realizado por: André Santos

Ensaio

Data: 06/02/2024	
Duração: 06:41:18	Tempo em pausa: 00:00:00
Início: 10:34:12	Fim: 17:04:12

Resultado da avaliação

Índice do instrumento	Modelo do instrumento	IBUTGi	IBUTGe
1	PROTEMP 4	34,20	34,20

Observações

André Santos
Registro: Day9

Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

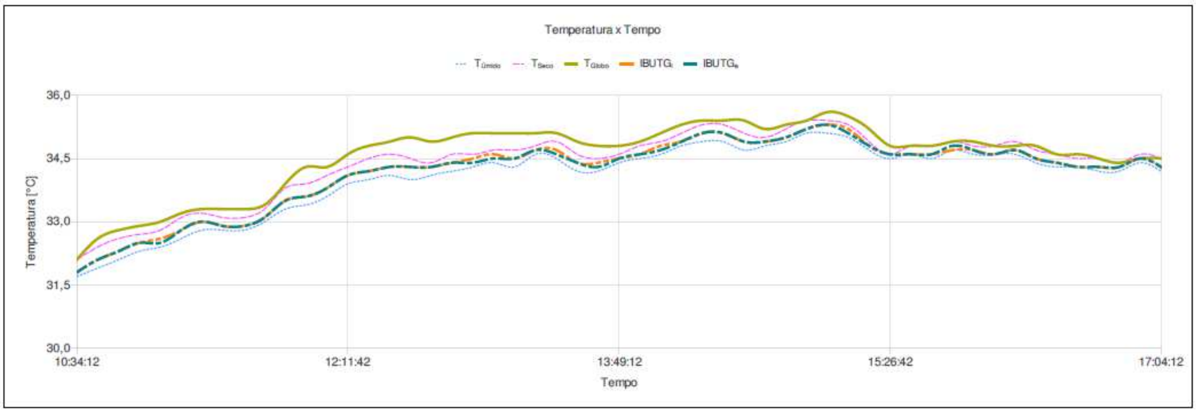
Informações do instrumento

PROTEMP 4(019050073)
Cert. cal.: CRL0860/2023 16/05/2023

Resultados parciais

Bulbo seco [°C]	Bulbo úmido [°C]	Globo [°C]	IBUTGi [°C]	IBUTGe [°C]
Máx: 35,40	Máx: 35,20	Máx: 35,60	Média: 34,20	Média: 34,20
Min: 31,60	Min: 31,30	Min: 31,50		

Gráfico



Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

Empresa avaliada: Indústria Embalagens Setor: Laminação	Empresa avaliadora: Realizado por: André Santos

Ensaio

Data: 31/01/2024 Duração: 07:27:34 Início: 09:39:52	Tempo em pausa: 00:00:00 Fim: 17:03:52

Resultado da avaliação

Índice do instrumento	Modelo do instrumento	IBUTGi	IBUTGe
1	PROTEMP 4	34,40	34,40

