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Workload Evaluation towards the *Dodol* Workers from Dryer Section in Buleleng Bali

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Abstract

Penglatan village, one of the villages in Buleleng Regency-Bali, is the center of dodol industry, with a number of makers up to 44 small group makers, on which each group consisting of 6 to 8 workers. Dodol is a sweet snack that has been sold to many regions in Bali as well as to modern markets such as minimarkets or supermarkets and Bali souvenir shops. In Bali, dodol has become one of the traditional snacks used for offering in the religious ceremony. The making process of dodol consisted of several processes, which were dough making, cooking, packaging/wrapping, and lastly, drying. The drying process was done by the workers through the natural method by utilizing the traditional tool to spread the dodol on the bamboo mat on which afterward, continued by drying them in the sun. The kind of drying process can cause ergonomic problems such as pain in the neck, shoulder, back, lower back, head, and hands. As a result, it can decrease work productivity as well as product quality. This research was an experimental research applying the treatment by subject design with 20 samples. The sample productivity was observed while working traditionally and while utilizing the techno-ergonomically hybrid solar dryer including solar thermal and biomass dryer. The data were analyzed by SPSS program applying the probability value of 0.05. It was expected that by using the hybrid techno-ergonomic dryer could create the work posture became more effective, convenient, safe, healthy, and efficient. This ergonomic work equipment could increase comfort and reduce injuries. Therefore, the performance and quality products in the making process of dodol could be improved as well. The results showed that the working position of back bending while drying dodol as well as being exposure to hot temperatures could cause the workload on dodol makers in the weight category which was at 126.03 beats per minute. There was a significant increase towards the subjective disorders of the workers, particularly related to musculoskeletal disorders and fatigue in between before and after work. Therefore, it was necessary to have the ergonomics interventions in dealing with the workload issues, subjective disorders, as well as to increase labor productivity of the workers. The alternative was to implement interventions designed by hybrid solar energy dryers using the techno-ergonomic application.

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1. Introduction

Penglatan village is one of the villages located in Buleleng regency, Bali. It is about five kilometers from Singaraja city, with its width area of 186.193 Ha and its population of 3583 people. This village can be categorized as a potential area for its agriculture (paddy field), livestock (cattle breeding: cow, poultry breeding: chicken, duck), handcrafting (bamboo wicker, weaving, songket), and small food industry such as dodol, which becomes an icon in this village. As a central site of dodol making in Buleleng regency, there are about 44 groups of makers consisting of 6 to 8 workers each.

These traditional snacks of dodol have been marketed around the area, as well as in modern markets such as mini market, supermarket, and souvenir shops. Particularly in Bali, they become one of the traditional foods use as the offering for a religious ceremony. As time goes by, these traditional snacks have become tourists' favorite in town as well as abroad. Therefore, they are marketed in many various selling places in Bali. Bali dodol or also known as Buleleng dodol is popular for its very sweet and sticky flavor as well as unique fragrant (Adiputra, 2004). Each dodol is wrapped by dried corn leaves called as *klobot*, which is made in a long shape with both sides tied by a string of raphia. The dried corn leaves aroma as a wrapper makes it taste more savoury. Another unique thing about dodol is that they are not packed into boxes. Each dodol is strung up together like grapes (Balinese: *direnceng*), on which one string consisting of ten dodols.

The making process of dodol included several steps, starting from the dough making, cooking and stirring, wrapping, up until the last step, drying. The drying process executed by the workers by applying the natural method and traditional tools. The way to dry the dodol was to spread the dodol on the top of bamboo wicker then dry them in the sun. According to Maheswari and Wulandari (2004); Almatzier (2001), if the water content of dodol was in the range of 20.05 up to 26.61%, they could only sit out for approximately two weeks. By applying the controlled heating of 80 up to 85 celcius degree, good sanitation, package design improvement could last the product longer of more than eight weeks. Lack of heating combined with poor packaging had caused some damages in dodol in the market. One of them was the stinking smell due to mold contamination of *Syncephalastrum racemosum* species. As the mold grew older, it would form a colony of white and grey colored. This kind of mold needed to be strongly avoided, since it could damage the quality of dodol sensory product. Therefore, based on those above, there had to be a way to halt the mold contamination to minimize customers' losses (Artayasa *et al.*, 2008). To enhance the quality of the product, it had to fill the requirement of the quality standards (Balipost, 2011). Those had become a problem that needed to be solved.

