Risk analysis of Musculoskeletal Disorder (MSDs) on corn noodles production

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Abstract. Corn noodles are one of the non-wheat food diversification products to reduce dependence on wheat flour. In making corn noodles, it is suspected that there is a risk of Musculoskeletal Disorders (MSDs). This study aimed to identify the level of risk of MSDs in workers while making corn noodles. Data were collected using questionnaires, interviews, and observations to determine the risk level of MSDs using the Rapid Entire Body Assessment (REBA) method. The results showed that when workers did the corn noodle-making process, several work activities showed the risk of MSDs. Activities that pose a high risk of MSDs are when using an extruder; medium risk during mixing and steaming, while weighing ingredients and drying noodles had a low risk of MSDs. Work postures that cause complaints include bending over, looking down, and when lifting. The MSDs complaints were in the neck, shoulders, back, waist, arms, and fingers.

1. Introduction
Corn noodles are a diversified product of non-wheat processed food. Corn noodles are made from corn kernels milled into flour, which can be done by wet and dry milling [1]. The sheeting slitting method in making corn noodles is done by compacting the dough and then making sheets and strands [2]. Corn noodles contain carotenoids as a source of vitamin A with a low glycemic index and can increase the added value of corn and are suitable for business. [2,3].

In a business, an ergonomic work system is one thing that is quite important because it can increase company revenues and reduce expenses [4]. Ergonomic work systems are designed to eliminate potential hazards at work by providing a comfortable and efficient work station design, equipment, and work equipment according to the needs of workers to produce a healthy work environment [5]. One of the impacts of a system that is not ergonomic is the risk of Musculoskeletal disorders (MSDs); for example, if someone is accustomed to working in a bent position, they will feel complaints in the form of pain or soreness in the back area [6].

MSDs are a disorder of the musculoskeletal system with symptoms such as pain due to damage to nerves and blood vessels in various body parts such as the neck, shoulders, wrists, hips, knees, and heels [7]. MSDs appear when workers perform repetitive movements exacerbated by various risk factors at work [8].

In member countries of the European Union (EU), MSDs are the main causes of work disability, sickness absence, presenteeism, and loss of productivity up to 2% of gross domestic product (GDP) [9]. In addition, in the United States from 1992-2010, MSDs accounted for 29-35% of all occupational
injuries [10]. Other research that has been conducted shows that in Colombia during 2005, there were 23,477 cases of MSDs with a total cost of handling the US $171.7 million or 0.2% of Colombia’s Gross Domestic Product in that year [11]. Some work activities can cause the occurrence of MSDs, such as lifting objects, which has a very significant effect on lower back pain, and the movement of pulling important things makes wrist pain [12]. Therefore, it is necessary to conduct an ergonomic study on the corn noodle business to minimize the occurrence of MSDs during production.

The scope of the research is ergonomic testing in the aspect of motion analysis and work posture when doing noodle production. The purpose of this study is to identify the level of MSDs risk when workers produce corn noodles so that it can be a recommendation for improvement.

2. Material and Methods

2.1. Tools and materials
The equipment used in this research includes the manufacture of corn noodles such as extruders, mixers, steamers, scales, and other supports. In addition, the equipment for data collection includes a camera, stationery, hygrometer, infrared thermometer, sound level meter, and lux meter. The ingredients for making corn noodles include corn flour, mocaf flour, rice flour, salt, and water.

2.2. Data Collection Method
The research was conducted from March to September 2021 at Research Center for Appropriate Technology. The object of research is corn noodle SMEs. The data used are primary and secondary. Data were collected using questionnaires, interviews, and observations.

Information about MSDs complaints that were felt when making corn noodles was obtained through questionnaires and interviews. Meanwhile, direct observation was carried out to find out the description of the working posture of each stage of making corn noodles. The risk level for MSDs uses the Rapid Entire Body Assessment (REBA) method.

2.3. Data analysis
The questionnaire and interview data analysis results were to find out the complaints of MSDs that were felt during making corn noodles. In contrast, the observation data were analyzed using the REBA method.

3. Results and Discussion

3.1. Respondent Characteristics
Research respondents are corn noodle SMEs in Subang and have been producing noodles for 2-3 years. The number of respondents was three people, with an age range of 18-24 years, unmarried and not smoking. Respondents generally work for 8 hours a day for the noodle-making process with a rest time of about 1 hour.