Observações

André Santos
Registro: Day6

Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

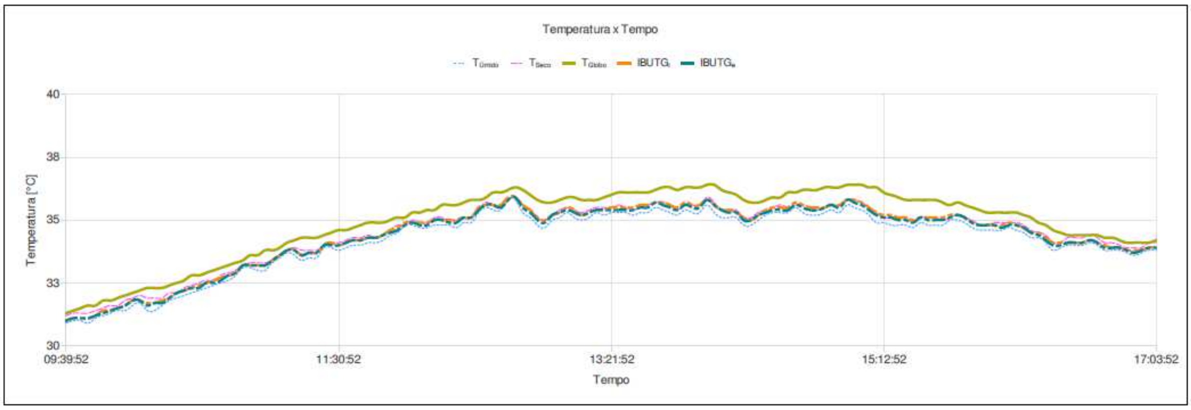
Informações do instrumento

PROTEMP 4(019050073)
Cert. cal.: CRL0860/2023 16/05/2023

Resultados parciais

Bulbo seco [°C]	Bulbo úmido [°C]	Globo [°C]	IBUTGi [°C]	IBUTGe [°C]
Máx: 36,00	Máx: 35,80	Máx: 36,40	Média: 34,40	Média: 34,40
Min: 31,10	Min: 30,80	Min: 31,10		

Gráfico



Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

Empresa avaliada: Industria Embalagens Setor: Rebobinagem	Empresa avaliadora: Realizado por: André Santos

Ensaio

Data: 08/02/2024 Duração: 06:56:47 Início: 10:16:08	Tempo em pausa: 00:00:00 Fim: 17:01:08

Resultado da avaliação

Índice do instrumento	Modelo do instrumento	IBUTGi	IBUTGe
1	PROTEMP 4	36,80	36,70

Observações

André Santos
Registro: Day11

Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

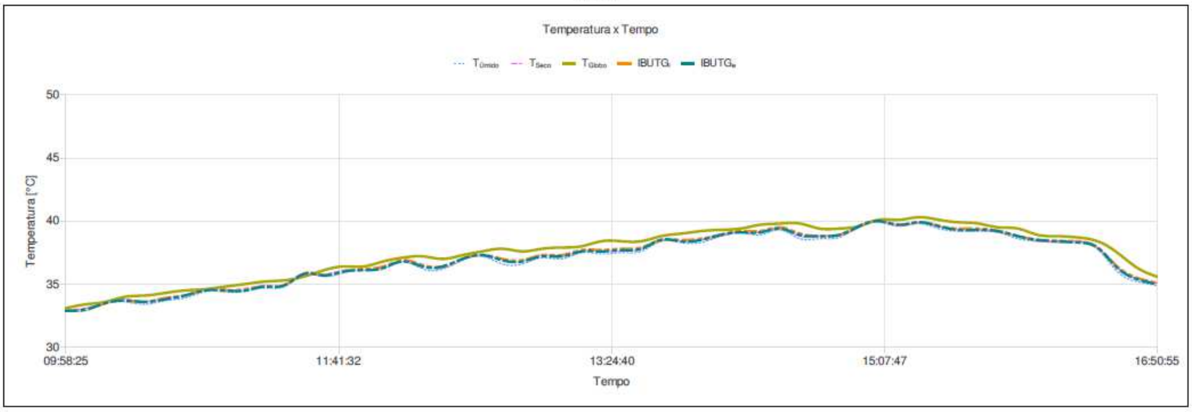
Informações do instrumento

PROTEMP 4(019050073)
Cert. cal.: CRL0860/2023 16/05/2023

Resultados parciais

Bulbo seco [°C]	Bulbo úmido [°C]	Globo [°C]	IBUTGi [°C]	IBUTGe [°C]
Máx: 40,00	Máx: 40,00	Máx: 40,30	Média: 37,10	Média: 37,00
Mín: 32,70	Mín: 32,50	Mín: 32,70		

Gráfico



Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

Empresa avaliada: Indústria Embalgens	Empresa avaliadora:
Setor: Rebobinagem	Realizado por: André Santos

Ensaio

Data: 09/02/2024	
Duração: 07:02:00	Tempo em pausa: 00:00:00
Início: 09:58:25	Fim: 16:50:55

