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Environmental Ergonomic Analysis in MSMEs of 'Karak' using Working Environment Approach, HIRARC, and Kansei Engineering

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ABSTRACT

The working environment in Micro, Small, and Medium Enterprises (MSMEs) is considered less than ideal based on the Indonesian Minister of Health Regulation Number 70 of 2016 concerning Standards and Requirements for Industrial Working Environment, in relation to temperature, lighting, noise intensity, and humidity. Therefore, an analysis is necessary to improve MSMEs' ability to create an ideal working environment. This study aimed to analyze and improve working environment ergonomics by focusing on the physical working environment, workers preferences and sensitivities, as well as work environment risks associated with various factors. The case study examined MSMEs in Klaten Regency, Central Java. The methods used included working environment observation, HIRARC (Hazard Identification, Risk Assessment, and Risk Control), Kansei engineering, and multiple linear regression (MLR). Specifically, HIRARC was used to assess risks, Kansei engineering to identify workers preferences and sensitivities, and MLR to determine correlations between variables. One of the risky working conditions was observed at the smoking and frying workstation, where the temperature reached 32.81˚C, exceeding the reference value of 31˚C. Lighting levels were recorded at 101.09 lux, below the recommended 200-500 lux. Noise levels measured 68.38 dB, within the acceptable limit of 85 dB, while humidity was 52.63% compared to the reference value of 51.36% ± 5.72%. HIRARC assessment classified the risk level at the smoking and frying workstation as medium to extreme. Furthermore, Kansei engineering identified key perception variables, namely dark vs. light, dirty vs. clean, unpleasant vs. pleasant, stuffy vs. cool, and hot vs. cold. The results showed working environment parameters significantly correlated with HIRARC and Kansei engineering variables, which consequently correlated with HIRARC.

Keywords: HIRARC; Kansei; Multiple linier regression; Working environment

INTRODUCTION

Klaten Regency has numerous clusters for Micro, Small, and Medium Enterprises (MSMEs) in the agro-industry sector, primarily based in rural areas. One of the clusters, recorded in the database, has 48 snack producers employing approximately 270 workers and producing around 15 types of snacks. The most popular product among the MSMEs is 'Karak', a type of rice cracker shown in Figure 1 (c). The production process is carried out in each producer's home using conventional methods. Figure 1 shows workstations for draining (a) and frying (b) snacks in one of the villages. The snack production location may not be ideal due to inadequate lighting, suboptimal air circulation, and inefficient transportation processes.

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(A) (B) (C)

Figure 1. The production process at the MSMEs center in one village (a) draining work station (b) frying work station and (c) 'Karak' cracker

A preliminary study was conducted on a sample of 16 'Karak' MSMEs, referring to the assessment aspects of manual load handling requirements outlined in the Indonesian Minister of Health Regulation Number 70 of 2016 concerning Standards and Requirements for Industrial Working Environment (Peraturan Menteri Kesehatan Republik Indonesia, 2016). The results showed that several aspects did not meet ideal standards, including job, working environment, and individual ability factors. Therefore, an environmental ergonomics analysis and subsequent improvements are necessary.

Worker's safety and comfort are essential aspects that should be addressed through environmental ergonomic factors (Bai & Wicaksono, 2020). Environmental ergonomics is an integral part of ergonomics, examined from the perspective of both the physical environment and human characteristics influencing sensitivity and response (Parsons, 2000).

Kansei plays a crucial role in generating intuitive reactions to external stimuli, beginning with sensory input and progressing through perception, judgment, and memory (Fenech et al., 2019). Kansei engineering starts by collecting Kansei words related to the design domain and evaluating related products. The words are adjectives describing users' emotions and feelings, and their usage is effective in capturing psychological responses to design features (Guo et al., 2020).

Hazard Identification, Risk Assessment, and Risk Control (HIRARC) is a method for identifying and understanding hazards in both routine and non-routine activities, allowing for structured risk assessment of the identified hazards (Urrohmah & Riandadari, 2019). This assessment is particularly essential for minimizing potential risks. The relevant regulations provide several parameter references as follows.

According to these regulations, lighting levels should range from 200 to 500 lux. The noise limit for a standard eight-hour workday is set at 85 decibels by the Minister of Health's regulation. In addition, the research on agro-industry recommended a humidity range of 51.36% ± 5.72% (Risqi et al., 2015).

The relationship between a dependent variable and two or more independent variables can be analyzed using

Table 1. Working environment temperature parameters

Allocation of work and rest time	Threshold values (°C wet and bulb temperature index)			
	Light	Medium	Heavy	Very Heavy
75-100%	31.0	28.0		
50-75%	31.0	29.0	27.5	
25-50%	32.0	30.0	29.0	28.0
0-25%	32.5	31.5	30.0	30.0

Source: Indonesia's Minister of Health Regulation Number 70 of 2016 concerning Standards and Requirements for Industrial Working Environment

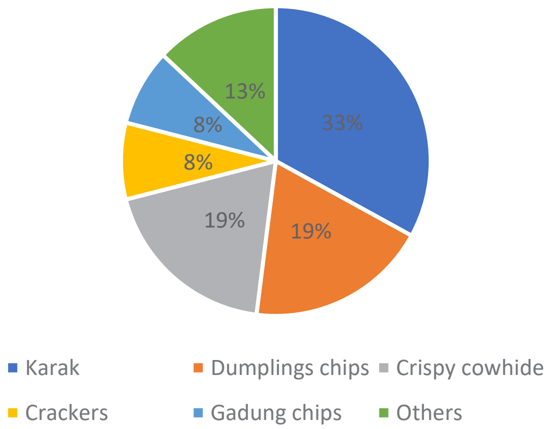

Figure 2. Percentage of the number of MSMEs in sample villages

multiple linear regression (MLR) (Uyanık & Güler, 2013). Data collected from the working environment are used to assess the physical working environment, HIRARC is used for evaluating risks, while Kansei Engineering aims to determine workers' preferences and sensitivities. This study aimed to conduct an environmental ergonomics analysis by examining the physical working environment, workers preferences and sensitivities, and working environment risks considering, relevant factors.