The drying process of dodol was done under the sun that needed a very wide area, therefore the process was mostly done on top of the roof. The activity of drying was in between 8 AM up to 4 PM. From 8 to 9.30 AM, the workers prepared the drying tools, set the place, and dry the dodol. At 9.30 AM to 12 PM, the workers watched the dodol from animals disturbing such as chickens, cats, and flies while once in a while taking shelter aside. From 12 to 1.30 PM, the workers had to flip all the dodol over to have the other side dried. This flipping process was for obtaining the total drying process of both sides of the dodol. Again, at 1.30 to 3 PM, the workers stayed to protect the dodol from any disturbance coming from outside. At 3 to 4 PM, the workers lifted up the drying dodol and repeated over again for along two days in a row, under the condition of sunny weather until the water content of all dodol was about ±15%.

This kind of drying process was considered as lacking viewing from the ergonomic side. The ergonomic work posture basically is a natural work position represented through a normal body posture. A natural work posture is a work posture that fits the body anatomy. By paying attention more to it, it can prevent body dislocation or pressure to certain part of human body, like organs, nerves, bones and there will be no more other musculoskeletal disorders as well as those will give more comfort, safety, and healthy feeling in working. The ergonomic problems were caused by the traditional drying process, on which it involved bad body position, such as squatting down or squatting down by moving to the side, bending, and circling. All those monotonous movements had to be done repeatedly. Besides, by doing this outdoor work, the workers had to be exposed by the overheated sun to do all the drying and flipping. Those work conditions were not suitable ergonomically. It can cause (a) additional workload; (b) musculoskeletal disorders on the neck, shoulder, arm, hand, waist, thigh, and leg; (c) fatigue; (d) inefficient drying time; and (e) low productivity. Those unnatural work posture can cause muscle pain, overuse of energy so that it can increase the risk of fatigue and muscle injury (Bridger, 2003). The bending work position can also cause musculoskeletal disorders (Darlis and Sigit, 2011; Hari and Dian, 2015). Approximately, around 30% of musculoskeletal injury is caused by the bending and spinning work position, as it can twist the spine as well (Hari and Dian, 2015; Helander and Lo Shuan, 2005).

As it is mentioned earlier, the drying process set the workers to work under the sun for such a long time. The overheated work environment can cause the stressed on the body as the result of the body effort to adjust itself with the heat. The physiology responses are seen clearly through the increase of blood pressure and pulse (Kee and Karwowski, 2007). To control the influence of hot work condition, there should be improvement related to the workplace, the source of heat, work activity, as well as reducing the workload factor through mechanization (Kimberly, 2011).

In order to give the solution of all the problems above, there needed to conduct a research to measure how much the workload of the drying workers objectively (based on pulse) and subjectively (based on fatigue and musculoskeletal disorders). This measurement was done based on the productivity of the workers, the quality of dodol, and the workers' income. This advance research was done to provide recommendations to solve the ergonomic problems that focused on the application of systemic, holistic, interdisciplinary, and participatory concept (SHIP approach) and the designing of intervention was based on appropriate technology. The application of the appropriate technology intervention could be in the form of designing a new tool that can help the workers to finish the job, therefore the needed of anthropometry data as the basis to determine the size of the tool was required.

2. Materials and Methods

This research was conducted observational towards 20 workers of dodol in Buleleng, Bali. The workload was determined by the workers' working pulse that was measured using a pulse meter. The microclimates of the workplace were measured through the wet temperature, dry temperature, humidity, the intensity of noise, and light. Subjective disorders were taken from the questionnaire of 30 fatigue items by Likert scale 4. Meanwhile, the musculoskeletal disorders were predicted from Nordic Body Map questionnaire. The statistical analysis was done descriptively based on the workload, musculoskeletal disorders, and subjective disorders of the entire sample.

