LITERATURE REVIEW: HUMAN FACTORS AND ERGONOMICS (HFE) IN THE FOOD INDUSTRY

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Abstract

In the era of sustainable development, humans are a system because of their role in development. The food industry is growing fast at this time, and it is important for the sustainability of a country, while the human factor and ergonomics will provide benefits if applied. Therefore, it is necessary to conduct a literature study. This study aims to provide a better understanding and research opportunities on human factors and ergonomics in the food industry. This review literature search was carried out using Publish and Perish based on the Google Scholar database with the search year 2015-2022, then checking the journals one by one. There were twenty-seven articles discussing human factors and ergonomics in the food industry. Based on the year of research, research on human factors and ergonomics began in 2017 and has increased every year until 2019. RULA, SNQ, and REBA are the ergonomics data analysis techniques most widely used by researchers, and Elsevier became the publisher most used. The focus of the research area is large on improving ergonomics. The discussion of human factors and ergonomics can be implemented in various sectors, including the food industry, the integration of human factors with other fields is also worth considering

Keywords: *ergonomics data analysis techniques; food industry; human factors and ergonomics; literature review*

1. Introduction

Humans from the beginning have thought about how to meet their needs to live, meet clothing, food, and shelter. Even though they move around and use tools that come from nature, they try to make these tools according to their body shape and ease of use, making them according to their anatomy (Zunjic, 2017). This ease and convenience in use have developed until now, in a broad scope such as the industrial world, we know the term ergonomics. Zunjic (2017) said in his research that ergonomics is widely used in Europe, America calls it the human factor, but now the use of the term ergonomics is in line. While food is the main human need, food is a source of energy to carry out daily activities derived from animals or plants (Amaliyah, 2017). Processing means creating from one or more materials or food plants including the activities in it, namely the process of preparing, mixing, adding, and dissolving (FDA.gov). Food processing from only the main ingredients or in combination with other mixtures, from only for personal consumption to being traded and becoming an industry that can absorb labor cannot be separated from the role of humans.

In this current era, especially in the era of sustainable development where development pays attention to all aspects of justice, order, survival of all creatures on earth, even the preservation of the earth itself. Humans are a system because humans participate in the development process, therefore the human aspect needs to be considered. In sustainable development, which began in recent years, countries have agreed not only as jargon or motivational words, therefore human factors and ergonomics should be considered better in the future (Fischer et al, 2021), even ergonomics in World war is used to make effective use of weapons and reduce errors (Zunjic, 2017), moreover, the character of society and complex work and global competition can also make human needs and ergonomics factors increase (Salmon et al., 2022).

Currently, the food industry is growing rapidly, from large, medium scale to even small industries or SMEs. It was engaged in semi-finished and finished products. In a country that has certain food or regional staple foods, such as pizza, rice, bread or cheese, the number of food processors will be very substantial. Carrera said in his research the number of bakers in Ecuador reached 6000 known craftsmen (Carrera et al, 2019).

The food industry plays a role in creating and distributing food to customers. So that customer needs are met in terms of availability. However, several studies have stated that the food industry tends to have a high tendency to musculoskeletal disorders. Both male and female workers. Over the past year, sixteen percent of all female workers in Sweden felt sick and

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missed work because of the disorder (Forsman et al, 2012). Musculoskeletal conditions are situations that reduce health, due to pain, and disturbances in carrying out activities, and can increase the risk of falls and fractures (Minetto et al., 2020). Thetkathuek et al (2016) details the musculoskeletal variables that occur in frozen food workers in Thailand, that they experience complaints of shoulder pain, elbow pain, neck pain, low back pain, hip and thigh pain, wrist and hand pain, knee pain, ankle pain, and foot. Excessive lifting (factory), excessive static work, repetition of tasks, improper posture, and others are said to be the cause of musculoskeletal disorders (Aguiar et al., 2020) whereas ergonomics can play a significant role (Thetkathuek et al., 2016). The focus of ergonomics is to prove the design of work in safe, comfortable conditions and improve performance (Kanyan et al., 2016).

Human factors and ergonomics can be a field that maximizes safety, human security, and overall organizational capabilities (Reiman et al, 2021) and can be applied also in the food industry. Safety means that workers can work without being injured, injured and or sick and free from suffering from occupational diseases. Meanwhile, the organization can create and build a work environment that can support increased safety and security for its assets. Jeong & Shin (2016) research on Korean, Chinese, Japanese, and Western cuisine restaurants stated that ergonomically working in the kitchen is because physically the work is heavy, the posture is unnatural, and often bends and twists in hot and wet kitchen situations. Workers in these restaurants suffered injuries such as slips, falls, burns, blisters, amputations, and punctures, from temperature factors, facilities, and machines, such as mixers, beaters, and cutting tools, while most worked in the kitchen until 8–12 hours per day, without guidelines on how to prevent work accidents. Cheng et al., (2021) added that in his research on employees in the food industry, he used the main factors in terms of organization, technique, and people. Organizational factors such as procurement management, when goods enter and leave the factory, do not prioritize safety and health, and the limited use of workers who comply with applicable national laws and regulations. When there is a change in the organization, the workers concerned are not provided with the latest information and training needed at that time. There is also a lack of communication with residents and nearby or adjoining companies which can minimize the risk of accidents. The organization also does not repair musculoskeletal injuries caused by human factors.