METHOD

Data collection was conducted from June to August 2022 in a village that served as MSMEs center, focusing on observations of the physical working environment. Figure 2 shows the number of observed MSMEs, representing 30% (16 MSMEs) of the total in the village.

Working Environment

The parameters of the working environment were measured directly using an environment meter, which was used to assess factors such as lighting, temperature, humidity, and noise levels. In addition, measuring tapes were used to determine room dimensions.

Kansei

The questionnaire related to Kansei words used a Semantic Differential (SD) scale to assess workers preferences and sensitivities. The collected data reflected perceptions of the working environment, described using Kansei words. These words, obtained from interviews with MSMEs workers in the sample villages, were used to evaluate working environment. Subsequently, a SD scale was used to measure attitudes and characteristics. The collected data were tested for validity and reliability to ensure the accuracy of the questionnaire items.

HIRARC

HIRARC assessment sheet was used to evaluate risks associated with different workstations, namely cooking oil heating, smoking and frying, draining, packaging, as well as workstations arrangement, as presented in Figure 3.

The risk value was determined through observations of risk conditions, categorized as normal (*N*), abnormal (*A*), or emergency (*E*). The likelihood measure was assessed based on the frequency of work accidents, which was determined through interviews and validated by direct observation. The severity measure was established by evaluating the impact of potential

METODE HIRARC

Kondisi Penentuan Risiko

No	Kondisi	Definisi
1	Normal (N)	Pekerjaan sehari-hari dan sesuai prosedur
2	Abnormal (A)	Pekerjaan diluar prosedur
3	Darurat (E)	Keadaan yang sulit dikendalikan

Ukuran Severity

Tingkat	Deskripsi	Keterangan
5	Bencana	Dampak mengakibatkan kecacatan permanen/parsial/meninggal dunia
4	Berat	Dampak luka berat dan membutuhkan perawatan dirumah sakit dan atau hari kerja hilang lebih dari dua hari
3	Sedang	Dampak cedera sedang, perlu penanganan medis, hari kerja hilang sedikitnya dua hari atau kurang
2	Kecil	Dampak luka kecil cukup hanya dirawat oleh P3K dan atau hari kerja hilang satu hari atau kurang
1	Tidak signifikan	Tidak ada dampak bagi pekerja, proses produksi, properti, atau menyebabkan perawatan fisik setidaknya dalam 15 menit

Ukuran Likelihood

Tingkat	Deskripsi	Keterangan
5	Almost Certain (Dapat terjadi setiap saat)	Kecelakaan terjadi dalam waktu sebulan sekali
4	Likely (Sering terjadi)	Kecelakaan terjadi dengan waktu 2-10 bulan sekali
3	Possible (Dapat terjadi sesekali)	Kecelakaan dengan rentan waktu 1-2 tahun
2	Unlikely (Kadang-kadang terjadi)	Kecelakaan terjadi dalam waktu 2-5 tahun sekali
1	Rare (Jarang terjadi)	Kecelakaan terjadi dalam 5 tahun sekali

Matriks Risiko

Likelihood	Severity				
	1	2	3	4	5
1	1 (Rendah)	2 (Rendah)	3 (Sedang)	4 (Tinggi)	5 (Tinggi)
2	2 (Rendah)	4 (Rendah)	6 (Sedang)	8 (Tinggi)	10 (Ekstrim)
3	3 (Rendah)	6 (Sedang)	9 (Tinggi)	12 (Ekstrim)	15 (Ekstrim)
4	4 (Sedang)	8 (Tinggi)	12 (Tinggi)	16 (Ekstrim)	20 (Ekstrim)
5	5 (Tinggi)	10 (Tinggi)	15 (Tinggi)	20 (Ekstrim)	25 (Ekstrim)

Figure 3. HIRARC assessment sheet (In Bahasa Indonesia)

risks, primarily through interviews. Subsequently, the likelihood and severity values were analyzed using a risk matrix to determine the overall risk level at each workstation. According to the risk matrix table, risk decreased toward the upper-left quadrant and increased toward the lower-right.

An analysis was conducted on working environment parameters, work accident risk (using HIRARC), workers preferences and sensitivities (using Kansei engineering), and the correlation between variables (using MLR). MLR was used to identify relationship patterns between a dependent variable and two or more independent variables. Data for this analysis included working environment measurements to assess physical conditions, HIRARC for risk assessment, and Kansei engineering for evaluating workers' preferences and sensitivities. Working environment parameters included temperature, lighting, humidity, noise, and space adequacy. The difference between the standard values and the observed field data was analyzed for these parameters to ensure accurate modeling and prevent underfitting in MLR analysis.

The parameters were measured using an environment meter across 16 MSMEs (Table 2). The measurements were used as variables for correlation analysis. The 16 MSMEs assessed were all 'Karak' producers, representing 30% of the total MSMEs in the village. Each assessment was conducted three times between 09.00 AM to 03.00 PM. The final dataset was selected based on the most extreme conditions, prioritizing the hottest, brightest (glare), darkest, most humid, and noisiest observations.

Risk assessment using HIRARC was conducted by evaluating each workstation, including workers, processes, and machines across all MSMEs. HIRARC data collection involved direct observation and interviews with workers. This assessment is essential for identifying, assessing, and controlling risk in MSMEs. Data obtained from HIRARC were subsequently used as variables for correlated analysis through MLR.

