Thai Journal of Ergonomics: Volume 5 Issue 1 January – June 2022: p. 50-60
วารสารการยศาสตร์ไทย: ปีที่ 5 ฉบับที่ 1 มกราคม--มิถุนายน 2565: หน้า 50-60

นิพนธ์ต้นฉบับ

(Original article)

Ergonomic design of dough sheet making machine in Krathok noodle community enterprise

การออกแบบอุปกรณ์ช่วยทำแผ่นแป้งตามหลักการยศาสตร์ในวิสาหกิจชุมชนหมี่กระโทก

Chalermsiri Theppitak, Arissara Latchapo, Nisarat Tengpakwaen, Nutthakan Meechamnan, Supisara Suebkrathok, Pimnapat Taevongcharoenjai, Thanyarat Saosin, Auraiporn Huangkrathok, Khanidtha meevasana*

เฉลิมสิริ เทพพิทักษ์, อริสรา ลัดจะโป๊ะ, นิศารัตน์ เต็งผักแว่น, นัฐกานต์ มีชำนาญ, ศุภิสรา สืบกระโทก, พิมณภัทร์ แต้วงศ์เจริญใจ, ธัญรัตน์ เสาสิน, อุไรพร ห่วงกระโทก, ขนิษฐา มีวาสนา*

School of Occupational Health and Safety, Institute of Public Health, Suranaree University of Technology

สาขาวิชาอาชีวอนามัยและความปลอดภัย,สำนักวิชาสาธารณสุขศาสตร์ มหาวิทยาลัยเทคโนโลยีสุรนารี (mkhanidtha@sut.ac.th)

***ผู้นิพนธ์หลัก**

Received: June 3, 2022/ Revised: June 24, 2022/ Accepted: June 25, 2022

ABSTRACT: The objectives of this research were to assess the ergonomic risk using Rapid Upper Limb Assessment (RULA) and the body discomfort of the Mee Kratok noodle making workers and to designed and developed the dough sheet making machine that help reduce the ergonomic risk. The data was collected from 17 workers. Normally, the Krathok noodle was made by hand. The dough sheet making process was divided into 4 steps: scooping the mix, spreading the mix, closing the lid, and shoveling the dough sheet. The analysis of body discomfort showed that most of the workers encountered lower back (L(n=17), R(n=12)), upper back (L(n=11), R(n=10)), hands/wrist (L(n=12), R(n=11) and foot (L(n=13), R(n=9)). The results of Rapid Upper Limb Assessment (RULA) showed that the step with greatest ergonomic risk was spreading the mix. In this step, the workers had to twist their wrists and move their arms repeatedly. The dough sheet making machine was designed, developed and used to help decrease the ergonomic risk. When using the machine, the steps of spreading the mix and closing the lid were processed inside the machine so the workers had only 2 steps to do (scooping the mix and shoveling the dough sheet). The risk level was reduced from level 3 to level 2 in the step of scooping the mix and remained at level 2 in the step of shoveling the dough sheet. Satisfaction to the developed dough sheet making machine in terms of equipment/tool, working procedure, working environment, working efficiency and overall were compared with the conventional dough making steps. The satisfaction levels of the dough sheet making machine were higher than those of the conventional method in 4 out of 5 topics. However, the satisfaction on work efficiency of the machine was lower than the conventional method which implied that the developed dough sheet making machine has some limitations and needs further improvement.

Keywords: RULA; Ergonomic risk; Noodle making process; Body discomfort; Machine development

