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1
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Freshness Detection And Sorting Of Pears Using The TCS-3200 Sensor

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ABSTRACT

Pears in early autumn can be harvested with the best quality. Pear farmers sort the fruit so that it can be consumed and sold with the best quality. Therefore automatic detection and sorting tools can make it easier for farmers to sort pears. This tool can sort fresh and rotten fruit using the TCS-3200 sensor based on the ESP32 microcontroller. The harvested fruit is collected in a container and the fruit will go out onto the conveyor. The conveyor has a length of 60 cm using a Nema 17 stepper motor that moves automatically, the TCS-3200 sensor is placed in the middle of the conveyor so that it can detect moving pears. The results of the sorting door servo if the fruit is declared fresh then the servo remains closed straight so that the fruit will go to the front container, and vice versa the fruit is declared rotten then the servo will open up so that the fruit will go down. At the end of the conveyor there is an IR sensor which is used to send a signal to the servo motor of the main container door, so that if the fruit has been detected and leads to the IR sensor, the main container door will open and take out new pears. And for data collection the number of pears can be seen through the LCD by calculating the number of pears that have been detected, the number of fresh fruit and the number of rotten fruit, and the overall calculation of the amount of data can be seen through a spreadsheet. In this case, it is hoped that this research can help and facilitate farmers in harvesting fruit on a large scale while being efficient in time and energy.

Keywords: Conveyors; ESP32; TCS-3200; Pears; IR Sensor;

INTRODUCTION

Fruit is one of the foods that are needed for the human body as fiber so that it can help in human digestion(Rianto P & Harjoko A, 2017). Sometimes fruit also has different durability periods so that it is good for consumption. Fresh fruit is fruit that has just been picked straight from the tree, but there are also rotten fruit even though it has just been picked, usually caused by animals or ripe trees.(Prayoga et al., 2018). Pears are one that many people like, pears have good content to prevent cholesterol and also improve digestion, that's why this fruit is much sought after by people. the fruit is harvested in early autumn and farmers can produce up to two tonnes at a time depending on the field. After the harvest, the farmers do the sorting to produce fresh and rotten fruit so that the quality is guaranteed until it reaches the consumer, the sorting process is still mostly done manually by the pear farmers.(Syahrorini et al., 2021). Therefore this research was made to make it easier for farmers to select fruit with automatic detection and sorting tools(Desy et al., 2020).

This fruit freshness detector can determine which fruit is fresh and rotten by using the TCS-3200 color sensor(Juliano et al., 2020). Harvested fruit is collected in a container and the fruit will come out one by one to the conveyor. the door of the container uses a servo motor that moves quickly to open and close so that the fruit can come out one by one, for a conveyor length of 60cm which uses a stepper motor Nema 17 to move automatically using a Push Button(Supriyadi et al., 2020). the pears then go to the TCS-3200 sensor and are immediately sorted into containers according to the fruit yields that are available with the door if the fresh fruit remains motionless and the fruit will go straight through the door and vice versa if the fruit is detected as rotten the door will open up and go down(Rijal, 2023). The IR sensor is located at the end of the conveyor which functions to detect fruit that will pass and sends a signal to the door servo motor to open the fruit so that the next pear can be removed.

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This research develops a tool to identify fruit conditions based on RGB color using the TCS-3200 sensor and displays the results on the LCD screen. The results of the TCS-3200 sensor value are that fresh fruit has a reading value of red above 450, green above 380, and blue above 300. Then in the rotten fruit test the values obtained are red below 450, green below 380, and the blue color is below 300. The results of the fruit detection can be seen via the LCD, and the results for the total number of fruit data that have been detected can be seen via a spreadsheet(Ashari et al., 2022). The process of developing this tool begins with designing a series of tools to measure the RGB color composition of fruit objects which will be used as a reference for sorting fruit(B. Nugroho et al., 2021). It is hoped that this research can make farmers' time efficient in processing and sorting pears.