In Kansei engineering, data collection focused on workers preferences and sensitivities regarding working environment, expressed through Kansei words. These words, obtained through interviews with MSMEs workers, were used to assess working environment. Kansei words and their antonyms were tested using the Semantic Differential (SD) scale to measure attitudes or characteristics. Kansei engineering method was used to extract relevant Kansei words from interview responses. The SD scale analysis was based on the total frequency of word repetition and the number of workers who provided similar responses during interviews (Ushada et al., 2021). Responses reflecting a positive impression were positioned on the right side of the scale, while negative impression were positioned on the left, using a 1 – 7 scale. The SD results were further analyzed using Kolmogorov-Smirnov test to assess differences in data across different time intervals and to evaluate data behavior over time (Porwik & Dadzie, 2022). After the normality test, data adequacy and factor analysis were conducted. Specifically, data adequacy test used Kaiser-Meyer-Okin (KMO) and Bartlett methods. KMO test determined sample adequacy for each variable in the model and was also used in factor analysis, while Bartlett test was applied for null hypothesis testing. Anti-Image Matrix test was conducted to verify whether variables met the criteria for inclusion in factor analysis.

Multiple Linear Regression

Multiple linear regression (MLR) defines the linear relationships between independent (predictor) and dependent variables (Waghmare et al., 2022). Based on Figure 4, MLR was used to analyze the relationship patterns between a dependent variable and two or more independent variables. Data obtained from the working environment, HIRARC values, and Kansei words were incorporated input the conceptual model in Figure 4. The working environment parameters (variable *X)* and Kansei words (variable *Y)* were analyzed using MLR. Regression analysis using IBM SPSS Statistics 25 generates the MLR equation, *t*-test results, *F*-test results, and determination coefficients, serving as references for improving the working environment. This method applies to the working environment parameters as variable *X* and risk ratings from HIRARC as variable *Y* as well as Kansei words in Kansei engineering as variable *X* and risk ratings from HIRARC as variable *Y*. The regression analysis conducted using IBM SPSS Statistics 25 produced an MLR equation along with *t*-test results, *F*-test results, and determination coefficients. The following assumptions were verified and met. The relationship between the independent variable (*X*) and the dependent variable (*Y*) was linear. Residuals (errors) were not correlated, as confirmed by Durbin-Watson test. Moreover, residual variance was constant across the range of independent variable values, as tested using the residual plot. Residuals followed a normal distribution, as tested using the P-P plot and the Kolmogorov-Smirnov test. A high correlation between independent variables was observed and assessed using the Variance Inflation Factor (VIF) and Tolerance tests.

The *t*-test was used to determine whether an independent variable *(X)* had a significant individual (partial) effect on the dependent variable (*Y)*. Meanwhile, *F*-test assessed whether the independent variables collectively (simultaneously) influenced the

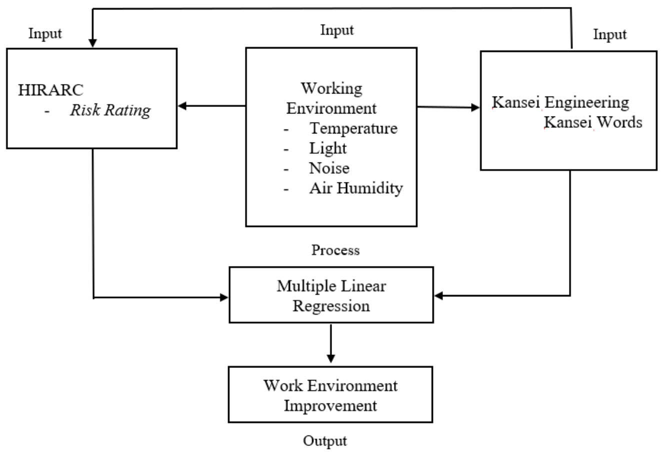

Figure 4. Conceptual model

dependent variable. The overall impact of variable *X* on *Y*, expressed as a percentage, was measured through the coefficient of determination.

The results of *t*-test showed that when the significance value is less than 0.05 or the calculated *t*-value exceeds the critical *t*-value from the *t*-table, there is a significant effect of variable *X* on *Y*. Meanwhile, when the significance value is greater than 0.05 or the calculated *t*-value is lower than the critical *t*-value, there is no significant effect. *F*-test showed that when the significance value is less than 0.05 or the calculated *F*-value is greater than the critical *F*-value from the *F*-table, variable *X* has a significant simultaneous effect on variable *Y*. Meanwhile, when the significance value exceeds 0.05 or the calculated *F*-value is lower than the critical *F*-value, there is no significant simultaneous effect. By meeting these assumptions, the results of *t*-test, *F*-test, and coefficient of determination obtained from the regression analysis could serve as valid and reliable references for improving the working environment.

RESULTS AND DISCUSSION

Working Environment Parameters

Based on the working environment parameters presented in Table 2, the average temperature at each workstation was 33 °C for heating cooking oil, 32.8 °C for smoking and frying, 33.1 °C for draining, and 31.6 °C for packaging and arrangement. These values showed the temperatures at the heating, smoking and frying, as well as draining workstations slightly exceeded the reference standard of 28 °C - 31 °C for a work and rest time allocation of 75%-100%. Workers in close proximity to heat sources, especially those involved in frying, were more susceptible to heat-related conditions, such as heat stroke, potentially impairing the body's ability to regulate temperature. High indoor temperatures also contributed to excessive sweating, leading to discomfort and stickiness, which can negatively impact work performance (Parsons, 2000).

Lighting levels at various workstations varied significantly across the sampled MSMEs. For instance, the cooking oil heating workstation recorded 2-1086 lux, frying 3-1175 lux, draining 3-565 lux, while packaging and arrangement 11-691 lux. The lighting data for each workstation are presented as follows.