Human resources are the key asset in every organization (Joshi & Deshpande, 2019). The ergonomics may be combined with other disciplines with the support of sophisticated technology. It will produce terrific benefits for the industrial world. It means that the current working environment in the industrial world continues to develop tools, machines and work processes (Fayomi et al, 2021). However, designs that prioritize safety and are analyzed for their use to minimize risk need to be carried out on an ongoing basis (Cox, 2020).

Perhaps it is prominent to do research in the vast field of food. As expressed by Carrera et al. (2019), there has been no research that connects the baking process and ergonomics, especially in the Quito area of Ecuador. According to (Joshi & Deshpande, 2019), ergonomics research in the food sector is only 8%. That is the research sector in ergonomics is still niche. Based on the description, it is necessary to make a review of human factors and ergonomics in the food industry, where the limitations of this study do not include agriculture.

This literature review uses 27 articles in the food industry with the scope of human factors in the industry. In (Thatcher et al., 2018) article, it was stated that the focus of ergonomic research on the food industry was only found a number of studies, more research on energy and health issues Hopefully, the researchers who have interested in human factors and ergonomics will get an idea of the position of research on this theme. The results of the 27 articles reviewed are in Table 1. This research should be a future study where human factors are more intensely considered, especially in the food industry.

Table 1. Current Research on HFE in The Food Industry

Author and Year Publication	Title	Source Title	Focus Area	Methodology Used	Outcomes
Fazi et al. (2017)	Ergonomics study for workers at food production industry	MATEC Web of Conference	Identify ergonomic problems, analyze actual work postures, and provide recommendations for improvement	The methodology used in this article are: • Learn the flow of food processing in all areas, then conduct interviews and observations in the work area identified as problematic • The selected workstation is a filling and tasting station, the subject's height is between 150-180 cm,	The outcomes of this study are • The workplace is too dangerous for the subject. • The condition of worker A is always in an unnatural condition • The appropriate height of the worker in that place is 155-160 cm

Author and Year Publication	Title	Source Title	Focus Area	Methodology Used	Outcomes
				the subject is asked to work as usual to be measured using RULA and REBA.	
Susana (2018)	Improve of worker performance and quality of anchovy with ergonomic hybrid solar dryer	ARPN Journal of Engineering and Applied Science	to improve the quality of workers and products	This study used a sample of 20 women, there are steps • Observing the sample on the previous working method • Provide ergonomic intervention	The outcome of this study is • Ergonomics intervention can increase drying speed, reduce workload and reduce MSDS complaints • Improve product quality
Mokarami et al. (2019)	Low-cost ergonomic interventions to reduce risk factors for work related musculoskeletal disorders during dairy farming	Research Gate	The goal of this article is to minimize and eliminate unnatural posture	The methodology used in this article are: • Designing research and workstations • Intrude ergonomically using a REBA	The outcomes of this study are • Intervention using machines can reduce two high risks • The highest risk score is on the back and legs
Gomez (2020)	Prediction of work-related musculoskeletal discomfort in the meat processing industry using statistical models	International Journal of Industrial Ergonomics	Develop statistical models to reduce musculoskeletal complaints.	The method in this research consists of six steps: • Choose sample • Measuring worker discomfort using SNQ • Prevalence of musculoskeletal discomfort using SNQ • Identify physical variables using RULA, OCRA, NIOSH, ERGO/IBV Methods) (Copenhagen Psychosocial Questionnaire-ISTAS21) • Categorize and select appropriate variables • Constructing model and validating model	The author found: • The population of musculoskeletal complaints was found to be 77,7% • For excessive workload 82.2% are at medium level risk for excessive workload 82.2% are at medium level risk and 11.5% at a high level • Based on repetition rate using OCRA equally distributed workers, both medium, high, and acceptable repetition rates • Active work, insecurity, insecurity, age, smoking habits, and exercise are not important for musculoskeletal complaints
Accorsi et al. (2019)	An application of collaborative robots in a food production facility	Procedia Manufacturing	To design automation projects	The method in this research consists of four steps: • Select Layout • Designing layouts automated • Analysis using Monte Carlo • Implementing the project	The outcomes of this study are: • Generate economic returns analysis by using atomization can restore the project within 2 years • Lot size affects ergonomic load reduction

