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Development of automatic melinjo puncher machine using pneumatics pressure

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Abstract

Melinjo chip is one of Indonesia's facourite food. Melinjo chip is not only marketed in Indonesia, but they have been exported to various countries including Netherlands, United State of America, and Middle East. Mostly melinjo chips are produced in the traditional way by home industry and MSMEs. The existing machines to produce melinjo chips are not operated fully automatically; hence they still require significant operator involvement. The machine developed in this study uses a pneumatics pressure as power driver. Pneumatics cylinders are used to push the melinjo seeds onto the flattening base, and to move the puncher rod during flattening process. The developed automatic melinjo punching machine has been tested. The tests were carried out to determine the parameters used for programming the machine, sucah as punching time and pneumatic presure, and for checking the capacity of the machine. The test results show that the most effective punching time is 5 seconds at pressure between 5-7 bar. In 5 seconds, the machine can change melinjo seed into chips shape with thickness in between 1,20-1,45 mm. The capacity of the machine in processing melinjo has also been tested. The results showed that this machine can process 528 melinjo into chips shape melinjo per hour.

Keywords: Automatic machine, Melinjo seed, Puncher machine, Pneumatics pressure

1. Introduction

Indonesia is an agricultural country where the agricultural sector is one of the pillars of national economic growth. Therefore, the development of agricultural products into derivative industries needs to be continuously encouraged and supported. Furthermore, processing of agricultural products needs to be supported so that the products are not only sold directly to the consumer, but it could give added value. The activities to process agricultural products to increase the added value, produce marketable products, and increase storing duration and income are called agroindustry [1]. Some agro-industry products that have succeeded increase added value of the product significantly, such as breadfruit chips [1], coconut/palm sugar [2], tempe chips [3], corn chips [4], cassava chips [5 - 6], and melinjo chips [7].

Melinjo chip is still one of the most favourite traditional snacks. The increasing public interest in melinjo chips made an impact to the emergence of new production centers in the community. Innovations have also emerged for the melinjo chip flavor, in addition to the original taste, melinjo chip has also begun to be obtained with several different flavors. This improvement has an impact on increasing demand for the chips.

The high production of melinjo chips and the tendency to continous increase of the production rate, as well as the increasing of public interest in consuming melinjo chip, make the industry of this product has a good prospects. Therefore, the assistance from various parties so that this industry to keep growing and developing are needed. However, the industries of melinjo chip in Indonesia are still dominated by small industries or home industries. There are very few industries on a medium scale.

Several studies have been performed to support the production of melinjo chips that have been carried out [8 - 14]. Ardiyanto & Salahudin [8] developed a machine using 0.5 HP electric motor as a power driver, and then the rotation of the motor is linked to gearbox using a v-belt. The gearbox used has a ratio of 1:50. The rotation of the gearbox was transmitted to an uncenter disc. Then the rotation from the uncenter disc was passed to a small wheel, and finally, the rotation from the small wheel was transferred to a pressing pipe. By utilizing the power of the disc, the pressing pipe will flatten out melinjo with full power. This mechanism was aimed so that melinjo, which enters to the table, could be flattened by the pressing pipe.

Another study to develop melinjo seed pressing tool using a rolling system was also conducted by Radhityo et al. [9]. They developed a pressing tool with a capacity of 5 Kg/hour. The roller of the machine was constructed using stainless steel and driven by an electric motor. The electric motor was connected to the pulley, and the pulley is linked to the roller. When the motor rotates, the roller also rotates to press the melinjo seeds with a pressing roller speed of 19 rpm.

A pressing machine using a diffrent driver system for melinjo chip was developed by Rusman [10]. The machine was actuated using a hydaulic system. The diameter of cylinder used for pressing melinjo seed was 40 mm, with a maximum working pressure of 16 Mpa. The electric motor used was 0.5HP/0.37KW with 1400rpm rotation. The pump used for the machine has a maximum working pressure of 20 Mpa with a capacity of 3.42 cm3/rev. Meanwhile, the hydraulic lubricant used was a lubricant that has a kinematic viscosity of 30 mm2/s.