The assessment showed that lighting conditions in MSMEs varied, ranging from very dim to excessively bright. In MSMEs with inadequate lighting, the issue is often caused by small, enclosed spaces and exposure to smoke, which darkens the room despite the use of artificial lighting. Inadequate lighting can lead to rapid eye fatigue among workers (Faritsy & Nugroho, 2017). However, MSMEs with brighter lighting tend to have larger spaces, better ventilation, and transparent ceilings, allowing smoke from the fryer to dissipate quickly without darkening the room. The lighting assessment across workstations showed a considerable variation, with many workstations failing to meet the reference standard of 200-500 lux.

Noise levels can vary across different workstations. For instance, the cooking oil heating workstation recorded 47-77 dB, smoking and frying 55-77 dB, draining 54-77 dB, while packaging and arrangement 50-80 dB. The distribution of the noise data for each workstation across the 16 MSMEs is presented as follows.

Noise levels at all MSMEs across each workstation met the ideal conditions of the referenced standards, stating that daily noise intensity should not exceed 85 dB over an eight-hour work period. However, noise can still increase the workload for workers in certain conditions and may impact performance (Parsons, 2000).

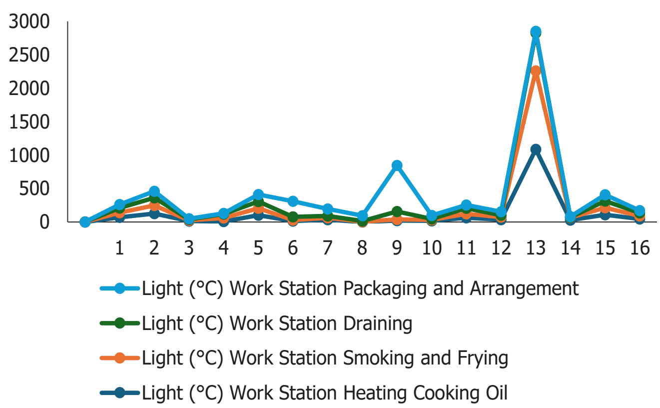

Figure 5. Light intensity (lux)

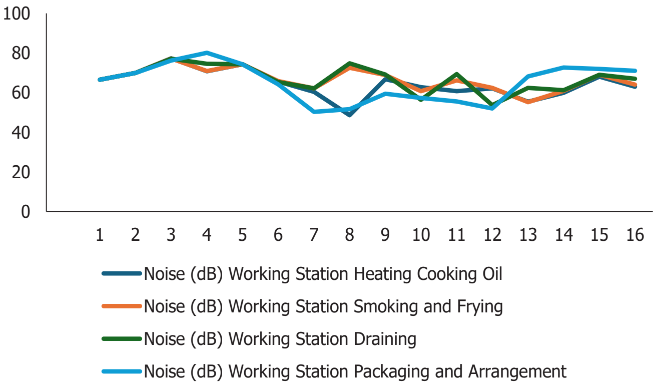

Figure 6. Noise level of each workstation (dB)

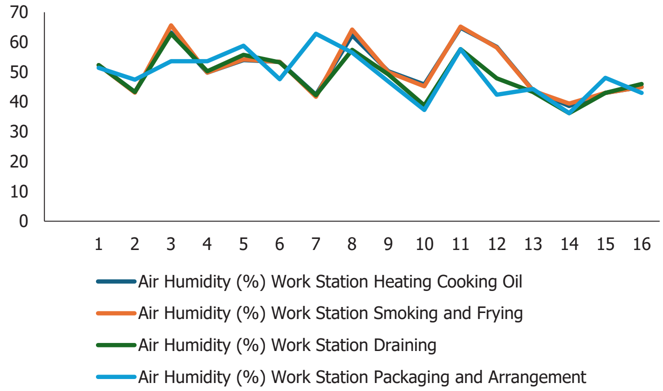

Figure 7. Air Humidity (%)

Table 2. Results of observations of working environment parameters

No	MSMEs (initials)	Temperature (°C)				Lighting (lux)				Noise intensity (dB)				Air humidity (%)			
		S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
1	AWK	32.6	32.4	32.4	29.3	70	70	68.4	52.4	66.5	66.5	66.5	66.5	52.3	52.3	52.3	51.4
2	KS	32.8	33.1	33.1	30.3	124.3	124.3	112.2	98.4	70	70	70	70	43.3	43.1	43.3	47.4
3	P23	31	32.1	31.7	28.8	12.8	12.8	12.9	11.7	77.3	77.2	77.1	76.2	63.2	65.6	62.8	53.6
4	EJ	32.7	33.2	33.4	32.8	6.42	53.9	56.8	10.7	70.8	70.9	74.5	80.1	49.8	49.8	50.2	53.8
5	SK	32.4	32	32	33.6	102.5	102.5	102.4	102.3	74.3	74.3	74.8	74.3	54	54.2	55.7	58.8
6	NR	35.4	35.2	35	32	14.6	14.1	48.2	234.2	65.6	65.8	65.4	64.2	53.4	53.4	53.2	47.6
7	S	30.8	31.6	32.2	28.8	34.6	28.6	28.9	102.7	60.4	62.1	62.2	50.3	42.4	41.7	42.2	62.8
8	H	32.1	34.7	29.8	29.8	1.82	3.1	9.3	80.7	48.6	72.5	74.8	51.7	62.3	64.2	57.4	56.5
9	P	32.4	32.3	33.2	32.6	20.4	19.4	116.3	691	66.8	68.9	69.1	59.5	50.2	49.9	49.2	46.8
10	SR	33.8	33.9	35	34.1	16.3	16.44	12.8	52.3	62.8	60.7	56.4	57.3	45.8	45.2	38.8	37.3
11	MH	30.4	30.6	29.9	30	62.4	58.3	84.8	47.6	60.7	66.2	69.3	55.6	64.8	65.2	57.6	57.6
12	W	32.2	32.8	33.4	31.1	36.4	36.8	26.7	54.4	62.2	62.4	53.7	52	58.4	58.2	47.9	42.4
13	PR	34.8	35	35	35.4	1086	1175	565	25.7	55.4	55.2	62.4	68.2	43.8	43.7	43.3	44.3
14	DAL	40.5	32.1	36,6	33.1	29.1	37	2.8	12	59.9	60.9	61.2	72.6	38.6	39.4	36.2	36.2
15	SP	33	33	33	31	108	103	101	97	68	69	69	72	43	43	43	48
16	WD	31	32	32	34	45	45	45	35	63	64	67	71	45	45	46	43