Author and Year Publication	Title	Source Title	Focus Area	Methodology Used	Outcomes
Santosa & Yusuf (2017)	The application of a dryer solar energy hybrid to decrease workload and increase dodol production in Bali	International Research Journal of Engineering, IT & Scientific Research	Seek improvement for product drying and work posture assessment	The methodology used in this article are: • This research was conducted experimentally with treatment by subject design • Give two treatments to the sample, old way, and new way (techno ergonomic hybrid solar energy application)	The author found: • The use of ergonomic techno-hybrid solar energy can reduce CVL, increase dodol quality and production quantity • Body parts that have a high risk are the back, neck, and upper arms
Rizkya et al. (2018)	Evaluation of work posture and quantification of fatigue by Rapid Entire Body Assessment (REBA)	IOP Conference Series: Material Science and Engineering	To the assessment of work posture in North Sumatra food SMEs	The methodologies of this research are: • Looking for information about musculoskeletal symptoms • Measuring musculoskeletal using a Standard Nordic Questionnaire (SNQ) • Record work step by step and measure posture using a REBA	The results in this study are: • Complaints of pain on the operator influenced by factors of gender, age, and length of work • Female operators feel more pain than male operators • Workers aged 35 years and over feel sicker than workers 35 years and under • The first and third work activities must be further investigated and repaired. • Second work activity has a moderate risk • Work facilities and work methods are needed to reduce complaints
Yen Siong et al. (2018)	Ergonomic assessment in small and medium enterprises (SMEs)	IOP Conf. Series: Journal of Physics	To identify health aspects and evaluate them ergonomically	The method in this research consists of: • Prepare questions for interview • Assess and evaluate instruments • Take photos of workstation • Use hazard identification • Give recommendation	The results in this study are: • Most of the employees in both companies do not know ergonomics • Hazard identified of work activities are divided into five (which are cassava roots skin peeling, slice cassava roots with cutting machine, transfer buckets of cassava roots from places to places, stirring cassava roots in frying oils, deep-frying, and packaging) • Stirring and frying activity has the highest score

Author and Year Publication	Title	Source Title	Focus Area	Methodology Used	Outcomes
					• Packaging activity is the activity that has the least risk
Trianasari et al. (2019)	Identification of environmental ergonomics control system for Indonesian SMEs	International Conference on Control, Automation and Robotics	1) To analyze the relationship between temperature and workload 2) To identify the environmental ergonomics control system	System identification consists of several steps: • Collecting data • Determine the temperature outside and inside the room before and after work • Group workload by heart rate • Analyze treatment results based on environmental parameters and workstations	The author found: • Workload varies by temperature • Identification of existing processes is expected to help further ergonomics development
Ayalp et al. (2017)	Effect on users of the seating element types in cafés/restaurants	Journal of Science	Designing a more ergonomic café or restaurant	The method in this research consists of: • Meet directly with the resource person • Create a digital image of a cafe or restaurant • Subject interview	The outcomes of this research are: • Subjects rate that cafes or restaurants equipped with booths are more ergonomic and comfortable than cafes or restaurants equipped with chairs • Subjects considered the cafés/restaurants furnished with booths to be more Subjects judged that cafes or restaurants equipped with booths were safer, providing privacy and tranquility than cafes or restaurants with chairs
Thamrin et al. (2020)	Ergonomics and musculoskeletal disorders among seaweed workers in Takalar Regency: a mixed method approach	Medicina Clinica Practica	Measuring the level of health and safety of workers	The research was carried out by: • Make all workers a sample • Distributing questionnaires • Discuss with a focus of group discussion (FGD)	The author found that 50% of workers often work in a bent condition, 40% of workers say they often sit in a sideways position
Chen et al. (2020)	Musculoskeletal disorders symptoms among Taiwanese bakery workers	International Journal of Environmental Research and Public Health	To assess discomfort or musculoskeletal disorders and look for risk factors	The research was carried out by: • Interview using nordic Musculoskeletal questionnaire • Monitor the dough process manually using a wrist-mounted goniometer	The results in this study are • Of 87 respondents, 81 valid questionnaires • Work is characterized by standing for long periods of time and very high dough processing times

Author and Year Publication	Title	Source Title	Focus Area	Methodology Used	Outcomes
					• Surgery and timing of dough causes musculoskeletal and shoulder, hand/wrist, and lower back/waist discomfort
Palit et al (2020)	The effect of ergonomic aspects on customers' convenience at restaurant in Surabaya	Journal of Quality Assurance in Hospitality & Tourism	Looking for the relationship between restaurant ergonomics and customer comfort	The method in this research consists of four steps: • Collect data directly and indirectly • Examine respondents' views on restaurants in terms of ergonomics and anthropometry using a questionnaire • Measure the restaurant directly from the ergonomic side (temperature, air humidity, and light intensity) compare it to the standard • Measuring the questionnaire using PLS SEM	The author found in this study that anthropometry and ergonomics have a positive effect on customer comfort and the restaurant has reached the ergonomic standard of 52.38%
I. M. Ali et al (2018)	Analysis awkward posture at food production activity using RULA assessment	Journal of Fundamental and Applied Sciences	The article aims to identify awkward postures during food production activities	The methodology is summarized in the following steps: • Observed critical food production activities at food production. There are four main Department chosen viz delivery or service, cooking, dish clothing, and utensils washing • Selected forty workers aged 19 – 25 years old with at least 1-year of experience • Recorded the activities using a camera. The activities were recorded for 20 – 30 minutes • The data analyze using RULA • The CATIA software produced the comfort level of working posture based on the RULA data	The outcomes of the paper are: • Four activities are contributing to RULA and are very risky • Lifting load for every worker must be below 5 kg at the food station • Work activities, working position, and duration of awkward posture contribute to the fatigue • The future research is to identify the connection between prolonged standing and fatigue during the task
Kumari (2018)	An ergonomic approach for modifying the workstation	The Pharma Innovation Journal	• To recognize the workstation	The article is structured in steps as below: • Selected the fruit and vegetable processing	The outcomes of the study are: • Awkward posture for a long duration of 8 to 9