บทคัดย่อ: การวิจัยครั้งนี้มีวัตถุประสงค์เพื่อประเมินความเสี่ยงทางการยศาสตร์ด้วยวิธี Rapid Upper Limb Assessment (RULA) และศึกษาความเมื่อยล้ากล้ามเนื้อตามส่วนต่างๆของร่างกายในกลุ่มคนงานผลิตหมี่กระโทก และออกแบบพัฒนาเครื่องทำแผ่นแป้งที่จะช่วยลดความเสี่ยงทางการยศาสตร์ โดยเก็บข้อมูลจากคนงานผลิตหมี่ 17 คน โดยทั่วไปการผลิตหมี่นั้นเป็นกระบวนการที่ต้องทำด้วยมือ สามารถแบ่งกระบวนการทำงานเป็น 4 ขั้นตอนได้แก่ การตักแป้ง การเกลี่ยแป้ง การปิดฝาหม้อ และการแซะแผ่นแป้ง จากการวิคราะห์ผลระดับความเมื่อยล้าที่ส่วนต่างๆของร่างกายพบว่าคนงานส่วนใหญ่รายงานความเมื่อยล้ากล้ามเนื้อที่บริเวณหลังส่วนล่าง (ซ้าย(n=17), ขวา(n=12)) หลังส่วนบน (ซ้าย(n=11), ขวา(n=10)) มือ/ข้อมือ (ซ้าย(n=12), ขวา(n=11)) และเท้า (ซ้าย(n=13), ขวา(n=9)) จากการวิเคราะห์ความเสี่ยงทางการยศาสตร์โดยใช้เครื่องมือ Rapid Upper Limb Assessment (RULA) พบว่าขั้นตอนที่มีความเสี่ยงทางการยศาสตร์มากที่สุดได้แก่ ขั้นตอนการเกลี่ยแป้ง ซึ่งในขั้นตอนนี้คนงานจะต้องมีการพลิกข้อมือและขยับแขนซ้ำๆ ทางผู้วิจัยจึงได้ออกแบบและสร้างเครื่องทำแผ่นแป้งเพื่อช่วยในการลดระดับความเสี่ยงทางการยศาสตร์ พบว่าการใช้เครื่องทำแผ่นแป้งจะสามารถลดขั้นตอนการเกลี่ยแป้งและการปิดฝาหม้อดังนั้นจะเหลือขั้นตอนที่คนงานยังต้องทำเองเพียง 2 ขั้นตอน (การตักแป้ง และการแซะแผ่นแป้ง) เมื่อเปรียบเทียบระหว่างการใช้เครื่องทำแผ่นแป้งกับวิธีดั้งเดิมพบว่า การใช้เครื่องทำแผ่นแป้งจะสามารถลดระดับความเสี่ยงในขั้นตอนการตักแป้ง จากระดับ 3 เหลือ ระดับ 2 แต่ระดับความเสี่ยงในขั้นตอนการแซะแผ่นแป้งไม่เปลี่ยนแปลง คืออยู่ที่ระดับ 2 เมื่อทำการประเมินความพึงพอใจในด้านเครื่องมือ/อุปกรณ์ ขั้นตอนการทำงาน สภาพแวดล้อมในการทำงาน ประสิทธิภาพการทำงาน และความพึงพอใจในภาพรวม ต่อการใช้เครื่องทำแผ่นแป้งที่ได้พัฒนาขึ้นเมื่อเปรียบเทียบกับวิธีดั้งเดิม พบว่า คนงานผลิตหมี่มีความพึงพอใจต่อการใช้เครื่องทำแผ่นแป้งมากกว่าวิธีดั้งเดิม ถึง 4 ใน 5 หัวข้อ อย่างไรก็ตามความพึงพอใจในหัวข้อประสิทธิภาพการทำงานนั้นน้อยกว่าวิธีดั้งเดิม แสดงให้เห็นว่าเครื่องทำแผ่นแป้งที่ได้พัฒนาขึ้นยังคงมีข้อจำกัดและจำเป็นต้องมีการศึกษาต่อไป

คำสำคัญ: แบบประเมิน RULA; ความเสี่ยงทางการยศาสตร์; กระบวนการผลิตเส้นหมี่; ความเมื่อยล้ากล้ามเนื้อ; การพัฒนาเครื่องมือ