Resultado da avaliação

Índice do instrumento	Modelo do instrumento	IBUTGi	IBUTGe
1	PROTEMP 4	37,10	37,00

Observações

André Santos
Registro: Day12

Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

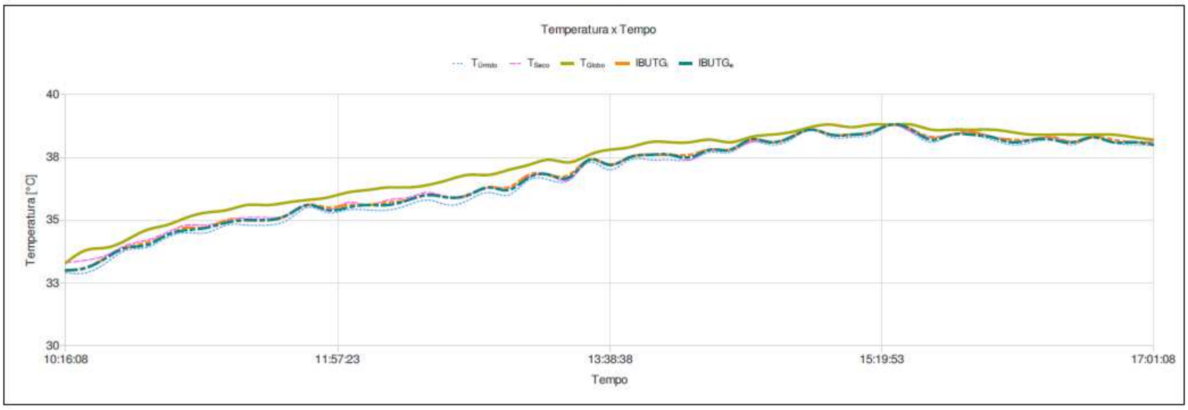
Informações do instrumento

PROTEMP 4(019050073)
Cert. cal.: CRL0860/2023 16/05/2023

Resultados parciais

Bulbo seco [°C]	Bulbo úmido [°C]	Globo [°C]	IBUTGi [°C]	IBUTGe [°C]
Máx: 38,80	Máx: 38,80	Máx: 38,90	Média: 36,80	Média: 36,70
Mín: 32,70	Mín: 32,40	Mín: 32,60		

Gráfico



Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

Empresa avaliada: Indústria Embalagens Setor: Rebobinagem	Empresa avaliadora: Realizado por: André Santos

Ensaio

Data: 12/02/2024 Duração: 07:03:12 Início: 10:20:41	Tempo em pausa: 00:00:00 Fim: 17:13:11

Resultado da avaliação

Índice do instrumento	Modelo do instrumento	IBUTGi	IBUTGe
1	PROTEMP 4	38,50	38,40