Author and Year Publication	Title	Source Title	Focus Area	Methodology Used	Outcomes
	design of food processing enterprises		having the risk of expanding task-related musculoskeletal disorders • To apply the ergonomic guidelines to modify the existing workstations of selected food processing enterprises	enterprise and observed six micro-scale, three small-scale, and two medium-scale food processing enterprises. • Keep track of five workers from each type of enterprise when working • Evaluate the risk of evolving work-related musculoskeletal disorders (WMSDs) using Quick exposure checklist (QEC)	in an existing workstation can cause musculoskeletal discomforts. • Modify the workstation viz standing workstation, packing workstation, washing area, and workstation for seated task
Brito et al. (2020)	Lean and Ergonomics decision support tool assessment in a plastic packaging company	Procedia Manufacturing	To adjust and improve a workstation assessment using ErgoSafeCI assessment	The methodology of this research consisting of five steps, as follow: 1. Diagnosis, mean problem analysis and collect the data 2. Action Planning: identified of measured the improvement 3. Implementation of measures, practice the planning action 4. Evaluation 5. Conclusions During the research, ErgoSMED was adopted to support the implementation of SMED (Single Minute Exchange of Die)	The outcomes of this research are: • The author found that changing some works methodologies can minimize the set up around 15% • Lean transformation can take ergonomics as principal and impossible to decrease the ergonomic risk
Lourenço et al. (2019)	Assessment and improvement opportunities for occupational health and safety in the Portuguese food processing industry	Occupational and Environmental Safety and Health, Studies in System, Decision Control	• This study aims to identify work patterns that are suitable for the agro-industry. It avoids work accidents and improves OSH management.	The methodologies of this study are: • The first collected the data to identify safety and health from 60 agro-industry • Analysis data and identify the main risk based on OSH parameters	The author found that the main risk is analyzed: • Lack of risk assessment about noise, lighting, thermal environment, and vibrations • Safety color for safety signal and the circulation way does not match with the guidebook • Too many shade areas Another risk recognized is some hazards, including ergonomic hazard, physic hazard
Markkanen et al. (2021)	Development and application of an	Work	• To represent the expansion,	The methodologies of this study are:	The outcomes of this study are the instrument recognize factors related

Author and Year Publication	Title	Source Title	Focus Area	Methodology Used	Outcomes
	innovative instrument to assess work environment factors for injury prevention in the food service industry		practice, and function of the new instrument to appraise ergonomics and safety for food service workers	• Take the sample and study state • Development of the safety and ergonomics instrument • Interviewed with the site manager • Worksite walkthrough • Collect the data and analysis use OSH	to the physical work environment and organizational and contextual environment
Ramadhan et al (2019)	Failure Mode and Effect Analysis (FMEA) Application for Safety Risk Assessment Design of "X" Bakery	Unnes Journal of Public Health	• Pattern a risk assessment to reduce the incidence of workplace accidents by arranging a risk assessment of the hazards found	The methodologies of this research are: • Find the potential problem. This stage starts with coherence with the company leader, interviewed an observation and collect the secondary data • Gathering information, including literature review guided by FMEA • Making product design by creating a matrix of potential hazard and risk • Make validation by evaluating the product design • Testing design	The results show 23 potential hazards spread over eight production processes. The highest potential hazard is slip (RPN=140), and the lowest is an explosion (RPN=10). So that needs administrative controls, engineering, routine inspections. Correction of the installation of electricity and gas pipelines can reduce the hazard, as well as using personal protective equipment
Mahmood et al. (2019)	Ergonomic posture assessment of butchers: A small enterprise study in Malaysia food industry	Jurnal Teknologi	The goal of this study was to recognize butchers' risks of working posture problems, and to propose an ergonomic workstation designed to lessen MSDs and CTDs	The methodologies of this study are: • Identified musculoskeletal disorders (MSDs) and cumulative trauma disorders (CTDs) by observing the working posture in the workplace • RULA and REBA were selected to criticize the working posture of butchers	The outcome of this study is that a butcher was exposed to a higher risk. A new workstation was proposed to anticipate MSDs and CTDs problems, complete with a footrest and anti-fatigue mat. All equipment is organized to reduce movement and no awkward position.
Trianasari et al. (2019)	Ergonomic Risk Analysis for Cassava Noodle Production System Using Occupational Repetitive Action (OCRA)	Proceeding International Conference on Science and Technology	The goals of this research are: • To analyze ergonomic risk level for cassava noodle production system • Over a recommendat	The methodologies of this research are: • Collect the sampling worker and identify the worker pain complaint by Nordic Body Map questionnaire, resting time, and the number of repetition activities	The author found that based on the OCRA index in the grinding station showed a high-risk level. It came about from strength, posture, repetition, and recovery. So, the grinding station needs improvement, ergonomic review, and training to alleviate the risk