1. INTRODUCTION

Local food "Mee Kratok", from Ban Kratok, Chokchai Subdistrict, Chokchai District, Nakhon Ratchasima Province, became widely known among food lover in Thailand. It can be called Krathok fried noodle (Mee Krathok in Thai). Krathok noodle has a special feature. It is sticky, thin, and soft noodle that can be well stir-fried. From preliminary investigation of the Krathok noodle production process, the ergonomic problems were found in the process of dough sheet making. In this process, the workers had to repeatedly use their wrists and arms to spread the mix in order to make the dough sheet for a long time. The workers had to turn left/right when bringing the dough sheet to the woven wood panel for drying. Past researches indicated that the work with awkward or repeated postures such as leaning, reaching, twisting, and bending of the body or other parts can cause the musculoskeletal disorders.[1-3] The prevalence of work-related musculoskeletal disorders (MSDs) among food manufacturing workers was high. In South India, It was found that 67.5% of male kitchen workers reported MSDs.[4] The method of food production in the local scale or SME level usually required worker's skill and man-power. There were researches on the ergonomic problem among noodle making but in other type of noodle in other countries.[5] Therefore, this investigation on ergonomic problems in the "Mee Kratok" noodle makers and the reduction of the ergonomic risk was interesting. The objectives of this research were to assess the ergonomic risk using Rapid Upper Limb Assessment (RULA) and the body discomfort of the Mee Kratok noodle making workers and to designed and developed the dough sheet making machine that help reduce the ergonomic risk. Moreover, the satisfaction of the workers in term of equipment/tool, working procedure, working environment, working efficiency and overall satisfaction from using the dough sheet making machine was compared to that of the conventional method.

2. METHOD

2.1 Research design

This was the quasi - experimental research that compared the ergonomic risk of the dough sheet making postures between the conventional steps and when using the developed dough sheet making machine. The satisfaction of the developed dough sheet making machine was also evaluated

The research was conducted in Ban Krathok, Chokchai district, Nakhon Ratchasima Province, Thailand, during November 2019 – February 2020. The purposive sampling was conducted among Ban Krathok villagers using inclusion criteria. The criteria included: participants must have never suffered a musculoskeletal injury or accident within the past 3 months and consent to participate in the research. The exclusion criteria were the participants' refusal to give the information during the research period or complete the questionnaire.

2.2 Research tools

The data was collected from 17 participants using the interview form which consisted of 2 parts: PART 1: General information related to gender, age, health status, working condition and PART 2: the Body discomfort assessment. The body discomfort assessment was conduct using the body map questionnaire asking the workers the level of pain on their body parts[6]. The levels of pain were divided as follows: 0 = no discomfort/ pain, 1 = weak (does not affect work), 2 = moderate discomfort/ pain (symptoms were disappeared after rest), 3 = strong discomfort/ pain (symptoms were not recovered after rest), 4 = severe discomfort/pain (must take medicine or apply balm to be able to work).

The Rapid Upper Limb Assessment (RULA) was used to assess the ergonomic risks and the satisfaction assessment form was used to evaluate the satisfaction of the workers to the developed dough sheet making machine. The result of the RULA assessment tool is the final RULA score, which represents the level of MSD risk for the working posture being evaluated. The minimum RULA score = 1, and the maximum RULA score = 7. Each score level has the definition as follow[7].

Action Level 1 – RULA score 1-2 means that the person is working in the best posture. There is no risk of injury from their work posture.

Action Level 2 – RULA score 3-4 means that the person is working in a posture that could present some risk of injury from their work posture. This score most likely is the result of one part of the body being in a deviated and awkward position. Investigate the reasons and correct.

Action Level 3 – RULA score 5-6 means that the person is working in a poor posture with a risk of injury from their work posture. Investigate the reasons and change them in the near future to prevent an injury.

Action Level 4 – RULA score 7-8 means that the person is working in the worst posture with an immediate risk of injury from their work posture. Investigate the reasons and change them in the near future to prevent an injury.

The satisfaction to the developed dough sheet making machine was collected be satisfaction questionnaire. The satisfaction level ranges from 1 to 5. The scale represented the level of satisfaction as follows: 1 = lowest, 2 = low, 3 = moderate, 4 = high, and 5 = highest. The average satisfaction criteria: 4.51-5.00 = highest satisfaction level, 3.51-4.50 = high satisfaction level, 2.51-3.50 = moderate satisfaction level, 1.51-2.50 = low satisfaction level, 1.00-1.50 = lowest satisfaction level.

2.3 Analysis of results

The characteristics of the participants, level of fatigue, and the ergonomic risk level were described by descriptive statistics in term of frequency, average, maximum, minimum and percentage.

2.4 Ethical consideration

This research has been certified by the ethical committee of Suranaree University of Technology (EC62-0120).