3. Results and Discussions

3.1 Characteristics of Subjects

Subjects of the research were 20 female works. All subjects follow the research well and none of them were classified as drop out. The characteristics of the subject consisted of age, height, weight, body mass index (BMI), and work experiences. The results of the analysis were presented in table 1 followed.

Table 1
Characteristics of Subjects

Description	n	Minimum	Maximum	Mean	Std. Deviation
Age (Years old)	20	24	35	29,68	4,91
Height (cm)	20	151	169	159,43	5,29
Weight (kg)	20	54,5	64,7	58,31	3,73
BMI (kg/m2)	20	19,22	21,47	20,31	1,08
Work experience (years)	20	1	7	4,62	3,12

The average of the age above was 29.68 or ± 4.91 years and the range of age were between 24 to 35 years old. The range above is categorized as working age population, as it is stated by Indonesia Statistic Center (*Badan Pusat Statistik* / BPS) that the working age population in Indonesia is between 15 to 64 years old.

The range of body mass index (BMI) of the research was 20.31, or ± 1.08kg/m^2. The mean value of the BMI above was in the condition of normal nutritional status, on which the normal nutritional status in Indonesia is in the range of 18.5 to 25 kg/m^2 (Kroemer and Grandjean, 2009). BMI is a measure of body fat based on weight in relation to height. So, if BMI is under 18,5 kg/lmz categorized as very slim or *underweight* and if it is above 25,0 kg/m^2 categorized as obesity or *overweight* because the accumulation of fat is excessive (Leilanie, 2007). Some previous studies also used subjects with normal BMI categories, including study that involved around 17 subjects with its mean of BMI around 22.50, or ± 3.99 kg/m^2 Maheswari and Wulandari (2004), as well as by Muliarta Manuaba (2000) that involved around 20 subjects with its mean of BMI around 22.68, or ± 2.70 kg/m^2.

The average years of their work experiences were around 4.62 or ± 3.12 years. The significance of the work experience mean value was based on how well the subject been skilled and able to adapt to the job. The work experience informal sector employment is generally considered to increase the ability of a person's work (Manuaba, 2003).

The characteristics of the subjects above indicated that the subjects were in the condition of optimum working. The age number showed that the strength of the bodywork was all in good conditions. The peak muscle strength in the work experience above was in the age range of 25 to 35 years (Darlis and Sigit, 2011). The work experience above illustrated the subjects were in a reasonable condition in experiencing the job.

3.2 Work Conditions

The temperature of environment measured in the research location during the drying process was based on the wet temperature, dry temperature, ball temperature, humidity relative, wet-bulb globe temperature (WBGT), light intensity, and noise. The measurement results were presented in table 2 below.

Table 2
The result of analysis in the measurement of work environment

Variable	Average	SD	Min	Max
Wet Temperature (ºC)	27,19	2,79	25,11	28,32
Dry Temperature (ºC)	32,21	3,18	28,06	35,21
Bulb Temperature (ºC)	26,16	2,08	24,51	27,36
Humidity Relative (%)	74,22	4,76	71,31	80,48
WBGT	29,13	2,76	28,87	32,42
Light Intensity (Lux)	1138,42	141,57	973,95	1326,47
Sound Intensity (dBA)	69,21	2,41	66,78	73,13

Note: SD: Standard Deviation

Table 2 above showed that the average of dry temperature was 32.21 ºC, on which still in the range of temperature that can be adapted by Indonesian workers. However, the repetitive of the sun exposure had become the addition of workload. Furthermore, the humidity range was in the range of 71.31% to 80.48%, on which it is still categorized as normal. Meanwhile, WBGT (*Wet Bulb Globe Temperature*) in the average of 28.93 ºC was in the range of 26.87 to 31.42 ºC. The Threshold Limit Value (TLV) for heavy work with WGBT around 30.5 ºC indicated that the working hours were only allowed to reach the percentage of 25%. Meanwhile, TLV for medium work with WBGT around 29 ºC indicated that the working hours were only allowed to reach the percentage of 50% to 75%. If it was based on the sun exposure with the temperature of 32.21 ºC with WBGT up to 29.13 ºC, then it would become the additional workload for the workers; due to the work recommendation that must be applied was 75% working and 25% resting. Therefore, it needed intervention so that the workers can work in a repetitive way for eight hours long. It could be done by reducing the heat as well as applying the appropriate technology intervention that was being designed in this research.