Author and Year Publication	Title	Source Title	Focus Area	Methodology Used	Outcomes
			ion for improving work methods and minimizing MSDs risk	• Use 905 of confidence level and 10% of accuracy • Analyze the data by the OCRA checklist	
Ushada et al (2020)	An Optimization Model for Environmental Ergonomics Assessment in Bioproduction of Food SMEs	HAYATI Journal of Biosciences	The goals of this study are: • To configuration an environmental ergonomic assessment system for bioproduction of Food SMEs • To expand an optimization model for the environmental ergonomic assessment using a Genetic Algorithm	The methodology of this study is based on genetic algorithm methodology, including set initial population, do selection, crossover, and mutation, the last to get the best chromosome to optimize environmental ergonomics.	The result of the research indicated the model has optimum values of environmental ergonomics parameters in the bioproduction of food SMEs. The model produces errors less than 0.01 and iterations less than 200. The parameters of environmental ergonomics in food SMEs were specified as optimum heart rate, indoor temperature, relative humidity before working, relative humidity after working, and light intensity. Some suggestions to suit the characteristics of SMEs are flexible job scheduling and multi-tasking job descriptions.
Lohasiriwat & Chaiwong, (2020)	Ergonomic Design for Sausage Packing Hand Tool	Procedia CIRP	• To verify the health risk of the packing job position at a sausage manufacturing enterprise	The methodology consists of two steps: • Work analysis and redesign • Testing the prototype, and measuring with ANOVA	The sausage task discovered ergonomic risk, i.e., wrist awkward posture and fast repetitive movement. The use of automation tools during the packing process can reduce the risk during the picking process. And this can be linked to industry 4.0 in ergonomics.
Sari et al. (2019)	Hybrid Methods of MOST and 5S for Reducing Time Processing and Waste Motion in Milk SMEs Industry: A Case Study	IOP Conference Series: Material Science and Engineering	• The objective of this study is to minimize the processing time by eliminating the motion using the hybrid of MOST and 5S	The methodology of this study starts with collecting the data from sample selection and then identifying ineffective motion. The steps in detail: • Activity identification • Classification of motion • Identification of movement • Proposed the improvement	The outcome of this study is • At division milk receiving, processing, milling, and packaging. • Standard time is significantly different before and after the application 5S

Author and Year Publication	Title	Source Title	Focus Area	Methodology Used	Outcomes
Andriani & Syntia (2020)	The Impact of Anthropometry on Terasi Packaging	IOP Conference Series: Materials Science and Engineering	• To pattern an ergonomic packaging using anthropometric methods for terasi products.	The methodology of this study, start with • Pick up the sample, aged between 25 to 55. The number of volunteers for women and men was 100 for each • The measure of the anthropometric dimension of the hands • The dimension of the palm length is adopted as a guide to the length and width of the packaging	The outcome of this study is the author found that with the percentile 5% percentile, design packaging with anthropometric method has a mean value of boys and girls 7.11 centimeters
Akbilek (2018)	Ergonomic Assessment and Workplace Design in Dairy Processing Industry	Advances in Social and Occupational Ergonomics	• Identified Musculoskeletal System Diseases (MSDs) using RULA	The methodology of the research used the RULA method	The author found there are many small and medium-size organizations in the dairy processing industry. The working environment in the dairy industry must pay attention so that productivity can increase. Setting ergonomic risk analysis is needed as a control in ergonomic evaluation
Ghorbanpour et al. (2019)	Study of Risk Factors of Ergonomic Work Environment and Its Relation with Self-Efficacy and Job Performance of Employees of A Food Industry	Iranian Journal of Ergonomics	• Identify risk factors of ergonomic work environments in the food industry	The methodologies of this research are: • Selected the sample group using a random sampling method • Deployed questionnaires consisting of Paterson's job performance questionnaire, Scherer general self-efficacy, key indicator method, and a five-point body questionnaire for assessing body organs. • Analyse the data used SPSS 19	The author found that self-efficacy will improve work performance and productivity and support better production processes. It can avoid musculoskeletal disorders