3. RESULTS

3.1 The noodle making process

From the preliminary investigation, the noodle make process can be divided into 6 steps: Flour milling, streaming, dough sheet making, drying, oiling, and chopping. Among these steps, the step of dough sheet making required the workers to use their wrist and arm to spread the dough into sheets with repeated gestures for a long time. Also they had to turn their body to bring the dough sheet to place on drying plate. Because of repeated and awkward postures that were found in the dough sheet making step, the deeper investigation was conducted further. In dough sheet making, there were 4 steps: scooping the mix, spreading the mix, closing the lid, and shoveling the dough sheet.

3.2 General information of the participants

The data from 17 participants (noodle making workers) was collected. The average age of the participants was 45.41 years old (range 24-80). The average height and weight were 161.94 cm (range 153-178) and 69.18 kg (range 44-104), respectively. Most of the participants had never experienced any musculoskeletal problems. Most do not drink alcohol. However, almost all of them do not exercise regularly. The workers work continuously for a long time (8-12 hr/day, 5-7 days/week). Other information from the interview revealed that the problem occurred in the step of dough sheet making. In this step, workers had to frequently lift the pot lid twice per one dough sheet and the number of dough sheet making per day was 180 sheets, approximately. That was 360 times lifting-closing, repeatedly. The repeat working posture is one of the factors related to the ergonomic problems. From the interview, most workers reported that the working step that causes the most muscle pain was the dough sheet making. Most workers' pain relief method is medication. From the open-ended questions, the points that workers suggested for improving their working condition were 1) make the chairs adjustable 2) improve the working step to have less open-close the pot lid.

3.3 Body discomfort assessment

The result of the body discomfort assessment in Table 1 revealed that most of the workers experienced discomfort/pain (level 1-4) at their shoulders, upper back, lower back, upper arms, hands/wrists, and feet. The symptoms found in both left and right side. According to their workstation, there was no footrest, no lumbar support, and the chair was not adjustable. The improper workstation could be one of the factors that led to musculoskeletal disorders among noodle making workers.

Table 1 Discomfort/pain reported from noodle making workers (n=17)

Body parts	Left					Right				
	Number	Percent	Mean	Max	Min	Number	Percent	Mean	Max	Min
Neck	8	47.06	0.71	3	0	3	17.65	0.35	2	0
Shoulder	9	52.94	1.65	4	0	9	52.94	1.12	3	0
Upper back	11	64.71	2.00	4	0	10	58.82	1.00	3	0
Lower back	17	100.00	1.41	3	0	12	70.59	2.00	3	0
Upper arm	14	82.35	1.41	2	0	10	58.82	0.88	3	0
Elbow	8	47.06	0.71	2	0	4	23.53	0.53	3	0
Lower arm	5	29.41	0.53	3	0	4	23.53	0.59	3	0
Hand/wrist	12	70.59	0.88	3	0	11	64.71	1.59	4	0
Hip/thigh	7	41.18	0.82	2	0	7	41.18	0.90	3	0
Knee	8	47.06	1.35	4	0	8	47.06	1.41	4	0
Calf	2	11.76	0.24	2	0	4	23.53	0.10	2	0
Foot	13	76.47	1.06	3	0	9	52.94	1.47	2	0

Deeper investigation on the level of discomfort/pain, the severe discomfort/pain (level 4) was report at various body parts, e.g., shoulder (left), upper back (left), hand/wrist (right), knee (both left and right). The parts of the body that the workers reported discomfort were associated with the characteristic of their tasks. In the dough making process, the workers had to use their left hand lift the heavy lid up and down for many times while their right hand spread the dough on the pot surface. This might cause the discomfort/pain on their shoulders and right wrist. There was no lumbar support on the non-adjustable chair which caused workers back pain. Moreover, lacking of foot rest might cause the knee and foot discomfort when sitting for a long period.

3.4 Rapid Upper Limp Assessment (RULA)

The RULA assessment results of each step (scooping the mix, spreading the mix, closing the lid, and shovelling the dough sheet) were shown in Table 2.