Furthermore, the light intensity was in the average of 1138.42, or ± 141.57 lux. This intensity was quite large because they were in direct sunlight. The mean of noise intensity reached the number of 69.21, or ± 2.41 dBA. The intensity was still within normal limits because it was below 85 dBA (Mei *et al.*, 2002). Air velocity was on average 0.194 m/sec^2. The airspeed value in this research was still in decent working conditions due to exposure to hot working environment required wind speeds higher than indoors (Darlis and Sigit, 2011; Muliarta, 2014).

3.3 Anthropometry

Results of Anthropometry measurement were presented in table 3 as follows.

Table 3
Anthropometry data on dodol workers

No	Variable	Average (cm)	SD (cm)	Range (cm)	Percentile 5	Percentile 50	Percentile 95
1	Height	158,16	2,91	151 – 161	156,0	155,5	159,3
2	Elbow Standing Height	105,44	2,03	103 – 112	102,3	105,7	109,4
3	Arm Reach Upward	198,12	2,87	191 - 202	195,4	198,2	199,7
4	Arm Reach Forward	64,12	1,96	59,3 – 68,7	61,2	65,1	67,3
5	Palm width	9,8	0,21	8,1 – 10,7	8,5	9,8	10,1
6	Palm length	18,45	1,05	16,4 –20,1	17,2	18,8	19,1

Note: SD: Standard Deviation

The anthropometric data, as shown in Table 3 above, could be used as consideration in designing the size of the solar dryer in this study. The anthropometric data, as shown in table 5.3 above, could be used as consideration in designing the size of the solar dryer in this study. There were benefits of anthropometry application in designing the tools in this research. The benefits were to provide comfort towards the users, which in this case were the drying workers. If the tool did not work in accordance with anthropometry concept, then it would create various problems, ranging from discomfort to any other problems that might occur.

The standard height in working areas that are considered as ergonomic is when the muscle power is 15 to 40 cm below the elbow height (Darlis and Sigit, 2011). The adjustment of anthropometric data that refers to the 5th and 95th percentile can optimize the tool design so that it can facilitate the control operation, simplification of reach, reduction on joint stress, and comfort in the work (Pheasant and Haslegrave, 2006). The anthropometric data may be used for the assessment of health and safety, reduce the incidence of workplace injuries and illnesses in the manufacturing sector (Robbins and Timothy, 2008). The design that uses anthropometryic data and user requirements (user center design) can provide a competitive advantage and improve the health of users (Santoso, 2004). Therefore, the use of anthropometric workers is absolutely necessary for designing a work tool that can provide comfort, optimization of the tools usage, and increase the labor productivity.

3.4 Workload

The workload was measured by workers pulse rate at rest (resting pulse rate) and at work (working pulse). Afterward, it was predicted based on cardiovascular load value (CVL). The resting pulse rate was measured by the method of palpation of 15 seconds while the working pulse was measured by palpation method of 10 beats. The workload data measurement for this research was shown in Table 4 as follows

Table 4
The workload of dodol workers

Variable	Average	SD	t	p
Resting Pulse (beats/minute)	77,64	3,21	9,351	0,001
Work Pulse (beats/minute)	126,03	4,24		
CVL (%)	56,08	3,67		

Note: SD: Standard Deviation

As seen in the table above, the average rate of work pulse obtained was 126.03. The classification of this workload was included in the category of "heavy" workload since it was within the range of 125-150/min (Bridger, 2003). The workload data, when combined with WBGT, obtained the value of % CVL (cardiovascular load). The measurement result obtained by the average value of the cardiovascular load (% CVL) was 56.08. By this CVL category, the permissible work on hot temperature was supposed to be 50% working and 50% resting. Therefore, in order to facilitate the dodol workers to be able to work in a full day (8 hours of continuous work), it needed the intervention of ergonomics to create a new dryer.