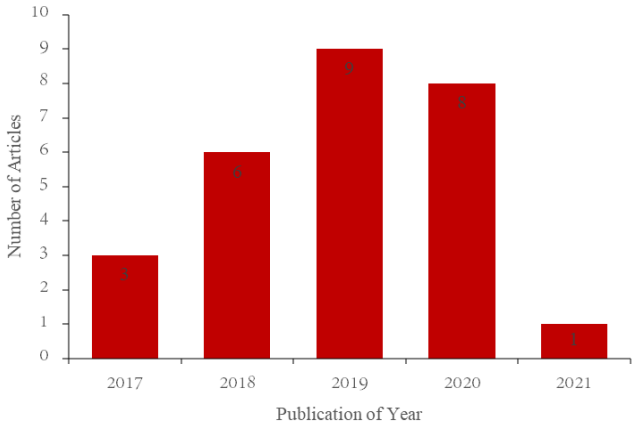

Figure 1. Categorization Based on Year of Publication

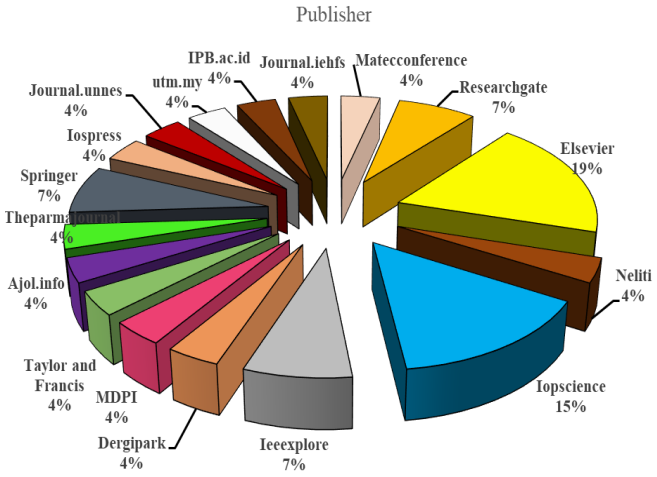

Figure 2. Categorization Based on Publisher

2. Methodology

Based on Malek & Desai (2020), a systematic literature review is needed to identify research gaps in current studies. It provides opportunities for conducting future research and provides a better understanding of a research theme. The methodology in this study was compiled based on bibliometric analysis. This analysis is used to obtain a literature review on ergonomic studies in the food industry. The research methods carried out in this study are as follows:

1. Determination of literature

The selection of literature in this study is described as follows:

a. The search was carried out using Publish and Perish based on the Google Scholar database. Google Scholar is free engine access, and easy to use (Rafika et al., 2017), with the keywords "ergonomic in the food industry" and "human factors in the food industry", with the search year 2015-2022.
b. The next step is to check the types of articles produced by Publish and Perish. At this stage, the books are removed, and the journal article is retained.
c. Then checked the journal one by one, both abstracts and keywords, to get the appropriate writing.

2. Category selection

The selected articles are then categorized based on the year of publication, the name of the journal publisher, the method used to solve the problem, and the focus area. A descriptive analysis was then carried out and found research gaps for the field in question.

3. Result and Discussion

3.1 Result

3.1.1 Categorization based on year of publication

The first is the research grouping by year publication. The articles were obtained between 2015-2022. Articles appearing on this theme began in 2017 and there was an increase every year until 2019. In 2021 it decreased but it was not significant. Articles that appeared the most in 2019 (33.3%) then in 2020 were 29.6%. In 2021 there is very little research on human factors in the food industry. The research on this theme in 2022 has not been discovered. The complete results can be seen in **Figure 1**.

3.1.2 Categorization based on publisher

The grouping of articles by the publisher will provide a relevant picture for further researchers in publishing their articles (Malek & Desai, 2020). There are 17 publishers used by researchers from 27 existing articles. The largest publishers were Elsevier (19%), IOP Science (15%), Researchgate, IEEE Xplore, and Springer with the same proportion of 7%. The complete results can be seen in **Figure 2**.

Table 2. Categorization Based on Publication Journals

Journal	Percentage (%)
IOP Conference Series	11.11
Work	7.4
Procedia Manufacturing	7.4
International Journal of Industrial Ergonomics	3.7
International Research Journal of Engineering, IT & Scientific Research	3.7
ARPN Journal of Engineering and Applied Science	3.7
IOP Conference Series: Journal of Physics	3.7
Gazi University Journal of Science	3.7
Medica Clinica Practica	3.7
International Journal of Environmental Research and Public Health	3.7
Journal of Quality Assurance in Hospitality & Tourism	3.7
Journal of Fundamental and Applied Science	3.7
Journal Ergonomics	3.7
Occupational and Environmental Safety Health	3.7
Unnes Journal of Public Health	3.7
Jurnal Teknologi	3.7
Proceeding International Conference Science and Technology	3.7
Hayati Journal of Biosciences	3.7
Procedia CIRP	3.7
Advances in Social and Occupational Ergonomics	3.7
Iranian Journal of Ergonomics	3.7
Matec Web of Conference	3.7
International Conference on Control, Automation and Robotics	3.7