Observações

André Santos
Registro: Day13

Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

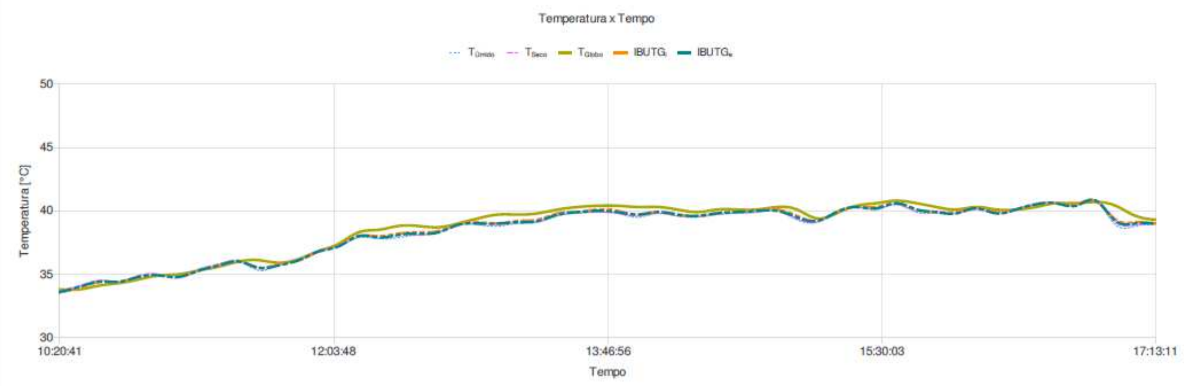
Informações do instrumento

PROTEMP 4(019050073)
Cert. cal.: CRL0860/2023 16/05/2023

Resultados parciais

Bulbo seco [°C]	Bulbo úmido [°C]	Globo [°C]	IBUTGi [°C]	IBUTGe [°C]
Máx: 40,80 Mín: 33,60	Máx: 40,90 Mín: 33,50	Máx: 40,80 Mín: 33,70	Média: 38,50	Média: 38,40

Gráfico



Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

Empresa avaliada: Indústria Embalagens Setor: Rebobinagem	Empresa avaliadora: Realizado por: André Santos

Ensaio

Data: 13/02/2024 Duração: 06:48:48 Início: 09:59:27	Tempo em pausa: 00:00:00 Fim: 16:36:57

Resultado da avaliação

Índice do instrumento	Modelo do instrumento	IBUTGi	IBUTGe
1	PROTEMP 4	27,80	27,80

Observações

André Santos
Registro: Day14

Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

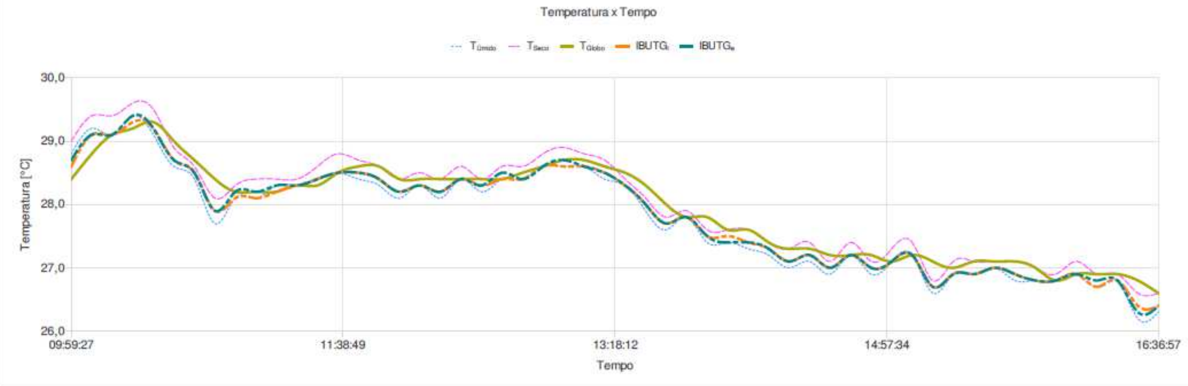
Informações do instrumento

PROTEMP 4(019050073)
Cert. cal.: CRL0860/2023 16/05/2023

Resultados parciais

Bulbo seco [°C] Máx: 29,60 Min: 26,40	Bulbo úmido [°C] Máx: 29,40 Min: 26,10	Globo [°C] Máx: 29,30 Min: 26,50	IBUTGi [°C] Média: 27,80	IBUTGe [°C] Média: 27,80

Gráfico



Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

Empresa avaliada: Indústria Embalagens Setor: Rebobinagem	Empresa avaliadora: Realizado por: André Santos

Ensaio

Data: 14/02/2024 Duração: 07:00:10 Início: 10:11:45	Tempo em pausa: 00:00:00 Fim: 17:04:15

Resultado da avaliação

Índice do instrumento	Modelo do instrumento	IBUTGi	IBUTGe
1	PROTEMP 4	30,10	30,10