Description:
S1: Heating cooking oil
S2: Smoking and frying
S3: Draining
S4: Packaging and arrangement
Source: Primary data analysis, 2022

Air humidity levels can vary across different workstations. For instance, the cooking oil heating workstation recorded 39%-65%, smoking and frying 40%-66%, draining 36%-63%, while packaging and arrangement 36%-63%. The humidity data for each workstation across the 16 MSMEs are presented as follows.

The assessment explained the variations in workstations, with some meeting the humidity standards while others did not. Based on a previous study, the

Table 3. Kansei words

Kansei Words	Antonyms of Kansei words
Dark	Light
Dirty	Clean
Unpleasant	Pleasant
Hot	Cool
Sore	Not sore
Uncomfortable	Comfortable
Stuffy	Not stuffy
Hot	Cold
Noisy	Quiet

Source: Primary data analysis, 2022

ideal humidity level is expected to be around 51.36% ± 5.72% (Risqi et al., 2015).

Light typically disperses in multiple directions and spreads over a larger area as it moves away from the source. The intensity of light also fluctuates depending on the distance from the source (Ching dan Binggeli, 2011). Noise intensity refers to the amount of noise energy per second that passes through a perpendicular plane of one unit area (Jamaludin et al., 2014). Air humidity is considered a key environmental factor affecting various aspects of human health (Davis et al., 2016). Meanwhile, temperature is a purely statistical quantity and holds a clear meaning only for macroscopic systems (Boltachev dan Schmelzer, 2013).

Table 4. Re-analysis of the anti-image matrix values

Anti-image matrix		
No.	Kansei Words	*a* Value
1.	Dark vs light	0.645
2.	Dirty vs clean	0.656
3.	Unpleasant vs Pleasant	0.530
4.	Hot vs cool	0.563
5.	Hot vs cold	0.657

Source: Primary data analysis, 2022

Table 5. HIRARC risk rating results

No	MSMEs	Work Station			
		Heating cooking oil	Smoking and frying	Draining	Packaging and arrangement
1	AWK	1	10	1	1
2	KS	3	9	1	3
3	P23	1	6	1	1
4	EJ	2	4	2	2
5	SK	4	4	4	4
6	NR	4	12	6	4
7	S	2	6	4	2
8	H	4	12	4	4
9	P	2	12	2	2
10	SR	2	9	4	2
11	MH	2	9	2	2
12	W	4	9	2	4
13	PR	1	4	1	1
14	DAL	2	9	1	2
15	SP	3	9	1	3
16	WD	2	6	4	1

Source: Primary data analysis, 2022

Kansei Engineering

Kansei Engineering is used to determine workers preferences and sensitivities regarding the working environment across all MSMEs. A total of 88 workers participated in the assessment, with the number of workers per MSME ranging from a minimum of 4 to a maximum of 12. Kansei Engineering captured workers' preferences and sensitivities through Kansei words, presented as follows.

Kansei words were analyzed using the SD scale. The SD results underwent further testing with the Kolmogorov-Smirnov and data normality tests. Sampling and data adequacy were assessed using KMO test, while null hypothesis testing was conducted using the Bartlett test. The suitability of variables for factor analysis was determined using the Anti-Image Matrix test, with the results presented in Table 4. The data showed that the values for each category exceeded 0.50, confirming suitability for factor analysis.

Hazard Identification, Risk Assessment, And Risk Control (HIRARC)

The risk levels of workstations in MSMEs were determined using HIRARC. Key components of HIRARC included hazard identification, evaluation of the possibility of hazards occurring, and relevant control recommendations (Saedi et al., 2014). The mapping results showed that each MSME had four operational processes and one inspection process, presented as follows.

The operational process included heating cooking oil, smoking and frying, draining, as well as packaging and arrangement. The inspection process was carried out during the packaging and arrangement stage, presented as follows.

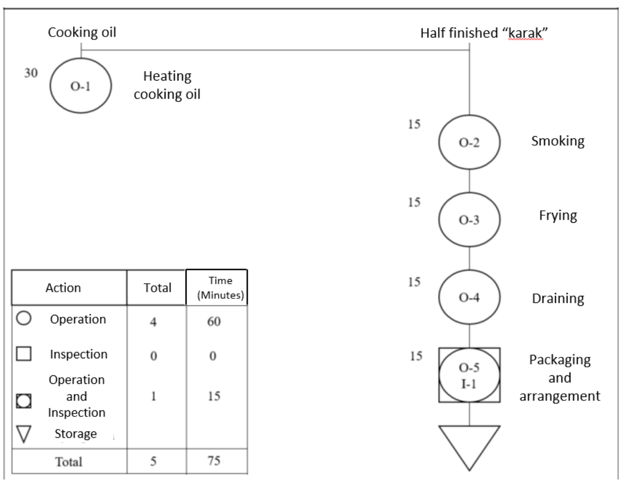

Figure 8. Map of 'Karak' MSMEs operational process

Risk rating values ranged from 1 to 4 at the cooking oil heating workstation. Ratings of 1 and 2 showed a low-risk level, a rating of 3 could be categorized as either low or medium, and a rating of 4 classified as either medium or high, depending on the risk matrix reading. At the smoking and frying workstation, risk rating values fell within the medium to extreme categories, namely 4, 6, 9, 10, and 12. A risk rating of 9 fell under the high-risk category, while ratings of 10 and 12 could be classified as either high or extreme risk, depending on the risk matrix reading. The appearance of values 10 and 12 on the right side of the matrix could mean extreme risk, with a position confirming high risk.