Table 3. Categorization Based on Citation of Articles

Authors	Title	Year	Source Title	Cited by
Hamizatun Mohd Fazi, Nik Mohd Zuki Nik Mohamed, Mohd Fadzil Faisae Ab Rashid, Ahmed Nasser Mohd Rose	Ergonomics study for workers at food production industry	2017	MATEC Web Of Conference	15
I Gede Bawa Susana	Improve of worker performance and quality of anchovy with ergonomic hybrid solar dryer	2018	ARPN Journal of Engineering and Applied Science	14
Hamidreza Mokarami, Sakineh Vermazyar, Reza Kazemi, Sayed Mohamamd Taghavi, Lorran Stallones, Hossein Marioryad	Low-cost ergonomic interventions to reduce risk factors for work related musculoskeletal disorders during dairy farming	2019	Work	14
Mervyn Marquez Gomez	Prediction of work-related musculoskeletal discomfort in the meat processing industry using statistical models	2020	International Journal of Industrial Ergonomics	13
R Accorsi, A. Tuffano, A. Gallo, F. G. Galizia, G. Cocchi, M. Ronzoni, A. Abbate, R. Manzini	The application of a dryer solar energy hybrid to decrease workload and increase dodol production in Bali	2019	International Research Journal of Engineering, IT & Scientific Research	12
I Rizkiya, K. Syahputri, R M Sari, Anizar, I Siregar	Evaluation of work posture and quantification of fatigue by Rapid Entire Body Assessment (REBA)	2017	IOP Conference Series: Material Science and Engineering	11
I Gede Santos, M. Yusuf	The application of a dryer solar energy hybrid to decrease workload and increase dodol production in Bali	2017	International Research Journal of Engineering, IT & Scientific Research	9

3.1.3 Categorization based on publication journals

There are twenty-three journals used in this study consisting of international journals and international conferences. The journals used are eighteen and five conferences. The most international conferences were from the IOP Conference: material

science and Engineering (11.1%), while the most widely used journals were Work and Procedia Manufacturing with each (7.4%). Most of the international journals and conferences handled by the authors in the field of human factors in the food industry are engineering, ergonomics, public health, environmental health, and two journals are journals in the areas of management, marketing, quality planning, and physics. Categorization based on publication journals can be seen in **Table 2**.

3.1.4 Categorization based on citation of articles

The number of citations shows the quality of the article. The more quoted the better the article. A Review of articles in terms of citations is intended so that writers in the field or theme of human factors can be assisted in finding articles so that the resulting research can be even better. **Table 3** shows the citing articles. It represents the most recent article entitled Ergonomics study for workers in the food production industry written by Fazi et al (2017) with fifteen citations.

3.1.5 Categorization based on data analysis techniques

On the theme of human factors in the food industry, the researchers used several data analysis methods, in this study, there were thirty-five data analysis methods because researchers tend to use multiple data analyzes in their research, but the authors grouped them into eleven core groups, as for these methods, namely RULA (Rapid Upper Limb Assessment), SNQ (Standard Nordic Questionnaire), REBA (Rapid Entire Body Assessment), OCRA (Occupational Repetitive Action), OSH (Occupational Safety and Health), Simulation, HIRARC (Hazard Identification Risk Assessment and Risk Control), Heuristics/metaheuristic methods, statistical analysis, MOST (Maynard Operation Sequence Technique) and Anthropometry methods. Statistical analysis used such as chi-square, PLS-SEM (Partial Least Square-Structural Equation Modeling), KAPPA. Metaheuristics such as Montecarlo analysis. Simulations are used in research on the use of solar energy hybrids carried out in the production of Balinese dodol. Of the 35 methods of data analysis, the most widely used methods are RULA, SNQ, and REBA, in this study the author also uses statistical analysis to solve problems combined with core methods on ergonomics or other appropriate methods. **Table 4** can see the results.

3.1.6 Categorization based on focused area of HFE in the food industry

The purpose of an article is to describe what problems exist and will solve them. Of the 27 existing journals, the purpose of this article is to improve working conditions by using an ergonomic approach, designing tools and work methods, and analyzing the health risks of the work environment. The most common goal is to improve ergonomics. The complete results will be illustrated in the pie chart below, but please note, the total percentage is taken from 31 total focus areas because several studies have more than one focus area. Categorization based on focus area can be seen in **Figure 3**.

Table 4. Categorization Based on Data Analysis Techniques

Techniques	Percentage (%)
Statistical Analysis	20
RULA	14.2
SNQ	14.2
REBA	11.4
OSH	8.5
Simulation	8.5
Heuristics/Metaheuristic	8.5
OCRA	5.7
HIRARC	2.8
MOST	2.8
Anthropometry	2.8

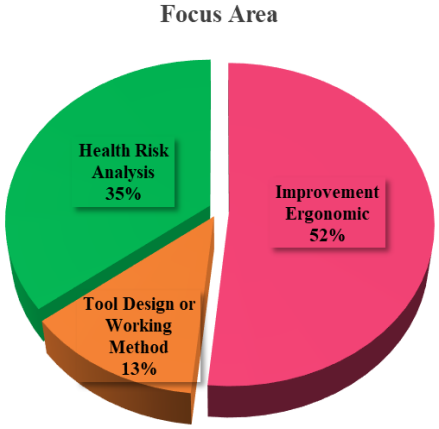

Figure 3. Categorization Based on Focus Area

3.2 Discussion

Research on human factors in the food industry began in 2017. It continues to grow around 2017-2018. The number continues to increase due to the increasing number of ergonomic studies in the industry. The SMEs industry is deployed in several countries such as Malaysia, Indonesia, India, Europe, and Taiwan. These industries include processing cassava noodles, terasi (a unique spice from Indonesia), sausage, and bread. Other types of food processing are fish processing, dairy farming, meat processing, and the seaweed industry. Cafes or restaurants which serve food are also accommodated in the food industry.