From the explanation above, it could be concluded that the pressing melinjo seed into chips shape was mostly done manually. Several tools and machine, which were developed, are only able for helping the pressing process of melinjo seeds to make them thinner and wider. All the developed machines were operated unautomatically because they still require significant operator involvement. So the impact of the existing machines are still very limited.

Therefore, in this study, an automatic melinjo puncher machine, which is actuated using pneumatics pressure, has been developed. Instead of using a pressing system, this machine implemented punching system to change the shape of melinjo seed. As a result, this machine is able to place melinjo seeds on a punching base automatically using a pusher rod, which is also actuated by a pneumatics cylinder. When the pusher rod places the melinjo seeds to the punching base, at the same time it removes a chip shape melinjo seed on the base, which is obtained from previous process to the basket. The end side of pusher rod was designed a shovel shape tool so that it could perform both tasks at the same time. After the seed is located on the base, the pusher rod returns to its start position, and then the puncher rod moves down to punch the seed. Thus the process could be operated automatically, and the operator involvement in the process could be reduced significantly.

2. Design and mechanism of the machine

The design and the final construction of the developed melinjo puncher machine is presented in Figure 1. Figure 1a present an isometric view of the design. Figure 1b and Figure 1c show the dimension of the machine from front view and side view, consecutively. The final construction of the machine can be seen in Figure 1.d. The melinjo seed punching process could be performed one by one continuously, the 0,5-inch hose was used as seed feeder. The melinjo seeds exit from the feeder and then enter the pusher rod by sliding due to gravity. The actuator used to drive the machine is pneumatics pressure. There are two pneumatics cylinders used in this machine, the first is pneumatics cylinder for driving the pusher rod and the second is the pneumatics cylinder for actuating the puncher rod. The driving cylinder serves to place the melinjo seeds on the punching base; simultaneously, it removes a chip shape melinjo seed, which is obtained from previous process, on the punching base. When the pusher rod moves forward to place melinjo seed to the base, the upperside of the pusher rod close the seed feeder to prevent the seed exit. After the pusher rod back to its start position, the feeder reopens, and the seed could exit from the feeder to lying in front of the pusher rod. This machine uses sensors to detect the existence of melinjo seeds. This sensor is used to determines whether the system continues to operate or stops. When the sensor detects the existence of melinjo seeds then the process is continued; otherwise, the operation is stopped.

In general, the operating mechanism of the machine was programmed using a flow chart, as shown in Figure 2. The process begins by inserting melinjo seeds into the feeder. Then the machine is turned on by pressing the on button (PB On). After the machine is turned on, the sensor will detect whether melinjo seed exists on the output of the feeder hose or not. If the sensor detects melinjo seeds, then the process is continued; otherwise, the operation is stopped. If the process is continued, then pusher rod, which has shovel shape, pushes the seed to the punching base. The function of pusher rod is not only for placing the seed to base but also for removing the chip shape melinjo on the base from the previous process. After the melinjo seed is put on the punching base, the pusher rod moves back to its start position. Then, the puncher moves down to punch the seed several times. The punching process will be carried out for “T” seconds to achieve the desired thickness. The number of 'T' will be determined

through a testing process after the machine is developed. It will be discussed in the subsequent section. After the punching process is completed, then a similar process and procedure will be repeated since the sensor detects the existence of melinjo seeds.