The ergonomics intervention by using the total ergonomic approach can reduce the workload and productivity of workers (Saptarini, 2007). The improvement in working conditions with ergonomic approach will decrease the workload, musculoskeletal disorders, and general fatigue (Setiawan, 2014). The design improvements based on the total ergonomic workplace and utilize appropriate technology can reduce the workload, musculoskeletal disorders, fatigue in general and increase the labor productivity (Maheswari and Wulandari, 2004). From the explanation above, the ergonomics interventions are necessary to provide solutions to the workload problems and increase their productivity. Thus, by utilizing the appropriate technology in this study, it can create the hybrid solar energy dryers with the application of techno-ergonomic.

3.5 Subjective Disorders (Musculoskeletal Disorders and General Fatigue)

The subjective disorders of the workers were measured from musculoskeletal disorders and general fatigue. The musculoskeletal disorders subjects were measured from Nordic Body Map (NBM) questionnaire in before and after work activities. Meanwhile, the fatigue, in general, was measured from the 30 questionnaire items of fatigue in general.

Table 5
Scores of musculoskeletal disorders and fatigue

Description	Mean	Std. Deviation	t	p
Scores of Musculoskeletal Disorders before the work	32.61	2.69	45.657	0,001
Scores of Musculoskeletal Disorders after the work	52.37	4.98		
Fatigue before the work	31.82	2.48	68.328	0,001
Fatigue after the work	64.29	5.46		

The mean score of fatigue before work was 32.61 then increased to 52.37 after work, while fatigue in general before work was 31.82 then increased to 64.29 after work. The increase in the mean score of musculoskeletal disorders and fatigue, in general, was caused by the bending work body position accompanied by the environmental exposure of hot temperatures and solar radiation. The bending position while doing the drying process repeatedly for such a long time was not physiological. The work posture which is not physiologically caused by the characteristics of the task demands, work tools, workplaces, and work posture that were not compatible with the capabilities and limitations of workers (Darlis and Sigit, 2011; SNI, 1992). The work posture that was not physiological done for many years can cause skeletal abnormalities in workers (Darlis and Sigit, 2011).

The need for changes in work systems can reduce the worker fatigue level (Suma'mur, 1982). The working models that were based on ergonomics rules will reduce the fatigue up to 17.71% (Torik *et al*., 2009). The ergonomic work system design can reduce worker fatigue level. The work postures should be cultivated in a physiological position, which is standing up and without bending. The use of the ergonomic dryer tool will also help to reduce the sun heat exposure. This intervention is indispensable because it can suppress musculoskeletal disorders and fatigue in general.

4. Conclusion

Based on the discussion above, it can be concluded as follows:

a) The working posture while doing the dodol drying process that involved the bending work position and exposure of excessive hot temperatures had caused the workload to the workers in the weight category of 126.03 beats per minute.
b) There was a significant increase in subjective disorders related to musculoskeletal disorders and fatigue in general, between before and after the working process.
c) It was proved that the need for ergonomics intervention to overcome the problems of workload, subjective disorders, and increase the labor productivity was necessary. The alternative was to implement the interventions designed in the form of hybrid solar energy dryers with the techno-ergonomic application.

Suggestions

Based on the research findings above, to improve the working conditions by using the design tool of hybrid solar energy dryers with the techno-ergonomics application was proved to be very important to do. By using this new dryer, it was predicted to be able to reduce the workers' workload, fatigue, and muscle disorders. Thus, the workers do not have to be working under the sun's heat and to bend anymore. Besides, the tool is expected to be able to increase the workers' productivity, increase the dodol quality, and income of the workers.

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The author(s) have a responsibility for the conception and design of the study. The author(s) have approved the final article.

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