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Improvement of Work System and Physical Work Environment to Increase Worker Productivity in Natural Tofu Factory

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Abstract: Ergonomics is a scientific discipline that studies the capabilities and limitations of humans, as well as interactions between humans and other system elements (such as machines, workplaces and work environments) in order to create an optimal work system. Ergonomics should be applied to work systems or industries that are generally done by humans manually. One of the industries that is done manually is the business of making tofu at the Natural Tofu Factory. The postures analyzed were the soybean extraction process, the screening process, the printing process and the cutting process. From the assessment of work posture, there are several work postures that are classified at the level of moderate risk in the sense that changes may be needed to improve work attitudes. Work posture that

is classified as a high risk level which means it is very dangerous to the musculoskeletal system, needs improvement now. It is influenced by unnatural posture (bent over, neck bent, arms away from the body), repetitive activities, muscle use and excessive exertion.

Keywords: work posture, musculoskeletal, tofu industry

Introduction

The basic human need for food today is increasing along with the increasing population in Indonesia. In addition to clothing and shelter, food is needed by humans to support their activities. One type of food that is often consumed and easily obtained by the community is tofu. According to the 2015 National

Statistics Agency's SUSENAS results, the coverage of soybean consumption with soy ingredients is only in the form of tofu, tempeh and soy sauce, but in 2017 the food made from soybeans in SUSENAS increased, namely tauco and oncom. The development of tofu consumption at the household level in Indonesia during 2002-2018 fluctuated. The average consumption of tofu in 2002-2017 was 7.41 kg/capita/year.

The prediction of soybean consumption in the form of tofu in 2019 to 2021 is estimated to increase by an average of 1.78%. Tofu consumption is predicted to be 8.38 kg/capita in 2018 and will continue to increase to 8.67 kg/capita in 2021.

Ergonomics is a scientific discipline that studies the capabilities and limitations of humans, as well as interactions between humans and other system elements (such as machines, workplaces and work environments) in order to create an optimal work system. Ergonomics will be found in every workplace, especially humans must be in it [1]. In the application of ergonomic principles in the workplace, three aspects are seen, namely task, organization and the environment in harmony with the abilities, abilities and limitations of humans as workers [2]. The material handling system that is not systematic is also a big problem and disrupts the production process so that it affects the system as a whole [3]. A well-designed facility layout will generally make a positive contribution in optimizing the company's operating processes and will ultimately maintain the survival of the company and the success of the company [4]. Layout as a collection of physical elements arranged according to certain rules or logic [5]. If arranged properly, work operations will be more effective and efficient [6]. An industrial process is a work system that supports each other from each part in it. A work system that is not ergonomic in a company often gets less attention from company management. One part of the system, namely workers. Workers in factories know that they have a lot of less ergonomic attitudes and work positions. This will consciously or not affect the productivity, efficiency and effectiveness of workers in completing it. Tofu manufacturing factory is a business that produces tofu. Work posture or work

attitude is a work position naturally formed by the worker's body as a result of interacting with the facilities used or work habits. In the process of making tofu, there are unnatural postures performed by workers due to the characteristics of the task demands, work tools and work stations that are not in accordance with the abilities and limitations of the workers. An inappropriate work attitude can cause physical complaints in the form of pain in the muscles (Musculoskeletal Disorder). Thus it is necessary to analyze and carry out interventions on work postures and ergonomic work facilities to provide work comfort to prevent complaints of occupational diseases and to increase productivity.

METHODS

Data collection through interviews was conducted to find out what complaints of inconvenience and difficulties the operator felt in the process of making tofu. Then given a Nordic Body Map questionnaire to the operator to support the results of the interview. This questionnaire is in the form of questions to find out which parts of the muscles experience complaints when doing tofu-making activities. This questionnaire was given to research respondents, namely operators in the process of making tofu. The emergence of complaints or discomfort is sufficient to support research. At this stage the results of the questionnaire that have been given to the respondents are displayed. In this study, the RULA value calculation will be carried out based on the worker's body posture during the tofu-making process.

Improvement of the working environment in this factory can be done by applying the 5S method. 5S is the easiest principle to understand, this principle makes it possible to obtain total participation. Referring to the expert's opinion that it will not be successful if 5S is not implemented, on the contrary the benefits obtained by implementing 5S will be clearly seen, including the creation of order through good work environment management.

According to [7] the elaboration of the "5S" method is as follows: 1). Seiri, Set aside items that are not needed at work. 2). Seiton, Arrange the necessary items so that they can be easily found by anyone if needed. 3). Seiso, Clean the workplace regularly so

that there is no dust on the floor, machinery and equipment. 4). Seiketsu, Maintain a good level of household stewardship and workplace organization at all times. 5). Shitsuke, Providing counseling to all people to comply with the discipline of good housekeeping on their own awareness.

