Design of Tofu Cutting Tools to Improve Repetitive Tasks Using OCRA

Benedikta Anna Haulian Siboro\textsuperscript{1}, Vera Methalina Afma\textsuperscript{2}, Annisa Purbasari\textsuperscript{3}, Muhammad Qodri Kasim\textsuperscript{4}

Department of Industrial Engineering, Universitas Riau Kepulauan
\textsuperscript{1}anna@ft.unrika.ac.id, \textsuperscript{2}vera.afma@gmail.com, \textsuperscript{3}anice_nisa@yahoo.com

Abstract. Cutting process is one of processes in producing tofu before being packaged and marketed. Generally, cutting tofu is performed manually using a ruler with repetitive movements as 20-24 times, therefore it required longer time to cut and cause low back pain (LBP) in workers. Present study objective is to analyze the risk of work with repetitive task in the process of cutting tofu and designing tools to reduce these risks without decreasing the quality of the tofu. The methodology use OCRA and anthropometry which performed on two tofu factories (Mr. Joko and Mr. Udin) in Batam, as research subject. The results showed that repeated movements during tofu cutting were carried out for 33-35 seconds, with the percentage higher at hands work and waiting times in seconds. Furthermore, the OCRA risks of repetitive movements assessment is classified as medium-risk conditions (3.8-4.48). However, it is necessary to repair the cutting tools. Improvements are gained by designing cutting tools in accordance with the operator's hand anthropology. The new tofu cutting tool produces only 2 times repetitive movements, which is lesser and using OCRA assessment the level of movement risk becomes optimal (≤ 1.5).

Keywords: repetitive tasks, OCRA, anthropometry, low back pain

1. Introduction
Tofu has the heftiest quality vegetable protein because of its most complete amino acid composition and is believed to have high digestibility (85% -98%), which make tofu as one of favourite foods for most people [1]. Tofu heaviest ingredient is soybean and Indonesia is the largest producer of tempeh and soybean markets in Asia [2]. In Indonesia, tofu is processed using various methods which generate varied product. The process also has no standardization as a reference for producing a superior tofu. Tofu is processed through several stages; soybean cleaning, milling, boiling, filtering, printing, tofu cutting and packaging. The Size of tofu is adjusted to market demand, thus the tofu factory usually produce several sizes. The tofu is cut using a cutting tool and measured by a ruler. The cutting of a tofu board generally took 20-24 times cutting movements. The process of cutting tofu is performed by several factories in Indonesia, including in Batam. To cut tofu, the worker’s posture must bent and are carried out repeatedly during daily production. This repetition posture that carried out day to day will cause Low Back Pain (LBP). Several factors including anthropometric characteristics, the nature and severity of physical work, working postures, and methods of manual lifting/handling have been related to the severity of LBP [3]. In addition, other aspects such as lifestyle conditions and psychological factors may also be considered as independent risk factors for the risk of LBP [4].
There are numbers of risk assessment methods that can be used to assess work risks. One of them is OCRA (Occupational Repetitive Action). OCRA is an ergonomic tool that suitable to analyse work risks due to exposure of repetition activities. In other hand, OCRA method is widely known as a valid, scientifically founded tool, to detect the presence of risk factors for the upper limbs, likely to determine the level, in the medium –long term, of work related pathologies [5].

Countless researches are focus to improve cutting tool design. Budihamsyah and Putra proposed the design of tofu cutters at affordable prices used the Value Engineering method to be expected to increase time efficiency by 56.5% and reduce the disability rate by 88%. The proposed tool was designed using food grade stainless material in boxes according to the size of the tofu [6]. Siboro [7] had researched and designed the cutting tools based on cutting process only two times which quicker. However, her research was required to be developed as the base to lay the tofu was uneven and the thickness was varied thus the tofu had not completely and evenly cut. In addition, Izzhati [8] had also designed cutting tools used iron and one handle. Her design was set for large and thick tofu.

Meanwhile, the purpose of this study is to analyse the work risk’s caused by repetitive movements during the process of cutting tofu using OCRA method and designing tools to reduce the risk of repetitive movements.

2. Methods

2.1 Procedure
This research was carried out on the two tofu factories in Batam (Mr. Udin and Mr. Joko's factories). At the beginning of the study, interviews and observations were conducted to collect information and identify the work process of cutting tofu, investigated workers complaint on health issue and collected input to improve the work system in cutting tofu. Observations also include working time, rest time, duration of repetitive work, etc. to get accurate data for OCRA assessment. Observations were also used video recordings to identify technical actions and calculate the number of technical actions, work time cycles.