Elsevier is one publisher that has a mission to publish articles in the field of health and support researchers and professionals in the health sector (Elsevier.com). So, it's no wonder why articles on human factors and ergonomics are published there. Elsevier published five articles in this literature review, i.e., journals of Procedia Manufacturing, Procedia CIRP, International Journal of Industrial Ergonomics, Medicina Clinica Practica. Among these journals, it is known that their focus and scope are industrial and occupational ergonomics, design systems, tools and equipment, human productivity, everything related to manufacturing and clinical practice. The most widely used journals in this literature review are the IOP Conference, Work journals, and Procedia Manufacturing.

Based on data analysis technique, Fayomi et al., (2021) said that ergonomics has many devices, Joshi & Deshpande (2019) further said: Methods There are 18 ergonomic assessment techniques in his research, namely OWAS (Ovako Working Posture Assessment System), REBA (Rapid Entire Body Assessment), RULA (Rapid Upper Limb Assessment), ULRA (Upper Limb Risk Assessment), SI (Strain Index), ALLA (Agricultural Lower Limb Assessment), OCRA (Occupational Repetitive Actions), QEC (Quick Exposure Check), LUBA (Loading on the Upper Body Assessment), NERPA (New Ergonomic Posture Assessment), ART (Assessment of Repetitive Task), HARM (Hand Arm Risk Assessment Method), SWEA (Model for Assessment of Repetitive Work by the Swedish Work Environment Authority, 4D (4D Watchback), ACGIH TLV (American Conference of Governmental Industrial Hygienists Threshold Limit Value), EWA (Ergonomic Workplace Analysis), EN 1005 -3 (EN 1500-3 Standard) and SES (Scania Ergonomic Standard), furthermore, in his research, Joshi & Desphande said that the most widely used in measurements were REBA, RULA, OWAS, OCRA and QEC, in line with the literature review in this article. Some of the articles analyzed in this literature review are simulated using systems or tools/machines directly but the numbers are still small, Sharma et al (2021) said in his research entitled systematic review of methodologies and techniques of ergonomics that it is still very rare for research to combine ergonomics in manual design, especially in low-income countries, Sharma recommends virtual design apps.

Based on the focus area, researchers mostly aim to improve existing conditions with an ergonomic approach to the workforce, such as improving work posture (Rizkya et al., 2018; (Ali et al., 2018); (Mahmood et al., 2019); (Ghorbanpour et al., 2019), measuring symptoms of MSDs (Mokarami et al., 2019);(Gomez, 2020); (Chen et al., 2020) (Mahmood et al., 2019), while as we know in ergonomics the human aspect is measured and becomes the object of research. In the articles, most of the work is still manual, so many studies look at the physical aspects felt by workers related to their work, only a few researchers have approached in terms of machines or tools, such as the research of (Santosa & Yusuf, 2017) who made a hybrid solar dryer machine to produce lunkhead to improve working conditions and product quality, (Susana, 2018) fish dryer manufacture, and (Accorsi et al., 2019) research which creates robots that result in reduced ergonomic loads. The focus area on health risk analysis was carried out by the research of (Yen Siong et al., 2018); (Trianasari et al., 2019); (Thamrin et al., 2020); (Lourenço et al., 2019); (Markkanen et al., 2021); (Ramadhan et al., 2019); (Ghorbanpour et al., 2019).

3.3 Future Research Directions

Future research can be identified based on the results and discussion of the literature review, including:

- Measurements can be done more in food processing activities (chefs), food serving in restaurants or cafes.
- Measuring the food industry can use a variety of ergonomic analysis techniques, in addition to RULA, REBA, SNQ, and OCRA mentioned in Joshi's research, and even combine them with other methods according to research objectives.
- Measurements on product integration, work environment, and work methods can be improved even further.
- Studies in developing countries, especially those related to manual design, can be carried out by researchers so that it can be an improvement for the food industry in that country as well as an increase in knowledge related to human factors and ergonomics.

3.4 Limitations of the current study

This article is limited to the Google Scholar database. Although Google Scholar is a search engine that is widely used by researchers, there are very many articles outside of Google Scholar that are not used in this study. More extensive research can be done by increasing the database used or adding the number of scripts. In this review of literature, only English-language journals are used

4. Conclusion

Discussions on human factors and ergonomics can be carried out in various sectors, including the food industry. The integration of human factors with other fields is also worth considering. This study proposes a classified analysis to map the articles that were categorized based on years, publishers, journals, citations, analysis techniques, and focus on human

factors and ergonomics in the food industry. The selected articles were delivered in several figures and tables for each category. When we notice the number of manuscripts published in human factors and ergonomics, we see that there is still less research in the food industry. That is becoming an opportunity for researchers to conduct research in this field.

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