The draining workstation had risk ratings of 1, 2, 4, and 6, confirming a variation in risk levels from low to high. A similar pattern was observed at the packaging and arrangement workstation, where risk ratings of 1, 2, 3, and 4 reflected a range of low to high risk.

Multiple Linear Regression Working Environment (*X*) with HIRARC Work Station (*Y*)

Table 6 presents MLR results for the working environment (*X*) and HIRARC (*Y*), with a *t*-table value of 1.992. The *F*-table value obtained was 2.4803, based on a 95% confidence level, a sample size of 88, and four independent variables (*X*).

The heating light variable (*X*) affected the heating HIRARC (*Y*) based on the calculated *t*-value > *t*-table and a significance value < 0.05. The heating light variable was inversely correlated with the heating HIRARC confirming that higher light levels in the cooking oil heating process corresponded to a lower HIRARC risk value. The *F*-test confirmed the effect of variable *X* on *Y* simultaneously, based on the significance value < 0.05 or a calculated *F*-value> *F*-table. The *F*- table result was 2.4803, based on four independent variables (X) and a sample size of 88.

The coefficient of determination measured how well the regression model fitted the data (Ajona et al., 2022). It ranged from 0 to 1, where values closer to 1 showed the independent variables effectively explained the variation in the dependent variable (An et al., 2021). The R-squared value of 0.126 confirmed the independent variables collectively accounted for 12.6% of the variance, with the remaining explained by other factors.

The variables of temperature, light, noise, and humidity in the frying process (*X*) influenced the HIRARC of frying (*Y*) based on the calculated *t*-value> *t*-table and a significance value <0.05. The frying temperature variable was directly correlated with the HIRARC of smoking and frying, confirming that

Table 6. Results of multiple linear regression for the working environment (*X*) and HIRARC workstation(*Y*)

HIRARC t-test heating (Y)					
(X)	*t*	Sig.	*t* Table	Description	
Warming light	-2.566	0.012	1.992	Inversely proportional	
HIRARC t-test smoking and frying (Y)					
(X)	*t*	Sig.	*t*-Table	Description	
Frying temperature	5.456	0.000	1.992	Directly proportional	
Frying light	-7.514	0.000	1.992	Inversely proportional	
Frying noise	-4.988	0.000	1.992	Inversely proportional	
Frying humidity	2.748	0.007	1.992	Directly proportional	
HIRARC t-test for draining (Y)					
(X)	*t*	Sig.	*t* Table	Description	
Draining noise	-2.007	0.048	1.992	Inversely proportional	
HIRARC t-test of packaging and arrangement (Y)					
(X)	*t*	Sig.	*t* Table	Description	
Packaging temperature	3.227	0.002	1.992	Directly proportional	
Packaging noise	-2.853	0.005	1.992	Inversely proportional	
Packaging humidity	2.695	0.009	1.992	Directly proportional	
F-test and working environment determination coefficient (X)					
HIRARC (Y)	*F*	Sig.	*F*-Tabel	Koef. Det.	Description
Heating	2.996	0.023	2.4803	12.6%	Correlated
Frying	20.852	0.000	2.4803	50.1%	Correlated
Draining	1.948	0.110	2.4803	8.6%	Not correlated
Packaging	5.564	0.001	2.4803	21.1%	Correlated

Source: Primary data analysis, 2022

higher temperatures in the smoking and frying process resulted in higher risk values. The addition of fans and exhaust systems could reduce room temperature.

The light and noise variables in the frying process were inversely correlated with the HIRARC value, confirming higher light intensity and noise levels during smoking and frying corresponded to a lower HIRARC value. Adjusting light intensity and noise volume should correspond with the parameters outlined in Minister of Health Regulation Number 70 of 2016. Meanwhile, air humidity was directly correlated with HIRARC value in the smoking and frying process, confirming higher humidity levels resulted in higher risk value.

The draining noise variable had a significant influence on the draining HIRARC (*Y*) based on the calculated *t*-value > *t*-table and significance value < 0.05. The draining noise variable was inversely correlated with the draining HIRARC, meaning that higher noise levels corresponded with lower risk. This correlation was related to workers' perception when transferring 'Karak' from the fryer to the draining area, producing a crunchy noise. The average crispy noise of crackers ranged from 70-84 dB (Salvador et al., 2009), which remained below the threshold.

The temperature, noise, and humidity variables in the packaging and arrangement process (X) influenced the HIRARC of draining (*Y*) based on the calculated *t*-value > *t*-table and significance value < 0.05. Therefore, higher temperatures corresponded with greater risk. The noise variable in the packaging and arrangement process was inversely correlated with its HIRARC value, confirming increased noise levels corresponded to lower risk. Meanwhile, humidity in the packaging and arrangement process was directly correlated with its HIRARC value, meaning higher humidity levels led to a greater risk value.

Multiple Linear Regression of Working Environment (*X*) with Kansei Words (*Y*)

Variable *X* comprised 16 variables, covering each process along with corresponding working environment parameters. The analyzed processes included heating cooking oil, smoking and frying, draining, and packaging and arrangement. The working environment parameters examined were temperature, light, noise, and humidity. Variable *Y* included 5 variables that passed the factor analysis, namely dark vs. light, dirty vs. clean, unpleasant vs. pleasant, hot vs. cool, and hot vs. cold.