2.2 Work Risk Assessment with OCRA
The work-risk assessment will be carried out on two operators who frequently cut tofu at Pak Joko's Factory and one tofu operator at Mr. Udin Factory. Assessment aspects include 1) force of exertion, 2) frequency, 3) discomforted postures / movements, 4) lack of sufficient recovery, 5) duration, and 6) additional factors. For consistency between force/exertion intensity, estimation between methods, all raters applied the Borg CR-10 scale [9] assessment which based on the items listed in the OCRA checklist. Furthermore, the work risk score will be calculated according to value of ATA (Actual Technical Actions), RTA (Recommended Technical Actions), and finally calculate OCRA index value.

\[
\text{ATA} = \text{Frequency} \times \text{Time total of repetitive task} \\
\text{RTA} = \sum_{i=1}^{n} \left[ CF \times (Ff \times Fpi \times Fc) \times D \right] \times Fr \times Fd \\
\text{OCRA}_{\text{index}} = \frac{n\text{ATA}}{n\text{RTA}}
\]

Where:
1. n = number of repetitive tasks performed
2. I = generic repetitive task
3. CF = constant of frequency of technical action per minute (=30)
4. Ff = frequent or high force exertions
5. Fp = uncomfortable posture factor or movement in each repetitive task
6. Fc = additional factor
7. D = net duration in minute of each repetitive task
8. Fr = multiplier for the risk factor lack of recovery period
Fd = overall duration factor of all repetitive tasks

Below is OCRA index to classify the activities, whether in optimal risk classification or not.

| Area          | OCRA Index Values | Risk Classification   | Consequent possible actions                                      |
|---------------|-------------------|-----------------------|-------------------------------------------------------------------|
| Green         | 1.5 and lower     | optimal               | None                                                              |
| Green-Yellow  | 1.6 - 2.2         | acceptable            | None                                                              |
|               |                   | uncertain or very     |                                                                   |
| Yellow-Red    | 2.3 - 3.5         | low                   | Check again, if possible improve work conditions                  |
| Red-Light     | 3.6 - 4.5         | light                 | Improve work conditions, health surveillance, training             |
| Red-medium    | 4.6 - 9.0         | medium                | Improve work conditions, health surveillance, training             |
| Red-high      | 9.1 and higher    | high                  | Improve work conditions, health surveillance, training             |

If the index value at OCRA is >2.2, it is necessary to re-established it for eliminate unwanted risk.

2.3 Tool Design

Tool design is carried out if the results of OCRA index are stated as risky and require improvements in order to reduce risk. In this study, tool design was carried out by measured the anthropometry of the worker's body. In stations, the worker should stand and most activities performed by hand. There are several dimensions that need to be considered as a guide in the measurement and retrieval of anthropometric data [10], namely: hand reach, elbow width, length palms, palms width, hand grip diameter. In determined those anthropometric data, normal distribution will generally be applied. In statistics, the normal distribution is formulated based on mean (x) and standard deviation (σ x) of the available data. Based on the calculation result, the "percentiles" can be appointed according to the normal distribution probability table. The percentile used in this study is 95th percentile which refer to 95% of the population, or below the mean. The percentile 5-th indicate that 5% of the population, or below, is valued and the 50th percentile indicate 50% of the population will be at the average value of that size.

3. Result and Discussion

3.1 Working Posture

Body postures during cutting tofu in both factories were dissimilar. Mr. Udin factory has a table to cut tofu which lower than the worker's body posture, while Mr. Joko's Factory already has a tofu cutting table that suitable with worker anthropometry. A bent posture in day to day basis will adversely affect the worker's health. Activities such repeated lifting, carrying, pulling and pushing heavy objects, frequent or prolonged bending, bowing, sitting or standing for a long time or other uncomfortable body postures, standing position prolonged will caused low back pain [11]. Research by Punnet [12] described 15% of adults, in general, suffering from frequent back pain or pain lasting more than two weeks, and 37% of LBP was attributable to occupational risk factors. In those both factories, it were identified that the repetition during the work cycle was the process of cutting tofu using a knife and ruler / mall as a size control (Table 1). High repetition of movements in manual tasks is related to musculoskeletal disorders, specifically on upper limb. Musculoskeletal disorders are among the most common working problems Buckle and Devereux [13] representing one-third of work injuries with significant economic and social consequences.
Table 2. Condition of Mr. Joko and Mr. Udin factories

| Conditions   | Mr. Joko                                      | Mr. Udin                                    |
|--------------|-----------------------------------------------|---------------------------------------------|
| Body Posture | Body is not bent                               | Body is bent due to lower worktable         |
| Tools        | Knife, and *mal*                               | Knife and ruler                             |
| Times        | 25-30 seconds each table                       | 30-35 seconds each table                    |
| Complaints   | Pain on wrist, back                           | Pain on wrist, back, neck                   |