Observações

André Santos
Registro: Day15

Relatório Protemp 4 @ PROTEMP 4 SN: 019050073

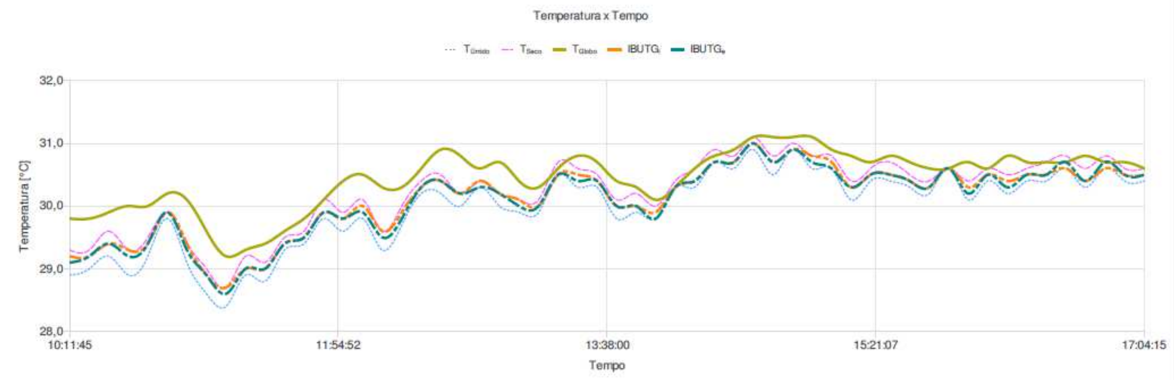
Informações do instrumento

PROTEMP 4(019050073)
Cert. cal.: CRL0860/2023 16/05/2023

Resultados parciais

Bulbo seco [°C] Máx: 31,10 Min: 28,50	Bulbo úmido [°C] Máx: 31,00 Min: 28,20	Globo [°C] Máx: 31,20 Min: 29,10	IBUTGi [°C] Média: 30,10	IBUTGe [°C] Média: 30,10

Gráfico



APÊNDICE B - Matriz de trabalhos base para o estudo de caso

MATRIZ DE TRABALHOS BASE PARA O ESTUDO DE CASO

TEMA	TÍTULO	MÉTODO	OBJETIVO
Temperatura Ambiente X Segurança Ocupacional	**Climate change and its effects on farm workers**	Análise de dados ambientais de 215 estações meteorológicas sinóticas coletando dados em três regiões climáticas (quente, ameno e frio). Uso de software matemático MATLAB R 2018b com base nos valores padrão ASHRAE/ISO7730, projetando alguns cenários, o índice de votação média prevista (PMV) e, em seguida, o índice de produtividade do trabalho foram estimados.	Determinar os efeitos do clima na produtividade dos recursos humanos.
	Occupational heat stress and economic burden: A review of global evidence	Revisão sistemática da literatura (LSR) utilizando software PubMed, Embase e Scopus para identificar artigos de periódicos científicos revisados por pares	Resumir a literatura que investiga as associações entre estresse ocupacional por calor e sobrecarga econômica
	Outdoor ambient temperatures and occupational injuries and illnesses: Are there risk differences in various regions within a city?	Análise de série temporal combinados com modelos não lineares de atraso distribuído (DLNMs) para projetar o risco de lesões e doenças ocupacionais em clima semi-árido frio e clima quente.	Analisar a relação exposição-resposta entre temperaturas ambientes nas lesões e doenças ocupacionais (OI) na escala intra-cidade.