Table 7. Results of multiple linear regression of working environment (X) with Kansei words (Y)

Dark vs light Kansei word t-test (Y)					
(X)	*t*	Sig.	*t* Table	Description	
Working environment (X)				Not correlated	
Dirty vs clean Kansei word t-test (Y)					
(X)	*t*	Sig.	*t* Table	Description	
Working environment (X)				Not correlated	
Kansei word t-test unpleasant and pleasant (Y)					
(X)	*t*	Sig.	*t* Table	Description	
Frying temperature	-3.143	0.002	1.996	Inversely proportional	
Frying noise	2.312	0.024	1.996	Directly proportional	
Frying humidity	-2.985	0.004	1.996	Inversely proportional	
Draining temperature	2.994	0.004	1.996	Directly proportional	
Draining light	2.630	0.010	1.996	Directly proportional	
Draining noise	2.621	0.011	1.996	Directly proportional	
Draining humidity	2.896	0.005	1.996	Directly proportional	
Packaging temperature	-2.301	0.024	1.996	Inversely proportional	
Packaging light	-3.007	0.004	1.996	Inversely proportional	
Packaging noise	-3.151	0.002	1.996	Inversely proportional	
Packaging humidity	-3.032	0.003	1.996	Inversely proportional	
Hot vs cool Kansei word t-test (Y)					
(X)	*t*	Sig.	*t* Table	Description	
Packaging temperature	2,036	0,045	1,996	Directly proportional	
Hot vs cold Kansei word t-test (Y)					
(X)	*t*	Sig.	*t* Table	Description	
Working environment (X)				Not correlated	
F-test of working environment (X)					
(Y)	*F*	Sig.	*F* Table	Koef. Det.	Description
Dark vs light	1.795	0.056	1.786	25.6%	Correlated
Dirty vs clean	3.471	0.000	1.786	40.0%	Correlated
Unpleasant vs Pleasant	2.245	0.013	1.786	30.1%	Correlated
Hot vs cool	2.128	0.020	1.786	29%	Correlated
Hot vs cold	2.852	0.002	1.786	35.4%	Correlated

Source: Primary data analysis, 2022

The t-table value of 1.996 was determined based on a 95% confidence level, a sample size of 88, and 16 *X* variables, and the *F*-table value obtained was 1.786. The results of MLR analysis of the working environment (*X*) and Kansei engineering (*Y*) are presented as follows.

The working environment variable (*X*) had no significant effect on the Kansei words dark vs light (*Y*) and dirty vs clean (*Y*) based on the calculated *t*-value <*t*-table and a significance value> 0.05. The *F*-test value for dark vs light (*Y*) was 1.795, with a significance of 0.056, confirming that variable *X* had a simultaneous effect on *Y* based on a significance value <0.05 or a calculated *F*-value> *F* -table. The R-squared value of 0.256 showed that the independent variables explained 25.6% of the variation, with the remaining attributed to other factors. For dirty vs clean (*Y*) variable, the *F*-test value was 3.471, with a significance of 0.000, meaning that variable *X* had a simultaneous effect on variable *Y* based on a significance value below 0.05 and the calculated *F*-value exceeding the *F*-table. The *R*-squared value of 0.400 showed that the independent variables collectively explained 40.0% of the variation, with the remaining explained by other factors.

Variable *X* had a negative *t*-value when inversely correlated with the *Y* variable unpleasant vs pleasant, and a positive *t*-value when directly correlated. The smoking and frying temperature variables were inversely correlated with the Kansei word pair unpleasant vs. pleasant, confirming that higher temperatures during the smoking and frying process resulted in a more unpleasant perception among workers. To maintain a pleasant working environment, the temperature at the smoking and frying workstation should be reduced by adding fans and exhaust systems. The smoking and frying noise variables were directly correlated with the unpleasant vs. pleasant Kansei word pair, meaning that the higher noise levels contributed to a more pleasant workers' perception. This was related to the auditory impression workers experience when listening to 'Karak' being fried, creating a tickling sensation or Autonomous Sensory Meridian Response (ASMR) in the brain and a pleasant sensation (Margawati et al., 2020). The smoking and frying air humidity variables were inversely correlated with the unpleasant vs. pleasant Kansei word pair, meaning that higher humidity levels resulted in a more unpleasant perception among workers. The temperature, light, noise, and humidity variables in the draining process were directly correlated with the unpleasant vs. pleasant Kansei word pair, meaning that higher levels of the factors contributed to a more pleasant and unpleasant perception. The *R*-squared value of 0.301 showed that the independent variables collectively explained 30.1% of the variation in workers perception, with the remaining explained by other factors.

The working environment variable (*X*) did not influence the Kansei word pair hot vs cool (*Y*) because the calculated *t*-value <*t* table and a significance value > 0.05, with the exception of the packaging temperature variable (*X*). The packaging and arrangement temperature variables were directly proportional to the hot vs. cool Kansei word pair, meaning that as the temperature increased in the packaging and arrangement process, workers perceived the environment as cooler. The *R*-squared value of 0.290 showed that the independent variables collectively explained 29% of the variation, with the remaining explained by other factors.

The working environment variable (*X*) had no effect on the hot vs cold Kansei word pair (*Y*) because the calculated *t*-value <*t*-table and a significance value > 0.05. The obtained *F*-table value was 1.786. The coefficient of determination, derived from the R-squared value of 0.354, meaning that the independent variables collectively explained 35.4% of the variation, with the remaining explained by other factors. The correlation analysis of the working environment showed a moderate positive relationship with workers performance. The performance tends to improve in a well-structured working environment (Lestary & Harmon, 2017), and when employees are positively motivated or influenced by a favorable working conditions (Yanuari, 2019). The relationship between attitudes and perceptions was positively related to motivation based on a calculated *F*-value of 218.971 with a significant level of 0.000, which was below the threshold of 0.05 (Indah et al., 2019).