One of the small and medium industries in the city of Padang which is engaged in tofu processing is the Natural Tofu UKM. Natural Tofu or Tofu Kitchen is an MSME which is located on Jl. Adinegoro, Lubuk Buaya, Padang City where this UMKM is engaged in making or producing tofu which was founded in 1999. The tofu industry has 2 work shifts (shift 1: 05.00 -11.00, shift 2: 12.30-18.30) with 4 workers per shift. Every worker at Natural Tofu UKM is tasked with producing tofu, starting from processing raw materials to ready-to-sell products.

The entire tofu production floor consists of four areas, where each area consists of four work stations. These work stations are milling, boiling, filtering and printing work stations. The pre-soaking, washing and final soaking processes of soybeans are carried out at the milling work station. The printing, pressing, measuring and cutting processes are carried out at the printing workstation.

Management is an important thing to pay attention to because it is the basis for achieving effectiveness and efficiency which later determines the company's performance. In addition, with good management, company stability can be better maintained and better prepared to face external challenges. Management must be comprehensive in all business functions including marketing, finance/accounting, production/operations and human resources functions. If the management has been carried out properly, the company will be better prepared for further business development. This business development is important to support the company's performance improvement. Development must be carried out because competitors also continue to grow, so that if the company does not develop its business, the company will be left behind by competitors. With the development of the company's business can also grow bigger and relatively stronger in facing competition.

FINDINGS

Milling process



Fig 1 Milling Operator's Body Posture

From Fig 1, it can be seen that the operator is loading the soybeans into the grinding machine.

Group A Posture

The upper arm forms an angle of 69.630, meaning that the angle is at 450-900 flexion, so the score is 3 and The forearm forms an angle of 86.650 meaning that the angle is at 600-1000 flexion, so the score for the forearm is 1. The wrist is in flexion 00-150, so the score is 2 and The wrist loop is on the center line in a twisted position with a score of 1. For Load and exertion scores, there is no resistance or loading and exertion erratically <2 Kg, so the score for loading is 0. So the total score for group A is $4 + 0 = 4$

Group B Posture

Neck posture forms an angle of 18,640 meaning it is at 100-200 flexion, Then the score is 2. The back in the work looks slightly bent to form an angle of 21.650, meaning that it is in 200-600 flexion, so the score for the body is 3. The feet in a balanced state due to standing, so they are given a score of 1. There is no resistance or loading and exertion erratically <2 Kg, so the score for loading is 0. The total score for group B is $4 + 0 = 4$. So the total score in the milling process is 4, which means that the risk of injury to the musculoskeletal system is moderate so that further investigation is needed, maybe a change is needed to improve work attitudes. Boiling Process.

Boiling Process**Fig 2 Boiling Operator's Body Posture**

Fig 2 shows that the operator is putting finely ground soybeans into the boiling tank.

Group A Posture

The upper arm forms an angle of 41.340, meaning that the angle is at 200-450 flexion, so the score is 2. The forearm forms an angle of 90,290 at 600-1000 flexion, so the forearm score is 1. The wrist is in flexion 00-150, so the score is 2. The wrist loop is on the center line in a twisted position with a score of 1. Loading and exertion are erratic between 2-10 kg, so the score for loading is 1. The total score for group A is $3 + 1 = 4$

Group B Posture

The neck forms an angle of 16,750 meaning it is at 100-200 flexion, then the score is 2. The back on the job looks slightly bent at an angle of 19.75, which means that it is in flexion of 00-200, so the score for the body is 2. The posture of the legs in work, namely the feet are in a balanced state due to standing, so they are given a score of 1. There is no resistance or loading and exertion erratically <2 Kg, so the score for loading is 0. The total score for group B is $2 + 0 = 2$. So the total score in the boiling process is 3, which means that the risk of injury to the musculoskeletal system is moderate so that further investigation is needed, it may be necessary to change the work attitude.

Filtering Process**Fig 3 Body Posture of Tofu Porridge Screening Operator**

From Fig 3, it can be seen that the operator is filtering the tofu slurry that has been mixed with wei water to make it easier for the tofu feeder process to make the printing process easier.