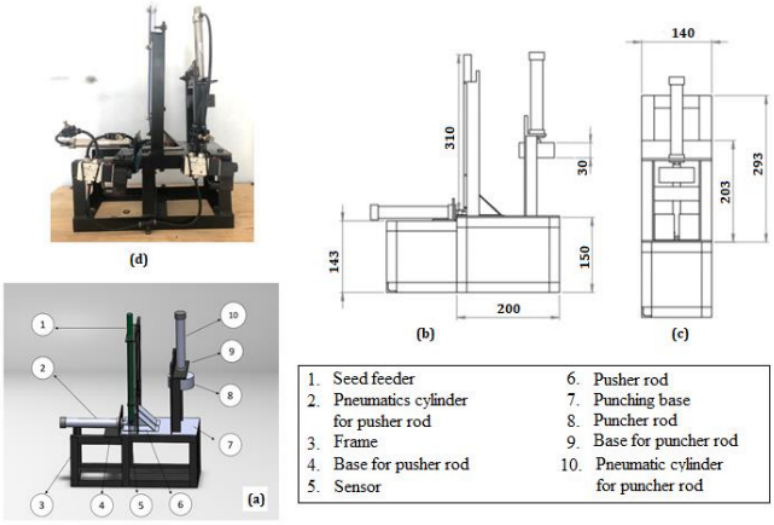

Figure 1. Automatic flattened melinjo seed machine, a) design, b) physical construction

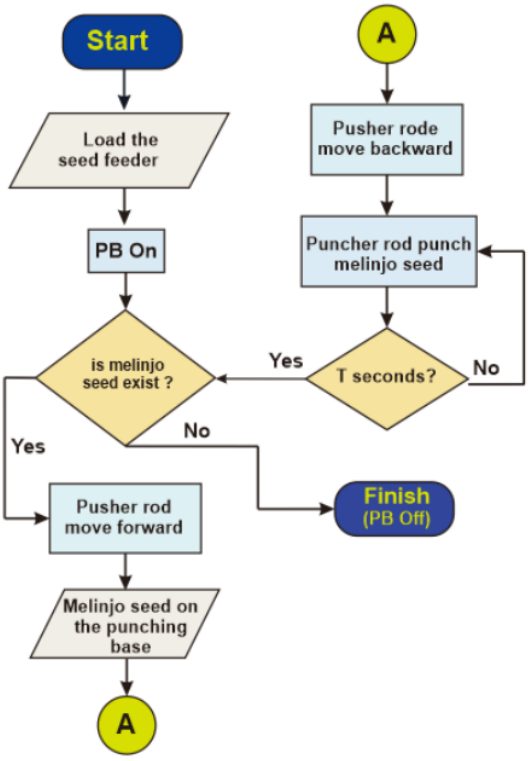

Figure 2. Flow chart of operating process

The electronic circuit required to operate this machine is a sequential and pneumatics circuit, as shown in Figure 3. This circuit uses six timers to control the movement of pneumatics cylinders. The designed circuit uses an infrared sensor for detecting the existence of melinjo seed. When the sensor detects the seed, then relay 5V is active. The contact changes from NO to NC and the power source 24V connects to PB On. Hence, when PB On is pressed, relay1 activate valve1 (V1) that makes the pneumatics cylinder move forward and simultaneously T1 count for 1 second.

When T1 is active, then the pneumatics cylinder retracts the pusher rod to the start position. T1 supplies the power to T6 and T6 start counting for 1 second. When T6 is active, the power source is connected to T2 and T2 start counting for 1 second. At the same time, valve2 (V2) of the pneumatics cylinder is actuated to move down the puncher rod. At this stage, T3 is active and change from NC to NO. In this case, power source to T2 is disconnected. T2 will reconnect to power source when T3 shift from NO to NC. This sequence makes the pneumatics cylinder move the puncher rod up and down several times. When T6 is active, T4 continues counting for 1 second. T5 is active after T4 changes from NO to NC. This circuit schematic repeats this process until PB Off is pressed or when the sensor detects no seeds.