LITERATURE REVIEW

In the research conducted by Asep Rachmat, namely designing a sorter tool for the maturity level of gedong lipstick using the TCS-3200 sensor. This tool can detect ripe and unripe gedong manga and automatically calculates the manga results that have been sorted and then displayed on the LCD.(Rachmat et al., 2018). In the research conducted by Ayu Lestari, namely making a prototype of sorting goods based on Arduino UNO, this tool is in the form of a conveyor belt equipped with a loadcell sensor to detect the weight of goods, and there is a servo motor that is useful as a pusher from the loadcell table to the conveyor and as a guide for goods according to the location specified weight(Lestari & Candra, 2021). In a study conducted by Iwan Fitrianto Rahmad entitled "Detecting Fruit Freshness Using Color and Humidity Sensors" this study aims to make a fruit freshness detection tool using TCS-3200 color sensor and DHT11 moisture sensor to determine the level of fruit freshness. Data processing is carried out by calculating and comparing the measurement results of fresh fruit with the measured fruit samples. To improve the color accuracy of the measured fruit, the TCS-3200 color sensor can measure 3 (three) basic colors, namely red, green and blue from fruit samples so that the identification of the level of fruit freshness is more accurate (Rahmad, 2019). In the research conducted by Alberth David Hetharua, namely making a detector on tomatoes using the TCS-3200 sensor, then selecting and grouping tomatoes according to ripe, half ripe and unripe categories. Tomatoes are selected by color detection by the TCS-3200 sensor and then driven by a servo motor so they can go to the available container box(Hetharua et al., 2021).

METHODS

In the current study, detection was carried out on pears using the TCS-3200 sensor using a conveyor as the path to transport the fruit to the sorter. The amount of fruit that has been detected which includes types of fresh and rotten fruit can be monitored via a spreadsheet for easy checking, the microcontroller used in this study is ESP32(Basri & Wahira, 2022). Fruit is collected in the main container and will exit through the servo door then will go to the conveyor. In the middle of the conveyor line there is a TCS-3200 sensor that will detect fruit that is passing, after which it will then go to the sorting door. The sorting door uses a servo motor with two freshness paths. If the fruit is detected as fresh, the door will remain closed and the fruit will pass forward, otherwise if the fruit is detected as rotten, the door will open up and the fruit will fall down. At the end of the conveyor there is an IR sensor that will send a signal if the fruit passes, the main container door will open a new pear(Kurniawan & Surahman, 2021). In addition to the spreadsheet, the number of fruit that has been detected can be monitored directly via the LCD(Nusa et al., 2015).

System Design

In this study there are several parts of the system design, the first is the wiring system which explains the connection of the components used such as the microcontroller, input and output components so that the system is connected to each other. The second is a block diagram, which explains the input and output components and the microcontroller used. The third is the flowchart section, in this section explaining the research flow in order to provide an understanding of how the tool works and operates.

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1
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Wiring System

In this part of the wiring system, you can see in the wiring design picture, from the picture it can be explained that all components are interconnected, starting from the TCS-3200 sensor input component and IR sensor, then the Servo motor output sensor, and the 20x4 i2c LCD, all connected to the microcontroller ESP32. The Nema 17 Stepper Motor is not connected to a Microcontroller because it moves the conveyor automatically by only using the ON/OFF push button to start it.

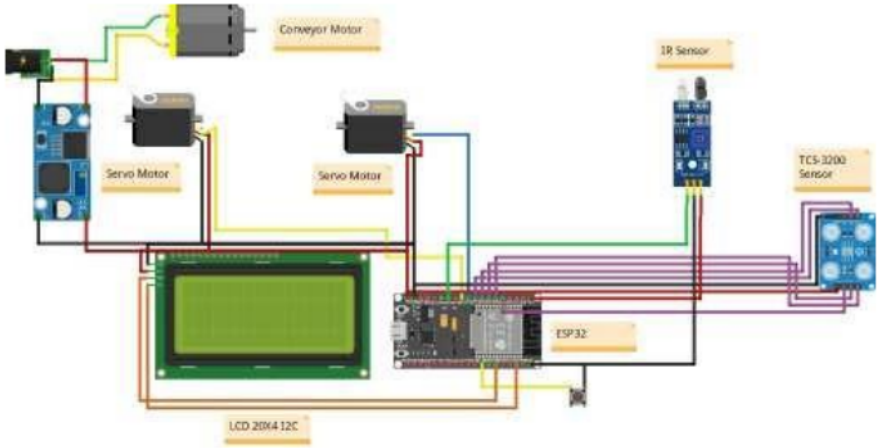

Fig. 1 Wiring Design
(Source : Research Property)