Group A Posture

The upper arm forms an angle of 41.070, meaning that the angle is in 200-450 flexion, so the score is 2. The forearm forms an angle of 106.030 at flexion > 1000, so the forearm score is 2. The wrist is in flexion 00-150, so the score is 2. The wrist loop is on the center line in a twisted position with a score of 1. There is no resistance or loading and exertion erratically <2 Kg, so the score for loading is 0. The total score for group A is $3 + 0 = 3$

Group B Posture

The neck forms an angle of 19,330 meaning it is at 100-200 flexion, then the score is 2. The back in the work looks slightly bent at an angle of 15,780, meaning that it is in flexion of 00-200, so the score for the body is 2. The posture of the legs in work, namely the feet are in a balanced state due to standing, so they are given a score of 1. There is no resistance or loading and exertion erratically <2 Kg, so the score for loading is 0. The total score for group B is $2 + 0 = 2$. So the total score in the screening process is 3, which means that the risk of injury to the musculoskeletal system is moderate so that further investigation is needed, it may be necessary to change the work attitude to improve.

Mixing with Wei Water**Fig 4 Body Posture of Tofu Printing Operator**

From Fig 4, it can be seen that the operator is mixing tofu pulp with wei water (water from fermented bean stew) to facilitate the clotting process of tofu.

Group A Posture

The upper arm forms an angle of 12.90, meaning that the angle is at 200 flexion, so the score is 2. The forearm forms an angle of 27,150 at flexion <600, so the forearm score is 2. The wrist is in flexion > 150, so the score is 3. The wrist loop is on the center line in a twisted position with a score of 1. There is no resistance or loading and exertion erratically <2 Kg, so the score for loading is 0. The total score for group A is $3 + 0 = 3$

Group B Posture

The neck forms an angle of 38,880 meaning it is in flexion > 200, then the score is 3. The back in the work looks slightly bent to form an angle of 40.370, meaning that it is in 200-600 flexion, so the score for the body is 3. The posture of the legs in work, namely the feet are in a balanced state due to standing, so they are given a score of 1. There is no resistance or loading and exertion erratically <2 Kg, so the score for loading is 0. The total score for group B is $4 + 0 = 4$. So the total score in the mixing process is 4, which means that the risk of injury to the musculoskeletal system is moderate so that further investigation is needed, maybe a change is needed to improve work attitudes.

Printing

From Fig 5, it can be seen that the operator is doing the tofu slurry molding which has previously been filtered and mixed with wei water to facilitate the tofu clumping process.

**Fig 5. Body Posture of Tofu Printing Operator****Group A Posture**

The upper arm forms an angle of 45,510, meaning that the angle is at 200-450 flexion, so the score is 2. The forearm forms an angle of 64.58. at 600-1000 flexion, the score of the forearm is 1. The wrist is in flexion > 150, so the score is 3. The wrist loop is on the center line in a twisted position with a score of 1. There is no resistance or loading and exertion erratically <2 Kg, so the score for loading is 0. The total score for group A is $3 + 0 = 3$

Group B Posture

The neck forms an angle of 48,930 meaning it is in flexion > 200. Then the score is 3. The back in the work looks slightly bent to form an angle of 33,960, meaning that it is in 200-600 flexion, so the score for the body is 3. The posture of the legs in work, namely the feet are in a balanced state due to standing, so they are given a score of 1. There is no resistance or loading and exertion erratically <2 Kg, so the score for loading is 0. The total score for group B is $4 + 0 = 4$. So the total score in the printing process is 4, which means that the risk of injury to the musculoskeletal system is moderate so that further investigation is needed, maybe a change is needed to improve work attitudes.

Cutting



Fig 6 Body Posture of Tofu Cutting Operator

From Fig 6, it can be seen that the operator is cutting tofu which was previously carried out by printing and pressing to remove water from it.

Group A Posture

The upper arm forms an angle of 16.050, meaning that the angle is at 200 flexion, so the score is 1. The forearm forms a 63.90 angle with 600-1000 flexion, so the forearm score is 1. The wrist is in a neutral position, then the score is 1. The wrist loop is on the center line in a twisted position with a score of 1. There is no resistance or loading and exertion erratically < 2 Kg, so the score for loading is 0. The total score for group A is $1 + 0 = 1$

Group B Posture

The neck forms an angle of 35.130 meaning it is in flexion > 200 , then the score is 3. The back in the work looks slightly bent at an angle of 29.050, meaning that it is in flexion of 200-600, so the score for the body is 3. The posture of the legs in work, namely the feet are in a balanced state due to standing, so they are given a score of 1. There is no resistance or loading and exertion erratically < 2 Kg, so the score for loading is 0. The total score for group B is $4 + 0 = 4$. So the total score in the cutting process is 3, which means that the risk of injury to the musculoskeletal system is moderate so that further investigation is needed, maybe a change is needed to improve work attitudes.

5S Method Design

This stage is the initial stage of implementing the 5S method. At this stage, an implementation design is carried out that will be carried out later. In addition,

at this stage the location of the 5S method was also determined. For example, in the sorting process, we first have to identify the scope and targets that will be applied to the sorting process in this research. The areas where the sorting process will be carried out are in the finished material warehouse area and the soaking and milling station area. After that, identify what needs to be sorted or separated in the selected scope, namely empty buckets separated from buckets containing soybeans and those containing finished tofu.