3.2 OCRA Analysis before Design Improvement

The above conditions were supported by the results of OCRA calculations at each tofu factory. At Mr. Joko’s factory, the number of actions taken in one work cycle were 29 activities by left hand, and 31 movements by right hand; generally activities include took and put the tofu mold, taking the size guidance, taking the knife and cutting tofu. At the Mr. Udin factory, one work cycle required 30 activities for the left hand and 33 activities by right hand, which involved picking and laying out the tofu mold, taking a ruler, picking up a knife and cut tofu. The Bhor score scale for each activity is determined by the duration of each activity. In both factories the longest time per activity was lifted and laid out the tofu mold (Bohr scale = 3), while other activities with a score = 1. The total score of the overall activities will influence the technical strength factor (FF) of the worker. Analysis of posture and movement in each single segments of the upper body (grip, wrist, elbow, shoulder) and associated with time (frequency and time period) static posture and dynamic movements were analyzed in Fp to determine the uncomfortable posture position. At the factory, Mr. Joko and Mr. Udin factories, the worker shoulder up 45° -80° when they lifted and placed the mold and when hold the knife to cut the hand was in pinch posture; both activities were uncomfortable posture. Another factor that influences the high OCRA index in these two factories is Fd, as the tofu cutting area is very close to the soybean milling station with a noisy machine level that affects tofu cutting work. Table below present both Mr. Joko and Mr Udin Factories have an OCRA index at the red light level which requires improvement of the work system, health and training for the workers.

Table 3. OCRA Index before Improvement

| Calculation items | Mr. Joko | Mr. Udin |
|-------------------|----------|----------|
|                   | Right Hand | Left Hand | Right Hand | Left Hand |
| ATA               | 11160     | 10440    | 10080      | 9360      |
| CF                | 30        | 30       | 30         | 30        |
| FF                | 0.6786    | 0.6357   | 0.74464    | 0.54952   |
| Fp                | 1         | 1        | 0.7        | 1         |
| FC                | 0.8       | 0.8      | 0.8        | 0.8       |
| D                 | 360       | 360      | 360        | 360       |
| Fr                | 1         | 1        | 1          | 1         |
| Fd                | 0.5       | 0.5      | 0.5        | 0.5       |
| RTA               | 2932      | 2746     | 2252       | 2374      |
| OCRA              | 3.81      | 3.80     | 4.48       | 3.94      |
3.3 Design and OCRA after repair

From the OCRA index results, the next step is to improve the tofu cutting process by designing tofu cutting tools. Below is a design that equipped with size, disadvantages and advantages of each tool. The design of cutting tools for both factories will be dissimilar; according to actual conditions of the cutting process. In previous explanation, at Mr. Udin Factory, body posture of workers is bent during tofu’s cutting thus it require table in accordance to the worker’s posture. Therefore, in the design, tables and cutting tools are designed to fuse, so it more efficient. With the linear slider in the vertical and horizontal position, the operator will easier to cut the tofu. In the cutting tool for Mr. Joko, the cutting tool is designed not to be installed jointly with the table and cutting tools. It is also designed lightly to facilitate the cutting process of tofu.

Table 4. Improvement Design of Tofu Cutter

| Design Items | Mr. Joko | Mr. Udin |
|--------------|----------|----------|
| Design       | ![Design Image] | ![Design Image] |
| Dimension    | Hand reach: 77.6 cm (reference for length tofu cutting) | Hand reach: 77.6 cm (reference for length tofu cutting) |
|              | Elbow width: 97.8 cm (reference for width of tofu cutting). Height of man: 95 cm (reference of table high of table) | |
| Advantages   | Cutting process only 2 times, no need extra places | Cutting process only 2 times |
| Disadvantage | Need more times to set straight line |
|              | Need to lift 1 set cutter if cutting vertical or vice versa | Table take more places |