Table 1
ESP32 Port Usage

No	ESP32 ports	usage
1	Vin	VCC (TCS-3200)
2	GPIO 25	S0 (TCS-3200)
3	GPIO 33	S1 (TCS-3200)
4	GPIO 32	S2 (TCS-3200)
5	GPIO 35	S3 (TCS-3200)
6	GND	GND (TCS-3200)
7	3.3V	VCC (IR Sensor)
8	GND	GND (IR Sensors)
9	GPIO 12	OUT (IR Sensor)
10	GPIO 26	PWM (Servos)
11	GPIO 27	PWM (Servos)
12	Vin	VCC (Servo)
13	Vin	VCC (Servo)

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14	GND	GND (Servos)
15	GND	GND (Servos)
16	GND	GND(I2C LCDs)
17	Vin	VCC(I2C LCDs)
18	GPIO 21	SDA(I2C LCDs)
19	GPIO 22	SCL(I2C LCDs)
20	GPIO 19	VCC (Push Button Reset)
21	GND	GND (Push Button Reset)

Table 1 describes the pinout of the ESP32 microcontroller which connects input output components such as the TCS-3200 sensor, IR sensor, Servo Motor and LCD 20x4 i2c. while in figure 1 describes the TCS-3200 sensor there are 6 pins, 2 pins are connected to GND and VIN while for the other pins S0 to GPIO 25, S1 to GPIO 33, S2 to GPIO 32, S3 to GPIO 35 ESP32. Then the IR VCC sensor is connected to 3.3 V, Grounding to GND, sensor OUT pin to GPIO 12. For the VCC lines both Servo and GND are jumped into one, then for PWM servo 1 connected to GPIO 26, and PWM servo 2 connected to GPIO 27. Then the LCD for VCC is connected to Vin from ESP 32, SDA is connected to GPIO 21 pin, and SCL is connected to GPIO 22 ESP32 pin. Finally, there is a reset button used to reset the accumulated number of fruits. which is connected to ESP32's GPIO pin 19 for VCC and the button's GND pin to the GND pin on ESP32. The components used on the conveyor are the Nema 17 stepper motors which move automatically by simply pressing the ON/OFF push button.

Block Diagrams

For the block diagram system in this study can be seen in the following figure

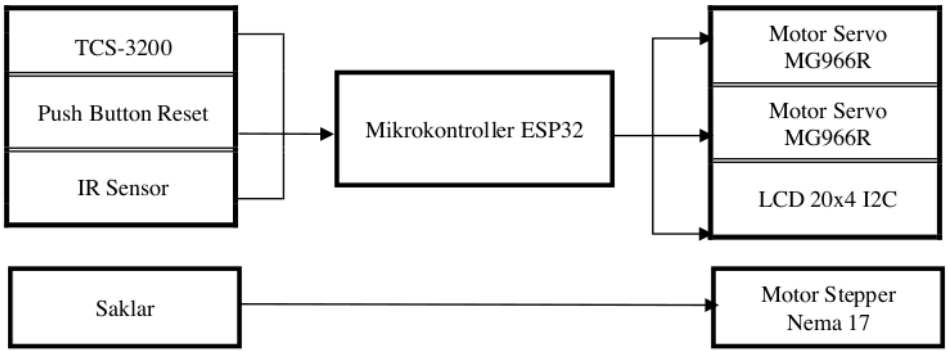

Fig 2. System Block Diagram

In the Fig 2 block diagram above, it is explained that there are input output components and the ESP32 microcontroller. For components connected to the ESP32 there is a TCS-3200 sensor input to detect the color of the fruit, the IR sensor is used to detect fruit passing on the conveyor and then sends a signal to the servo motor and the Push Button reset is used to reset the calculation results for the number of fresh and rotten fruit. For the output components, there are two Servo Motors that are used on the sorting door and the main container door and a 20x4 LCD that is used to display fruit detection readings. In the next block diagram, it is made separately as a series of implementing automatic conveyor drives with Nema 17 stepper motors and switches used to start and stop conveyors.