Multiple Linear Regression of Kansei Words (*X*) with HIRARC Workstation (*Y*)

Variable *X* comprised 5 Kansei engineering variables, namely dark vs. light, dirty vs. clean, unpleasant vs. pleasant, hot vs. cool, and hot vs. cold. Variable *Y* included 4 HIRARC-related variables, namely, heating cooking oil, smoking and frying, draining, as well as packaging and arrangement. Observations produced a *t*-table value of 1.993, based on a 95% confidence level, a sample size of 88, a total of 5 *X* variables, and an *F*-table value of 2.3245. The results of MLR analysis between Kansei engineering (*X*) with HIRARC (*Y*) are presented as follows.

The dark vs. light, dirty vs. clean, and hot vs. cold (*X*) variables did not significantly influence the heating HIRARC (*Y*), as the calculated *t*-value <*t*-table and a significance value > 0.05. However, the unpleasant vs. pleasant and muggy vs. cool (*X*) variables had a significant effect, with *t*-value > *t*-table and a significant value < 0.05. The unpleasant vs pleasant variable was

Table 8. Multiple linear regression results of Kansei engineering (X) with HIRARC (Y)

HIRARC t-test of cooking oil heating (Y)					
(X)	*t*	Sig.	*t* Table		Description
Unpleasant vs Pleasant	-2.604	0.011	1.993		Inversely proportional
Hot vs cool	2.051	0.043	1.993		Directly proportional
HIRARC t-test smoking and frying (Y)					
(X)	*t*	Sig.	*t* Table		Description
Dirty vs Clean	-4.168	0.000	1.993		Inversely proportional
HIRARC t-test for draining (Y)					
(X)	*t*	Sig.	*t* Table		Description
Unpleasant vs Pleasant	-2.419	0.018	1.993		Inversely proportional
HIRARC t-test of packaging and arrangement (Y)					
(X)	*t*	Sig.	*t* Table		Description
Unpleasant vs Pleasant	-2.235	0.028	1.993		Inversely proportional
Hot vs Cold	-2.005	0.048	1.993		Inversely proportional
Kansei engineering F-test (X)					
HIRARC (Y)	*F*	Sig.	*F* Table	Koef. Det.	Description
Heating	3.221	0.011	2.3245	16.4%	Correlated
Frying	6.163	0.000	2.3245	27.3%	Correlated
Draining	2.048	0.080	2.3245	11.1%	Not Correlated
Packaging	2.904	0.018	2.3245	15.0%	Correlated

Source: Primary data analysis, 2022

inversely correlated with the cooking oil heating HIRARC, meaning that a more pleasant workers perception corresponded with a lower risk value. The muggy vs cool variable was directly correlated with the cooking oil heating HIRARC. The coefficient of determination (*R*-squared) was 0.164, meaning that the independent variables collectively explained 16.4% of the variation, with the remaining explained by other factors.

The dark vs. light, unpleasant vs. pleasant, hot vs. cool, and hot vs. cold (*X*) variables did not significantly affect the smoking and frying HIRARC (*Y*), as the calculated *t*-value < *t*-table value and a significance value > 0.05. However, the dirty vs. clean (*X*) variable had a significant effect. The variable was inversely correlated with the smoking and frying HIRARC, meaning that as workers perceived working environment as cleaner, the risk value decreased. To reduce work-related risks, maintaining workstations cleanliness was essential. Proper hygiene and sanitation played a crucial role in ensuring product safety and maintaining a clean and healthy company environment (Yuliastri dan Yulianto, 2013). The obtained *F*-table value of 2.3245 showed that the independent variables collectively explained 27.3% of the variation.

The variables dark vs light, dirty vs clean, hot vs cool, and hot vs cold (*X*) did not affect the HIRARC of draining (*Y*), while the variable unpleasant vs pleasant (*X*) had a significant effect. The variable was inversely correlated with the HIRARC of draining, meaning that a more pleasant workers perception corresponded to a lower risk value in the draining process. The *R*-squared value of 0.111 showed that the independent variables collectively explained 11.1% of the variation, with the remaining explained by other factors.

The first result showed that the variables dark vs. light, dirty vs. clean, and hot vs. cool (*X*) did not affect the heating HIRARC (*Y*). The second result showed that the variables unpleasant vs. pleasant and hot vs. cold (*X*) affected the heating HIRARC (*Y*). The third result showed that the unpleasant vs pleasant variable was inversely correlated with the HIRARC of packaging and arrangement. Therefore, positive workers perception could decrease the risk value in the packaging and arrangement process. The hot vs. cold variable was also inversely correlated with the HIRARC of packaging and arrangement, meaning a colder working environment corresponded to a lower risk value. Based on the *t*-test summary in Table 4.12, the *R*-squared value of 0.150 confirmed the independent variables collectively explained 15.0% of the variation, with the remaining explained by other factors.

CONCLUSION

In conclusion, this study showed that the working environment significantly correlated with workers' risk in heating cooking oil, smoking, and frying, packaging and arrangement. However, in the draining process, the working environment parameters did not correlate with workers risk. The working environment was correlated with Kansei engineering across all processes, including heating cooking oil, smoking and frying, draining, and packaging and arrangement. Workers preferences and sensitivities were also found to be correlated with workers risk in the processes of heating cooking oil, smoking, and frying, as well as packaging and arrangement. However, similar to the working environment parameters, there was no correlation with workers risk in the draining process.

Improvements should be made in accordance with the Indonesian Minister of Health Regulation Number 70 of 2016 concerning Standards and Requirements for Occupational and Industrial Environmental Health, considering both risk values and workers perception. Excessive temperatures could be reduced by installing fans, blowers, or exhaust systems to prevent smoke accumulation, potentially posing health risks. Lighting could be improved by adding artificial lights or optimizing natural lighting to achieve an intensity of 200-500 lux, depending on the workstation area. In addition, air humidity could be regulated using a humidifier or by ensuring proper air circulation at each workstation.

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CONFLICT OF INTEREST

There were no conflict of interest during the study period or the journal writing process.

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