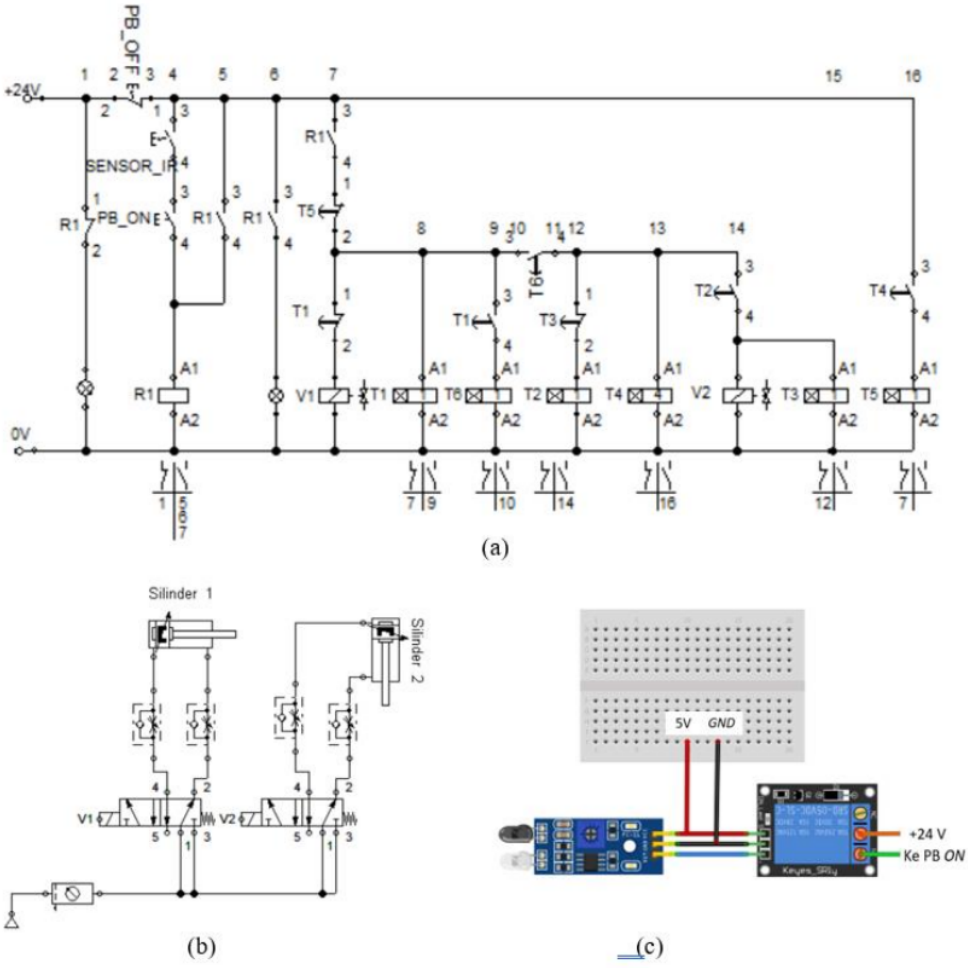

Figure 3 Electronics circuit, a) Sequential circuit, b) pneumatics circuit, c) sensor circuit

3. Testing and discussion

The physical construction of the machine as designed in Figure 1 was developed as can be seen in Figure 4a. Meanwhile, the electronics system, including cable and electronics components are set up in a panel box as presented in Figure 4b. After this machine was developed, then a set of tests has been performed for several purposes. The tests were carried out to check the ability of several components to perform the expected task. The test was also performed to determine the most effective parameters used in the programming of the system. Finally, another test was also conducted to measure the capacity of the machine in processing melinjo seeds into chips shape.