3.2. Workplace Characteristics
One that affects the comfort in working is the condition of the work environment. Working environment factors that influence include light intensity, air temperature, humidity, noise, and others. The average condition of the room at the time of corn noodle production is shown in table 1, and measurements were made when the noodle-making process was carried out.
### Table 1. Workplace Characteristics

| Activity Type          | Noise level (dB) | Light intensity (Lux) | Room temperature (°C) | Relative Humidity (%) |
|------------------------|------------------|-----------------------|-----------------------|-----------------------|
| Weigh                  | 56.13            | 326                   | 22.5                  | 72.5                  |
| Mixer                  | 69.1             | 375.33                | 23.1                  | 74.17                 |
| Steaming               | 62.77            | 848                   | 25                    | 83                    |
| Extrusion              | 79.17            | 364.78                | 26.67                 | 75.56                 |
| Noodle decomposition   | 53.54            | 562                   | 24                    | 67                    |

Based on Table 1, the noise level generated when work activities are carried out is in the Low-Intensity category (<85dB) and does not cause hearing damage [13]. The intensity of light in the workspace has met the requirements for the health of the work environment in offices and industry, which is at least 100 lux in the room [14]. The room temperature based on the health requirements of the work environment in offices and industry is in the range of 18-28°C so that it is included in the applicable prerequisites. The humidity in the room exceeds the prerequisite range (40%-60%), so it is recommended to use a dehumidifier so that the existing conditions follow the health requirements in the work environment [14].

#### 3.3. Corn noodle making

Corn noodles can be made using calendaring and extrusion techniques [1]. In this study, the manufacture of corn noodles using the extrusion technique. This process requires an extruder. The steps for making noodles with the extrusion technique are shown in Figure 1.

![Figure 1. Corn noodle making](image)

In the extrusion process, the equipment used is a single screw-type extruder (Figure 2). The capacity of the extruder used is 12 kg/hour. The extruder specifications are listed in Table 2.
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Figure 2. extruder single screw type

Table 2. Specification of Extruders

| Specifications             | Extruder                        |
|---------------------------|--------------------------------|
| Machine type              | Single Screw                    |
| Capacity                  | 12 kg/h                         |
| The product               | Gluten-free noodle              |
| Length of the screw       | 502 mm                          |
| Screw diameter            | 62 mm                           |
| Screw pitch               | 43 mm                           |
| Screw rotation            | 40-50 RPM                       |
| Transmission              | Gearbox                         |
| Heater                    | Electric Element 500 W          |
| Motor                     | Electric motor 3.77 kW          |
| Materials (screw and barrel) | Stainless Steel 304         |

3.4. REBA Analysis

There are several stages of activities in the manufacture of corn noodles, including:

a. Material weighing

Figure 3. Material weighing process
At this stage, the material is weighed according to the required formulation. The back is straight; the neck is slightly bent; the feet are resting on both feet and, the wrist is twisted.

b. Mixing and steaming

At this stage, all the ingredients are mixed using a mixer. When mixing the ingredients, the body position is resting on both feet, the body posture is flexion 20-60°, the neck is bent down, and the wrist is rotated when preparing for mixing the ingredients and changing the ingredients to be mixed.

c. Material steaming

The mixed ingredients are then steamed. At this stage, the neck is slightly bent, the body is resting on both legs, the arms are above the arm line, and the wrists are twisted and crossed.
d. Extrusion

At this stage, there are several activities, including entering the material in the extruder and cutting noodles. When inserting the material and ensuring that the material enters the tool, the back is bent, the neck is bent, the body is resting on both legs, and the arms are stretched out to spill the material onto the tool. The position of cutting noodles, the body position is in a sitting position, the back is bent, the neck is slightly bent, the arm position is sometimes above the upper arm line, and the wrist is sometimes twisted and crossed. Another position is to untangle the noodles and bring the pan containing the noodles to the drying.

![Figure 6. Extrusion process](image)

e. Decomposition and drying

Before the drying process, the noodles are separated, and then the noodles are arranged on a baking sheet. At this stage, the position of the back and neck is bent, the body position is resting on both feet and sitting, and the wrists sometimes twist or cross when storing the pan on the shelf.