Table 2 The RULA assessment of the conventional dough sheet making process

Step 1 Scooping the mix

Step	Description	Left	Right
Step 1	upper arm	1	3
Step 2	lower arm wrist	1	1
Step 3	wrist	2	2
Step 4	wrist twist	1	1
Step 6	add muscle use score	0	0
Step 7	Add Force	0	0
Step 9	Neck	2	2
Step 10	Trunk	4	4
Step 11	Legs	1	1
Step 13	add muscle use score	1	1
Step 14	Add Force	0	0
Step 16	**Final Score**	**5**	**6**

Step 2 Spreading the mix

Step	Description	Left	Right
Step 1	upper arm	1	3
Step 2	lower arm wrist	1	3
Step 3	wrist	2	4
Step 4	wrist twist	1	1
Step 6	add muscle use score	0	0
Step 7	Add Force	0	0
Step 9	Neck	2	4
Step 10	Trunk	4	3
Step 11	Legs	1	1
Step 13	add muscle use score	1	1
Step 14	Add Force	0	0
Step 16	**Final Score**	**5**	**7**

Step 3 Opening-closing the lid

Step	Description	Left	Right
Step 1	upper arm	6	2
Step 2	lower arm wrist	1	2
Step 3	wrist	2	3
Step 4	wrist twist	1	1
Step 6	add muscle use score	0	0
Step 7	Add Force	0	0
Step 9	Neck	1	1
Step 10	Trunk	4	4
Step 11	Legs	1	1
Step 13	add muscle use score	1	1
Step 14	Add Force	0	0
Step 16	**Final Score**	**7**	**5**

Step 4 Shovelling the dough sheet

Step	Description	Left	Right
Step 1	upper arm	2	4
Step 2	lower arm wrist	1	2
Step 3	wrist	1	3
Step 4	wrist twist	1	1
Step 6	add muscle use score	0	0
Step 7	Add Force	0	0
Step 9	Neck	1	1
Step 10	Trunk	2	2
Step 11	Legs	1	1
Step 13	add muscle use score	1	1
Step 14	Add Force	0	0
Step 16	**Final Score**	**3**	**3**

From the results, the high ergonomic risk levels were found among these steps. Especially, in step 2: Spreading the mix showed the RULA final score of 5 (left) and 7 (right). It meant that the risk level was at action level 3 (left) and 4 (right) and implied that the workers worked in a posture with a risk of injury. The finding indicated that the change needs to be investigated in order to help decrease the ergonomic risk.

3.5 The design of dough sheet making machine

The dough sheet making machine was designed and developed. The machine was designed in order to reduce the arm reaching and the body bending. The data below described compartments of the machine (Fig. 1).

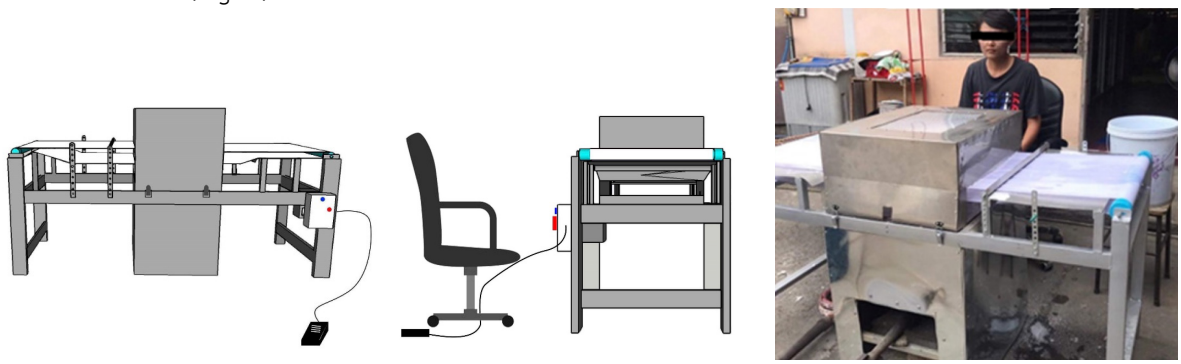

Fig. 1 The developed dough sheet making machine

• Size of the machine – the main compartment of the machine was a rectangular structure with dimension of L150xW50xH75 cm.

• Steamer cabinet – made of stainless steel with dimension of L60xW50xH20 cm. This was designed to be smaller than the conventional one in order the decrease the boiling time.

• Heating surface – The heating surface was designed to be round size with the diameter of 30.5 cm, 7.4 cm above the steamer.