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System Flowcharts

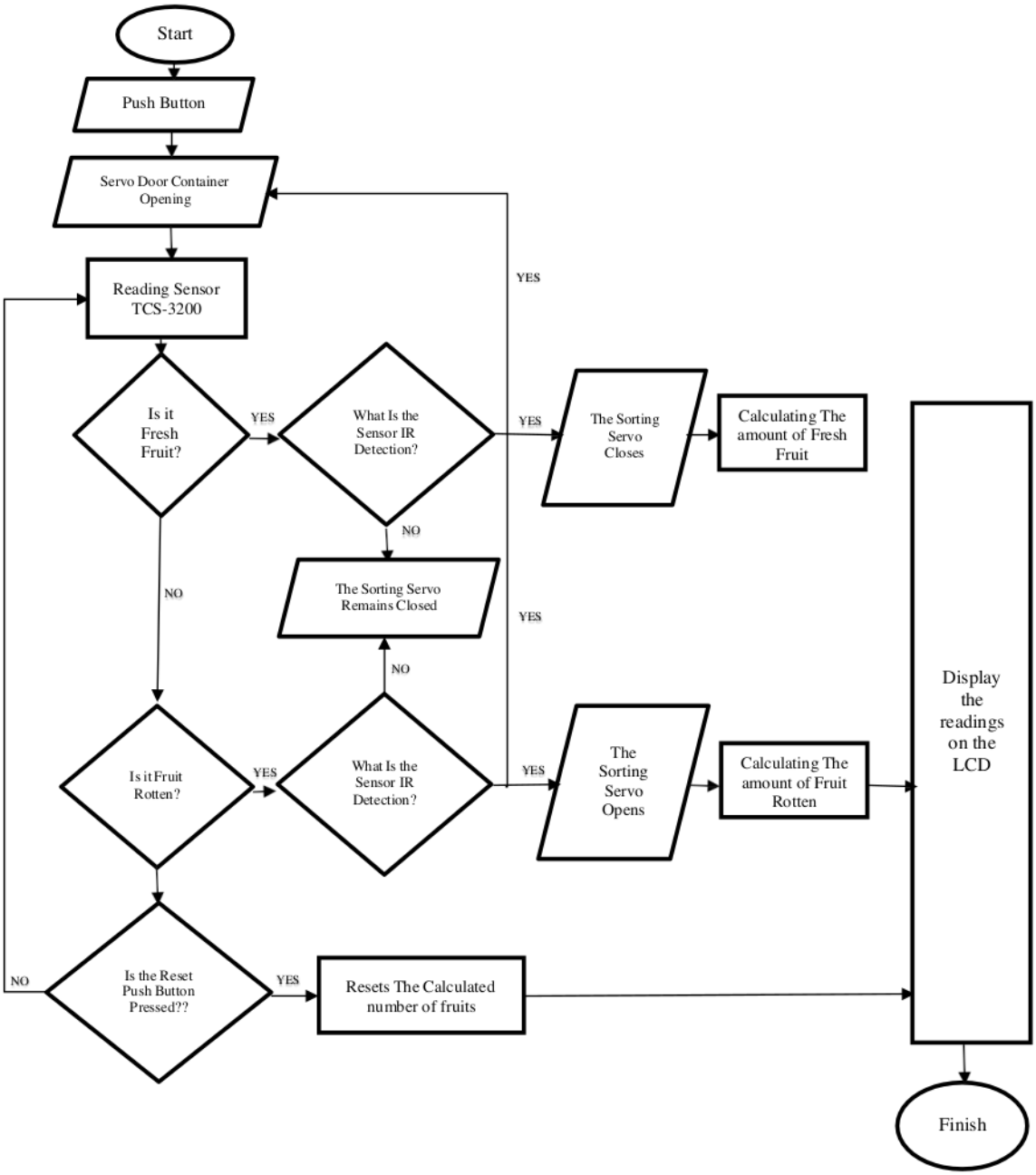

Fig 3. System Flowcharts

* Corresponding author

1
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In the early stages of using a pear detector and sorter using the TCS-3200 sensor, connecting the ESP32 microcontroller to a voltage source. Once connected, the servo on the door of the container will open and take out the pears one by one. After that the fruit goes with the conveyor towards the TCS-3200 sensor and starts the detection. If the fruit is fresh, it will go to the sorter and the servo closes so that the fruit moves forward, otherwise if the fruit is detected as rotten, the servo will open and the fruit will fall down. At the end of the conveyor there is an IR sensor to detect passing fruit that has been detected, then the proximity sensor will send a signal to the container servo motor so that the servo will open and eject the next pear. The results of the detection and the number of pears can be seen through the LCD.

RESULTS

This chapter contains the workflow of tools and component testing that has been installed on the entire Pear Freshness Detection and Sorting tool Using the TCS-3200 Sensor, which includes ESP32 Microcontroller testing, TCS-3200 Sensor Testing, IR Sensor Testing, MG966r Servo Motor Testing , 20x4 I2C LCD Testing, and Nema17 Stepper Motor Testing. The realization of the tool can be seen in the image below

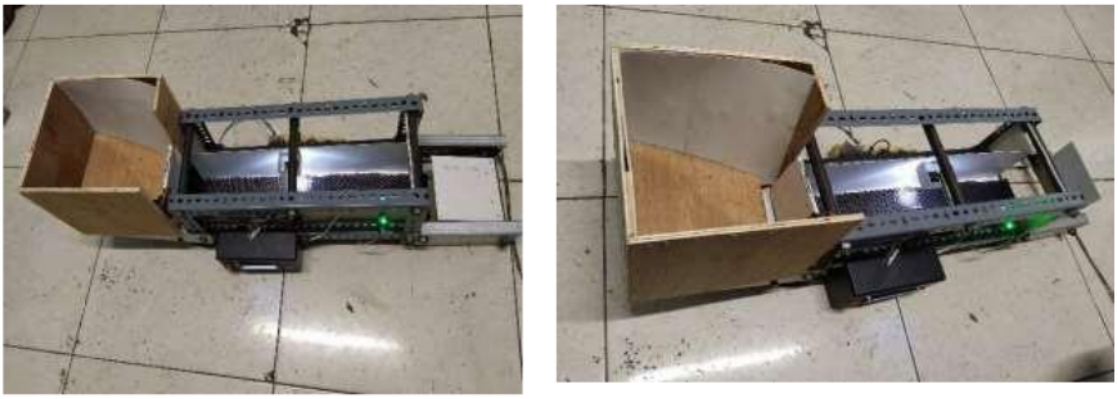

Fig 4. Result of tool realization