	Impact of climate change on occupational health and safety: A review of methodological approaches	Mapeamento sistemático (SM) realizado em sete bases de dados científicas internacionais: Emerald, IEEE Xplore, Science Direct, Scielo, Scopus, SpringerLink e Web of Science. Três questões de pesquisa orientaram o processo de extração resultando em 170 artigos sobre os impactos das mudanças climáticas na saúde e segurança ocupacional.	Avaliar os impactos das mudanças climáticas na saúde, segurança e desempenho dos trabalhadores, identificando os riscos ocupacionais e os locais de trabalho afetados buscando abordagens metodológicas para tratar o problema.
	Impact of rising temperatures on occupational accidents in Brazil in the period 2006 to 2019: A multiple correspondence analysis	Análise de variáveis dos registros de acidentes com as variáveis climáticas utilizando o método estatístico denominado MCA , trata-se de uma técnica multivariada e extensão da análise de correspondência (CA).	Analisar a relação entre dados climáticos e dados de saúde e segurança ocupacional.
	Perceptions of workplace heat exposure and adaption behaviors among Chinese construction workers in the context of climate change	Pesquisa de questionário on-line transversal via WeChat Survey Star com uma abordagem de amostragem intencional de bola de neve	Investigar as percepções e comportamentos de adaptação à exposição ao calor nos trabalhadores da construção civil e fornecer evidências para o desenvolvimento de estratégias de adaptação aos efeitos do calor.
	The relations of job stress dimensions to safety climate and accidents occurrence among the workers	Aplicação de questionários, tratamento de dados através da análise de correlação, modelos de regressão e coeficiente alfa de Cronbach, utilizando software SPSS versão 24	Investigar as relações de trabalho, stress ao clima de segurança e acidente de trabalho.

	Climate Warming and Occupational Heat and Hot Environment Standards in Thailand	Pesquisa exploratória com trabalhadores da construção civil e indústria de fundição, medições WBGT do ambiente laboral e entrevista com trabalhadores.	Explorar se o padrão de exposição ocupacional ao calor fornece ou não proteção ao trabalhador.
	INFLUENCE OF CLIMATE CHANGE ON WORKING CONDITIONS IN THE LATE 21ST CENTURY X1 - INFLUÊNCIA DAS MUDANÇAS CLIMÁTICAS SOBRE AS CONDIÇÕES DE TRABALHO NO FINAL DO SÉCULO XXI	Utilização de oito modelos climáticos Coupled*Model Intercomparison Project Phase 5* (CMIP5), CSIRO-Mk3.6.0,GFDL-ESM2G, GFDL-ESM2M, IPSL-CM5A-LR, IPSL-CM5A-MR,MIROC5, MIROC-ESM-CHEM e MRI-CGCM3, para projetar cenários.	Projetar modelos matemáticos visando avaliar as possíveis influências das mudanças climáticas sobre as condições de trabalho ao ar livre para o final do século XXI
Temperatura Ambiente X Competitividade	**Lean Six Sigma competitiveness for micro, small and medium enterprises (MSME): an action research in the Indian context**	Pesquisa de Ação (RA) para desenvolver um estudo de caso usando a abordagem LSS DMAIC	Entender as implicações gerenciais na implantação da competitividade Lean Six Sigma (LSS) para micro, pequenas e médias empresas (MPME)
	Global Inclusive and Sustainable Competitive Industrial Performance (ISCIP): An efficiency based spatio-temporal analysis for 139 countries	Aplicação de um modelo de Data EnvelopmentAnalysis (DEA) de eficiência cruzada para avaliar o ISCIP por rendimento e grupos geográficos com uma análise espaço-temporal do ISCIP para 139 países de 2010–2019.	Ampliar o escopo do Índice de Desempenho Industrial Competitivo da Organização das Nações Unidas para o Desenvolvimento Industrial
	Impacts of climate change on the livestock food supply chain; a review of the evidence.	Revisão do conceito de risco de impactos relacionados ao clima, do Grupo de Trabalho II do Painel Intergovernamental sobre Mudanças Climáticas (IPCC).	Analisar o risco de impactos relacionados ao clima na cadeia de suprimentos de alimentos.