• Cover – the cover prevents steam loss from the machine. The upper side made of transparent acrylic material. The worker can look through this window to see inside.

• Spreading pad – This was designed to be an adjustable stainless steel paddle. Set at 90 degree right angle, with dimension of L65xW2xH2 cm. The spreader was attached machine to help make the dough sheet.

• Cheesecloth belt - Designed by using a material made of thin white cloth with dimension of L302x50W cm. This belt moved through a PVC pipe spindle with constant speed.

• Power box - Designed using waterproof plastic material with dimension of L13xW17xH29.5 cm. Equipped with adapter LED power supply 12V, 3A-30A and a switch on-off.

• Foot switch - Designed with motor, adapter and wiring connections, it operates by pedaling to keep the belt moving. It stops moving, when release the pedal.

How is the machine work? Start by pouring the starch mix on the cheesecloth. Press the foot switch to allow the belt to pass through the spreader. The spreader spreads the dough into a sheet. Then continue pressing the foot switch, the belt moves into the steamer to cook the dough

sheet. After passing through the steamer belt will move out of the steamer cabinet, the dough sheet is ready. The worker can shovel the sheet out of the cheesecloth.

3.6 The ergonomic comparison between the conventional working posture and the use of the dough making machine

In an overview, the dough sheet making machine reduced the use of the worker's wrist, the arm reach to open and close the lid, the body twisting and bending. The detail of each steps showed in Table 3.

Table 3 Comparison of RULA assessment between the conventional method and when using the dough making machine

The dough sheet making process	Body side	RULA final score	
		Conventional method	Use the machine
Step 1 Scooping the mix	Left	5	3
	Right	6	3
Step 2 Spreading the mix	Left	5	N/A
	Right	7	N/A
Step 3 Opening-closing the lid	Left	7	N/A
	Right	5	N/A
Step 4 Shovelling the dough sheet	Left	3	3
	Right	3	3

N/A – there was no RULA results for step 2 and 3 because these steps were operated by the machine.

In step 1, the RULA score was decreased to 3 because, in this step, - the height of the container was adjusted to not be as deep as the old one to reduce the reach down when the amount of mix decreased and set up the container to be level with the chair to reduce the bending down to scoop the mix (Fig. 2). In step 2 and 3, the workers do not have to do the "spreading" and "opening-closing the lid" because the machine was equipped with the spreader where the dough fed automatically to the spreader as the belt moved. The upper cover of the machine was transparent so it was not necessary to open up to see inside the lid. In step 4, the RULA score did not change because after the sheet was cooked and moved out the steamer, the worker still had to shovel the dough sheet up for drying.

(A) (B)

Fig. 2 Working posture of A) conventional method B) Using of the dough sheet making machine, in step 1 - scooping the mix.

3.7 The satisfaction of the workers to the dough sheet making machine

The questionnaire was used to investigate the satisfaction of the dough sheet making machine. The topic consisted of 5 areas: The equipment/tools, working procedures, working environment, work efficiency, and overall satisfaction. It was found that the satisfaction levels were increased in 4 out of 5 areas as showed in Table 4.

Table 4 Average satisfaction levels of the workers to the dough sheet making machine in comparison with conventional method

Area of interests	Conventional method	Use the machine
The equipment/tools	2.79	4.07
working procedures	2.21	3.99
working environment	2.59	4.91
work efficiency	3.88	2.69
overall satisfaction	3.41	3.76

However, the developed machine had some limitation. This was reflected in the satisfaction of the work efficiency. The workers also suggested that the heating surface should be wider and the cheesecloth belt had wrinkles while moving which yielded the defected dough sheet.