![Figure 7. Decomposition and drying](image)
Table 3. Score A, Score B, and Score C in the process of making corn noodles

| Activity                  | Awkward posture | Score A | Score B | Score C |
|---------------------------|-----------------|---------|---------|---------|
|                           |                 | Right   | Left    | Right   | Left    |
| Material weighing         | Neck down       | 1       | 5       | 5       | 3       |
| Material mixer            | bend back and   | 4       | 5       | 5       | 5       |
| Steaming                  | Material weighing | 3       | 9       | 9       | 7       |
| Extrusion                 |                 |         |         |         |         |
| - Enter material          | bend back and   | 4       | 9       | 9*      | 9*      |
|                           | Neck down       |         |         |         |         |
| - Noodle cutting          | bend back and   | 5       | 7       | 6       | 9*      |
|                           | Neck down       |         |         |         | 8*      |
| Decomposition and drying  | bend back and   | 3       | 3       | 3       | 3       |
|                           | Neck down       |         |         |         |         |

*Addition of 1 due to repetition

Table 4. REBA Score and Action Level in making corn noodles

| Activity                  | REBA Score | Action level | Risk Level | Corrective action |
|---------------------------|------------|--------------|------------|-------------------|
|                           | Right      | Left         |            |                   |
| Material weighing         | 3          | 3            | 1          | Low               | May be necessary |
| Material mixer            | 5          | 5            | 2          | Medium            | Necessary       |
| Steaming                  | 7          | 7            | 2          | Medium            | Necessary       |
| Extrusion                 | 9*         | 9*           | 3          | High              | Necessary soon  |
| - Enter material          | 9*         | 8*           | 3          | High              | Necessary soon  |
| - Noodle cutting          | 9*         | 8*           | 3          | High              | Necessary soon  |
| Decomposition and drying  | 3          | 3            | 1          | Low               | May be necessary |

*Addition of 1 due to repetition

The following is an analysis of the REBA score at the stages of making corn noodles in Table 3 and Table 4. Activities that have MSDs risk are when mixing materials which can be caused by an inappropriate mixer storage position so that they have a moderate MSD risk, the use of an extruder in a position to enter the material is above so that it requires a footrest, lowering the neck and slightly bending the body in addition to that's the position of the noodles coming out of the tool in a position that causes the body to be in a sitting position and bent down to facilitate cutting. In addition to weighing materials and drying have a low risk of MSDs.

3.5. MSDs Complaints

Based on the questionnaire results, several complaints were felt at the time of making corn noodles. The perceived complaints are listed in Table 5. Activities in the manufacture of corn noodles that cause pain include: Insert dough into the extruder; Material Mixing; Turning the dough over; Cutting noodles and, Storing noodles on racks.

The pain has been felt for 1-3 days and, complaints of pain have been handled since using the extruder. When compared with the results of the REBA analysis, it is seen that there is a relationship between body posture and complaints of MSDs. Activities in making corn noodles that are felt to cause pain include entering the dough into the extruder, mixing ingredients, turning the dough over, cutting...
noodles, and storing noodles. The use of an extruder has a high risk of MSDs complaints, and according to the results of interviews, the pain is felt every time you use the tool, so it is necessary to take control measures to minimize the risk of MSDs. Control measures that can be taken include avoiding the same position simultaneously, and modifications can be made to the place and work pattern [15].

Table 5. MSDs Complaints on Corn Noodle Making

| Complaint type                        | Felt complaint |
|---------------------------------------|----------------|
| Pain or stiffness in the upper neck   | Sore           |
| Pain or stiffness in the lower neck   | Sore           |
| Pain in the left shoulder             | Sore           |
| Pain in the right shoulder            | Sore           |
| Pain in the left upper arm            | sore; fever    |
| Pain in the upper back                | Sore           |
| Pain in the upper right arm           | sore; fever    |
| Pain in the lower back                | Sore           |
| Pain in the waist                     | Sore           |
| Pain in the buttocks                  | Sore           |
| Pain in the left elbow                | Sore           |
| Pain in the lower left arm            | sore; fever    |
| Pain in the lower right arm           | sore; fever    |
| Pain in the fingers of the left hand  | sore; fever    |
| Pain in the fingers of the right hand | sore; fever    |
| Pain in the left calf                 | Sore           |
| Pain in the right calf                | Sore           |
| Pain in the left foot                 | Sore           |
| Pain in the right foot                | Sore           |

4. Conclusion
Corn noodle-making activities have a risk of MSDs complaints. Activities that have a high risk of MSDs are at the time of extrusion, so improvements are needed on the tool to reduce the risk of MSDs. Improvements can be made by redesigning the extruder; for example, the insertion section of the material can be made lower so that it is easier to insert the material into the tool and does not require additional footrests. Other; In addition, the noodle outlet can adjust the user's target anthropometry to reduce the slouching position, and it is also possible to manufacture an automatic noodle cutter. The process of mixing ingredients and steaming has a moderate risk, and the process of weighing and drying has a low risk for repairs on both risks can be done by improving the layout of the tool so that the user is more comfortable when using the tool. The MSDs complaints felt during the corn noodle manufacturing process were proportional to the MSDs risk level of each method.

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