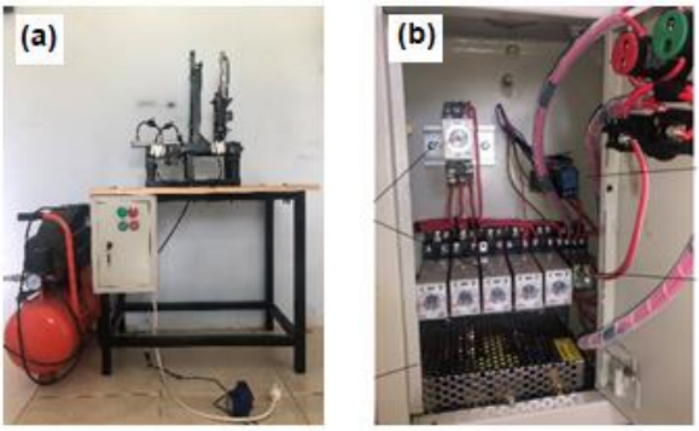

Figure 4 a) Physical construction of the machine, b) panel box

3.1 *Determining punching time*

The time set to punching melinjo seed will determine the number of puncher rod hit melinjo seeds. The number of puncher rod hit melinjo seed influence the thickness of the result. The test that was carried out in this section is for determining the punching time, and for checking the impact of pneumatics pressure to the thickness of the results. This machine is expected to operate using the pneumatics system with operating pressure between 5-7 bar. The selected punching time is determined based on the thickness of melinjo obtained from the test. The expected thickness was determined from a survey. A survey was conducted by measuring the thickness of various types of melinjo chips sold in the market. The result show that the thickness of melinjo chip in the market is between 1-1.5 mm. Therefore, the punching time is determined based on the time required by the puncher rod to obtain the expected thickness of melinjo chips.

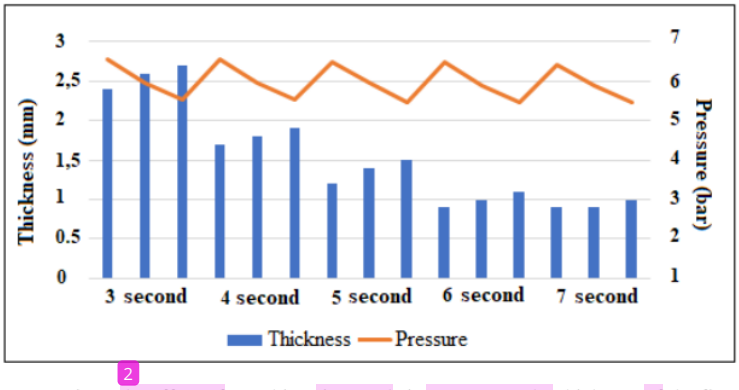

Figure 5 a) Test result on the effect of punching time and air pressure to the thickness of the flattened melinjo

The punching time test was carried out using 5 variations of time, they are 3, 4, 5, 6, and 7 seconds. Every variation was tested 3 times with different pneumatics pressures. The air pressure used during the test is measured and recorded. Pneumatics pressures during the test and the thickness of the chip shape melinjo after the punching process can be seen in Figure 5. This graph shows that pneumatics pressure significantly affects the thickness of the chip shape melinjo seed. The higher the pneumatics pressure tend to produce thinner chips shape melinjo, and vice versa. The same trend is also shown by the effect of the punching time. The longer the punching time, the thinner the chips shape melinjo seed produced. This result is strongly influenced by the frequency of puncher rod hit melinjo seed increase due to the increasing of punching time. Based on the test data in Figure 5, it can be seen that the punching time of 5 seconds produces chips shape melinjo seed with the thickness of 1,20-1.45 mm. The results are within the expected thickness. Hence, the punching time 5 seconds was selected for implemention in the machine program.

3.2 *Sensor testing in detection melinjo seed*

Sensor used in this machine was aimed to detect the existence of melindo seed for further process. If the sensor detects the presence of melinjo seed, then the machine keeps continues the operation. On the other hand, when the sensor detects no seed, then the system stops the process. In this section, the accuracy of the sensor detects the exitance of the seed was tested. In this test, the seed feeder was loaded with five seeds. The machine was expected to process all seed automatically and stop the process after melinjo seed on the feeder finish. The same tes was repeated three time and the result is presented in Table 1.