Seiton, for the initial stage of analysis, then determining the appropriate place of arrangement, determining how to store the equipment properly, then carrying out activities to comply with the storage rules that have been made.

Seiso, the initial stage carried out is to identify and determine targets. In this research, it can be identified that there is a lot of garbage scattered on the production floor and there is a lack of cleaning of equipment after finishing work. After the problem and target can be identified, then the cleaning process is carried out, whether it is cleaning the production floor or the equipment used. When it has been cleaned, it will be carried out to identify the source of the cause of dirt and seek preventive solutions in order to reduce the floor and equipment from being dirty anymore.

Seiketsu, the design that will be carried out at this stage is the labeling and boundaries of the work area so that workers know the place and limits for placing equipment and work areas, so that later workers can get used to the implementation of the 5S method that has been designed.

Shitsuke, the design carried out at this stage is aimed at the leadership of the company, to always control the workers so that they are familiar with the implementation of the 5S method by providing counseling every week or controlling directly to the field.

Socialization of 5S Method Implementation

After the design stage has been completed, then the socialization stage will be carried out. At this stage, socialization was carried out by providing an

explanation of 5S and giving directions on how to apply this method to the work environment, besides that it also explained the 5S design that had been made. This is intended so that workers can understand and understand about 5S, so that the implementation of 5S can be easier to implement.

Application of the 5S Method

At this stage, the 5S method is applied to the natural tofu making work environment.

1. Seiri. The seiri method is widely applied to soaking and milling stations as well as in the finished material warehouse area, because in these two departments it is clear that there are many buckets scattered on the floor. These buckets consist of buckets filled with soy as well as those filled with finished tofu and empty buckets, while these empty buckets are not needed in soaking and milling stations and in finished material stores. These empty buckets fill the floor so that there is no room for workers to carry out the soaking and milling processes. Seeing this situation, seiri was applied, namely by sorting unnecessary buckets or empty buckets and storing them in areas outside the finished material warehouse area as well as at the soaking and milling stations. From the results of this sorting, it is found that the floor has more space so that workers are more free to do their work, especially in the material handling process of moving soybeans that have been milled to the boiling station so that often the moving distance becomes far because workers have to pass through an empty area that is not blocked by a bucket. - scattered members of the soaking and milling station.
2. Seiton. At this stage it is a continuation of seiri, where the results of the sorting that have been carried out will be followed by the process of arranging the sorted equipment. For example, the buckets in the soaking and milling stations are arranged in the empty bucket area, to be precise, next to the finished material warehouse. Likewise, empty buckets that are mixed up in the finished material warehouse are also arranged in the empty bucket area. In addition to the arrangement of the bucket positions, this factory also arranges the calico cloth, namely the cloth for the tofu dregs filtering process and also the arrangement of the position of the press device. The calico cloth is hung in one place only so that it is easier for workers to find and pick it up when needed. Whereas the press is arranged at the pressing and cutting station, the press is arranged on the press table and cuts so that workers can easily pick up and use it.
3. Seiso. At this stage what is done is the cleaning process. The cleaning that is carried out is cleaning the production floor and the equipment used for the tofu production process, namely the grinding machine and boiling and seeding cauldrons. The factory floor is cleaned of rubbish, including plastic waste, fallen soybeans and liquid residue from washing and milling soybeans. Cleaning the production floor is intended for the safety and comfort of workers when doing their work, because if the floor is slippery and dirty it can make workers slip and fall. Meanwhile, cleaning of work equipment is carried out with the aim of maintaining the equipment.
4. Seiketsu. At this stage an effort is made to make the implementation that has been carried out continuously, not temporarily, by making work area labels such as the raw material area, the finished material area, the empty bucket and the calico cloth. In addition, the work area boundary was also made to make the arrangement of work equipment more organized. With the creation of labeling and work area boundaries, employees know where to place the equipment used and know the boundaries of the area, so that this application can take place continuously.
5. Shitsuke. This section focuses more on how to familiarize yourself with the application of this method. Therefore, it requires the awareness of the workers to have a work pattern that is in accordance with the 5S method for the sake of comfort and safety at work. Given the different human nature, it is necessary to have someone who can control it. In this case, the role of the

leader is needed to care and be able to control workers so that they always maintain the work environment based on the 5S method that has been applied.

CONCLUSION

From the results of the implementation of this research it can be concluded that in the process of milling, boiling, filtering, further investigation is needed and an improvement in work attitude. Through the application of the 5S method, the physical conditions of the work environment in the tofu factory are more organized and have an effect on workers' comfort.

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