	Competitividade: conceitos e medidas: uma resenha da bibliografia recente com ênfase no caso brasileiro	Resenha de bibliografia com ênfase no Brasil	Conceituar a competitividade, desempenho, eficiência, qualidade, tecnologia, salários, produtividade e condições de produção no cenário Brasileiro.
	Drivers for the adoption of integrated sustainable green lean six sigma agile manufacturing system (ISGLSAMS) and research directions	Revisão sistemática da literatura (LSR) com abordagem qualitativa de análise.	Identificar os Impulsionadores para a adoção de um sistema de manufatura ágil integrado, sustentável, verde enxuto seis sigma (ISGLSAMS) com base na revisão da bibliografia.
	Positive impacts of lean manufacturing tools on sustainability aspects: a systematic review	Revisão sistemática da literatura (LSR) com etapas de planejamento, condução e estágio de relatório.	Identificar os feitos positivos das ferramentas de manufatura enxuta (LM) nos aspectos de sustentabilidade
	The effect of firms' environmentally sustainable practices on economic performance	Pesquisa de questionário fechado com trabalhadores de manufatura, tratamento de dados pelo software SmartPLS	Explorar os efeitos das práticas ambientalmente sustentáveis nos ambientes de manufatura.
	Eco Lean Management – Recent Progress, Experiences and Perspectives	Análise holística do tema no meio acadêmico	Entender o nível de abrangência e entendimento do conceito Eco-Lean no meio acadêmico
	A competitividade das empresas do setor de embalagens para alimentos: um estudo de caso	Estudo de caso na indústria utilizando o modelo de Ecib, avaliando os fatores internos à empresa, fatores setoriais ou estruturais e fatores de natureza sistêmica, analisando variáveis quantitativas pelo período de um ano.	Identificar e avaliar fatores determinantes a competitividade das indústrias do segmento.
Temperatura ambiente X Indústria de Embalagens	**Waste management and competitiveness of firms in Europe: A stochastic frontier approach**	Modelagem estatística e probabilística	Investigar a relação entre as taxas de reciclagem alcançadas e a competitividade das empresas que trabalham em setores da economia circular.

	Assessment of the effectiveness and efficiency of packaging waste EPR schemes in Europe.	Análise de regressão de indicadores da relação custo-benefício e da eficácia da reciclagem das Organizações de Responsabilidade do Produtor (PROs) específicas.	Analisar o desempenho dos sistemas europeus de resíduos de embalagens, com foco nos esquemas de responsabilidade estendida do produtor e nas organizações de responsabilidade do produtor.
	Packaging plastic waste management in the cosmetic industry	Estudo de caso, identificação do problema, construção de uma estrutura modelo de comparação formulando um modelo qualitativo, definindo problemas dinamicamente	Explorar a relação entre as diversas variáveis presentes na embalagem sistema de gerenciamento de resíduos plásticos na indústria cosmética.
	Systems-based approach to contemporary business management: An enabler of business sustainability in a context of industry 4.0, circular economy, competitiveness and diverse stakeholders	Revisão sistemática da literatura (LSR) contendo duas etapas, a primeira baseada em sistemas e a segunda uma análise qualitativa dos trabalhos relacionados	Relacionar a sustentabilidade nunca ao estilo de gestão do negócio como um sistema.
	Implementation of 5S in a plastic bag manufacturing industry: A case study	Abordagem 5S em uma indústria de embalagens plástica, análise do fluxo de trabalho, mapeamento dos processos e análise de tempos e movimentos	Utilizar o método 5S como uma estratégia de manufatura enxuta.

APÊNDICE C – Outros trabalhos realizados durante o mestrado

Periódico/Congresso	**Título do documento**	**Status**	**DOI**	**ISSN**
RETEC. REVISTA DE TECNOLOGIAS (OURINHOS)	ESTUDOS DE CENÁRIOS PARA A OTIMIZAÇÃO DE TRÁFEGO EM SEMÁFOROS DE TRÊS TEMPOS: UM ESTUDO DE CASO UMA CIDADE DE MÉDIO PORTE	Publicado		1806-0323
XXXI SIMPEP	PROPOSTA DE MOCKUP INTELIGENTE PARA MONITORAMENTO DE RISCOS DO AMBIENTE FABRIL	Publicado		
Computer-Aided Design and Applications	*DIGITAL IMAGE PROCESSING IN VEHICLE AXIS IDENTIFICATION: CASE STUDY AT A TOLL BOOTH*	Submetido		
IJCIEOM 30th	*WORKFLOW* PARA A VIABILIDADE DE DESENVOLVIMENTO DE PDI PARA SUBMISSÃO DE PROJETOS PARA A LEI DO BEM	Submetido		