Tabel 1 Data of sensor testing in detection melinjo seed

Seed No.	1	2	3	4	5	No seed
Test-1	Active	Active	Active	Active	Active	Not Active
Test-2	Active	Active	Active	Active	Active	Not Active
Test-3	Active	Active	Active	Active	Active	Not Active

From Table 5, the sensor was able to detect the presence of melinjo since the first seed until the fifth seed accurately. The test also proved that the machine keeps operating when the sensor active. After the fifth seed comes out, there is no seed for the next process. The data in Table 5 show that the sensor inactive after the fifth seed. It means that the sensor detects no seed to be processed. During the test, when sensor inactive, then the operation stop the operation. Therefore, the test result in this section can be concluded that the sensor was functioning properly.

3.3 *Testing on machine capacity*

A test for determining the machine's capacity in processing melinjo seed into chips shape has been performed. In this test, 10 melinjo seed were processed continuously, and the total time was measured. The same test was repeated 8 times. The pneumatics pressure used in this test is between 5-7 bar. The duration required to process 10 melinjo seed and the air pressure using during punching process were measured and noted. The test result is presented in Figure 6. This figure shows that the processing time of 10 melinjo seeds slighly varies from the lowest 68.04 seconds and the highest 74.32 seconds. The average time of 8 tests was 68.13 seconds. By obtaining the time to process ten melinjo seeds, the the machine's hourly capacity could be calculated. The calculation found that this machine could process 528 melinjo seeds per hour.

In addition to measuring the processing time, the test also measured the average air pressure used during the punching process. The measurement results are also presented in Figure 6. From the graph can be seen that data of air pressure used in the test are very fluctuating. The fluctuation of air pressure shows the same trend as the fluctuations of processing time. From this graph, it can be concluded that the processing time is strongly influenced by the air pressure used by pneumatics cylinder. Air pressures

affect the speed of both pneumatics cylinders, which are pneumatics cylinder for pusher rod and pneumatics cylinder for punching rod. The higher the air pressure used, the faster the processing time. The time required for the punching process has been determined by the program, which is 5 second as the result of the test in section 3.1. The difference in processing time, as presented in Figure 6, is most likely caused by the time required by the pusher rod to place the seed on the base and returns to its original position. Moreover, the time difference is also influenced by the time required by the punching rod returns to its original position after the punching process is completed.

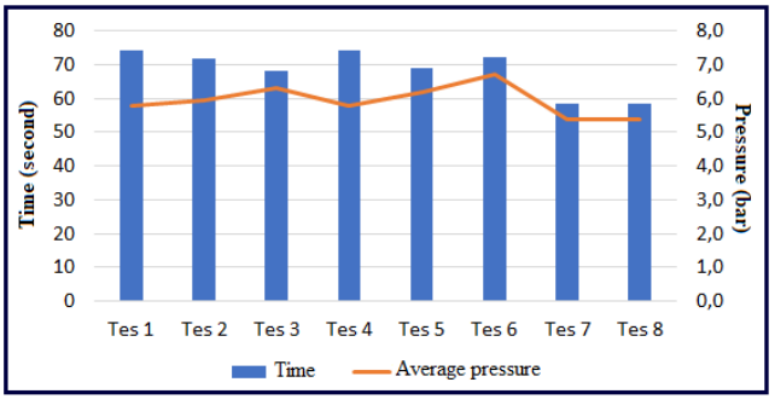

Figure 6 Data pengukuran waktu pemipihan dan tekanan udara rata-rata

4. Conclusion

In this study, an automatic melinjo puncher machine using pneumatics pressure has been developed. The developed machine has been followed by several tests, including test to determine the parameter used in the control system and test for checking the machine's performance. Based on the test that have been conducted, several conclusions can be taken, such as,

1. The developed machine is proven could be used to punch melinjo seed into chips shape automatically. The automatic system has succeded in significantly reducing the involvement of the operator.
2. The most appropriate punching time at pneumatics pressure between 5-7 bar is 5 seconds. In 5 second, the thickness of chips shape melinjo are in between 1,20 -1,45 mm. Therefore, the thickness of chip shape melinjo is within the expected thickness as sold in the market.
3. The test on machine capacity has been carried out. The results show that this machine could process 528 melinjo seeds per hour.

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