4. DISCUSSION

In the "Mee Kratok" noodle production, the workers had to work with the postures that had a high ergonomic risk. The body discomfort assessment showed that all of them reported low back pain. More than half of workers had pain on their shoulder, upper back, upper arm hand/wrist and foot. RULA Score of 7 (Action level 4) were found in these working steps: “Spreading the mix” and “Opening/closing the lid”. In the steps of “Spreading the mix” and “Opening/closing the lid”, the working postures were at risk of muscle injury or pain. For example, to open the lid, the worker had to lift and hold the heavy lid with the left hand and to spread the mix, the worker had to twist the right hand repeatedly. There were many attempts to decrease the ergonomic risk, for example, changing the height of working device or made it adjustable[8], using of additional device such as magnifying glass to prevent bowing down[9], and developing the new instruments or machine to do some ergonomic-unfriendly tasks instead of human.[10-11] The use of machine might help reduce the ergonomic risk and, in some case, reduce the working steps. In our research, after using the developed dough sheet making machine, the ergonomic risk was decreased. In the step of “Scooping the mix”, the RULA Scores were decreased from action level 3 (final score 5 and 6 for left and right) to action level 2 (final score 3 and 3 for left and right). Moreover, the steps of “Spreading the mix” and “Opening/closing the lid” were not conducted by the workers because the machine had a spreader and its own transparent lid. The worker reported higher satisfaction on the equipment/tool, procedure and working environment when using the machine comparing to the conventional methods. However, the satisfaction on the topic of working efficiency lower than

that of conventional method because the developed machine had some limitations and need further improvement.

5. CONCLUSION

It was found that the "Mee Kratok" noodle making worker suffered from muscle pain. Most of them had the lower back pain. The ergonomic assessment of their working postures revealed that the conventional work steps led to high ergonomic risk. To reduce the risk, the dough sheet making machine was developed. This machine reduced the working steps from 4 steps to 2 steps. The remaining steps were scooping the mix and shoveling the dough sheet. When using the machine, the ergonomic risk of the step “scooping the mix” was decrease from action level 3 to 2. However, further study needs to be conducted to improve the efficiency of the developed machine. This research had some limitation because of small number of participants. Also, the inferential statistics should be analyzed for the comparison of the outcomes.

ACKNOWLEDGEMENTS

This study was supported by Suranaree University of Technology (SUT). We would like to express our gratitude to our research volunteers at Ban Kratok village for the support in this study.

REFERENCES

1. Mokarami H, Varmazyar S, Kazemi R, Taghavi SM, Stallones L, Marioryad H, et al. Low cost ergonomic interventions to reduce risk factors for work related musculoskeletal disorders during dairy farming. Work. 2019;64:195–201.
2. Karuppiah K, Sankaranarayanan B, Ali SM, Kabir G. Role of ergonomic factors affecting production of leather garment-based SMEs of India: implications for social sustainability Symmetry 2020;12:1414. Available from: http://dx.doi.org/10.3390/sym12091414
3. Rai A, Gandhi S, Kumar N, Sharma DK, Garg MK. Ergonomic intervention in Aonla pricking operation during preserve preparation in food processing industries. Work. 2012;41:401–5.
4. Subramaniam S, Murugesan S. Investigation of work-related musculoskeletal disorders among male kitchen workers in South India. Int J Occup Saf Ergon. 2015;21(4):524–31.
5. Trianasari, Ushada M, Suharno. Ergonomic risk analysis for cassava noodle production system using Occupational Repetitive Action (OCRA) [Internet]. 2019. 5th International Conference on Science and Technology (ICST). IEEE. 2019. Available from: http://dx.doi.org/10.1109/ICST47872.2019.9166284
6. Corlett EN, Bishop RP. A technique for assessing postural discomfort. Ergonomics. 1976;19(2):175–82.

7. McAtamney L. Corlett EN. RULA: a survey method for the investigation of work-related upper limb disorders. Appl Ergon. 1993;24:91-9.

8. Jansen JP, Hoozemans MJM, van der Beek AJ, Frings-Dresen MHW. Evaluation of ergonomic adjustments of catering carts to reduce external pushing forces. Appl Ergon. 2002;33:117–27.

9. Aghilinejad M, Azar NS, Ghasemi MS, Dehghan N, Mokamelkhah EK. An ergonomic intervention to reduce musculoskeletal discomfort among semiconductor assembly workers. Work. 2016;54:445–50.

10. Eladly AM, Abou-Ali MG, Sheta AM, EL-Ghlomy SH. A flexible ergonomic redesign of the sewing machine workstation. Res J Text Appar. 2020;24:245–65.

11. Rai A, Gandhi S, Kumar N, Sharma DK, Garg MK. Ergonomic intervention in Aonla pricking operation during preserve preparation in food processing industries. Work. 2012;41:401–5.