Trial for the tools was carried out within one week to make sure that it could be used properly, and afterward the OCRA analysis was applied on the use of these tools. Table 5 below show the decrease in number of activities carried out (ATA) in one cycle of activities. The process of cutting tofu using the designed tool indicate positive impact on the efficiency of the cutting process time; the cutting process befall shorter 15-20 seconds after an average repair. For Fp, the uncomfortable posture in the tofu cutting process at Mr. Joko’s and Mr. Udin’s factories was remain endure during lifting and placing the mold where shoulder move to 45°-80°. Moreover, other additional factors such lighting and noise were remain present. The table 5 below display a significant decrease in the OCRA index to 0.48-0.9, where the score was based on Table 1 including the green level (optimal). Both of these tools can be used further without negative impact on the health of workers.
Table 5. OCRA Index after Improvement

| Calculation Items | Mr. Joko Right Hand | Mr. Udin Right Hand | Mr. Joko Left Hand | Mr. Udin Left Hand |
|-------------------|---------------------|---------------------|-------------------|-------------------|
| ATA               | 2520                | 1440                | 1440              | 1080              |
| CF                | 30                  | 30                  | 30                | 30                |
| FF                | 0.65                | 0.69                | 0.5               | 0.5               |
| Fp                | 1                   | 1                   | 1                 | 1                 |
| FC                | 0.8                 | 0.8                 | 0.8               | 0.8               |
| D                 | 360                 | 360                 | 360               | 360               |
| Fr                | 1                   | 1                   | 1                 | 1                 |
| Fd                | 0.5                 | 0.5                 | 0.5               | 0.5               |
| RTA               | 2808                | 2981                | 2160              | 2160              |
| OCRA              | 0.90                | 0.48                | 0.67              | 0.50              |

4. Conclusion
Based on above results we can conclude:
1. Repetitive activity and bending will impact people health, particularly low back pain.
2. Before improvement, tofu cutting activity at Mr. Joko and Mr. Udin factories have risk potentiality. It is indicated by OCRA index level that showed 3.80-4.49 (red risk level). After improvement, OCRA index reach optimal level due to decrease of repetition activity from 20-24 times cutting per table to 2 times cutting process.

Acknowledgement:
This research was supported by funding from Ministry of Research, Technology and Higher Education.

5. Reference
[1] Widyaningrum I 2015 Teknologi Pembuatan Tahu yang Ramah Lingkungan (Bebas Limbah). Jurnal Dedikasi 12(1) pp 14-21
[2] Astawan M 2004 Tetap Sehat dengan Produk Makanan Olahan (Solo: Tiga Serangkai)
[3] Sowah D, Boyko R, Antle D, Miller L, Zakhary M and Straube S 2018 Occupational interventions for the prevention of back pain: Overview of systematic reviews. Journal of Safety Research 66 pp 39-59
[4] Duthey B 2013 Update on 2004 background paper 6.24 low back pain. (WHO)
[5] Boenzi F, Digiesi S, Facchini F G and Mummolo G 2016 Ergonomic improvement through job rotations in repetitive manual tasks in case of limited specialization and differentiated ergonomic requirements. IFAC Conference Paper 48(12) pp 1667-1672
[6] Budihamsyah D and Putra B I 2017 Perbaikan Desain Alat Pemotong Tahu Dengan Pendekatan Rekayasa Nilai. Prozima 1(2) pp 123-135
[7] Siboro B A H, Siregar R.A and Purbasari A 2017 Perancangan Alat Pemotong Tahu Untuk Mengurangi Gerak dengan Metode Motion Time Measurement (MTM)-Motion Time Study (Studi Kasus Fabrik Tahu Pak Joko). Profisiensi 5(2) pp 115-122
[8] Izzhati D N 2010 Pengembangan Alat Pemotong Tahu yang Ergonomis Dengan Menggunakan Metode Rula. Prosiding Seminar Nasional Sains dan Teknologi 1(1) pp 7-11
[9] Rosecrance J, Paulsen R and Murgia L 2017 Risk assessment of cheese processing tasks using the Strain Index and OCRA Checklist. International Journal of Industrial Ergonomics 61 pp 142-148
[10] Irdiastadi H and Yassierli 2014 Ergonomi Suatu Pengantar (Bandung: PT. Remaja Rosdakarya)
[11] Kusuma I F, Hasan M and Hartanti R I 2014 Pengaruh Posisi Kerja terhadap Kejadian Low Back Pain pada Pekerja di Kampung Sepatu, Kelurahan Miji, Kecamatan Prajurit Kulon, Kota Mojokerto. Jurnal IKESMA 10(1) pp 59-66

[12] Punnett L 2005 Estimating the global burden of low back pain attributable to combined occupational exposures. American Journal of Industrial Medicine 48 pp 459-472

[13] Buckle P.W and Devereux, J.J 2002. The nature of work-related neck and upper limb musculoskeletal disorders. Appl. Ergon. 33(3) pp 207–217