(Source : Research Property)

Stages of how the tool works:
1. Connect the ESP32 Microcontroller to a 5 volt power source
2. Because the conveyor requires a different power then connect the conveyor to 12 volts
3. Put the pears into the container and the fruit will come out onto the conveyor.
4. The conveyor will pass through the TCS-3200 sensor then towards the IR sensor so that the door where the container will open and take out the next fruit.
5. The final stage of the fruit will go to the sorting door, if the fruit is detected fresh then the door does not move and the fruit will still go to the final container, otherwise if the fruit is declared rotten then the door will open and the fruit will be separated from the conveyor.

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Fig 5. LCD Integration Value
(Source : Research Property)

Description of the image above:

1. The results of the RGB value for fresh fruit detection will appear on the LCD, namely red above 450, green above 380, and blue above 300.
2. The results of the RGB value for fresh fruit detection will appear on the LCD, namely red below 450, green below 380, and blue below 300.

Microcontroller ESP32 Testing

Table 2.
ESP32 Mikrocontroller Testing

testing	Connected Components	Condition	accuracy
1stTest	TCS-3200	Connect	Good
2nd test	Push Button Reset	Connect	Good
3rd test	IR Sensors	Connect	Good
4th test	MG966r Servo Motors	Connect	Good
5thTest	LCD 20x4 I2C	Connect	Good

The table 2 is the result of testing between the microcontroller and all the components used, all components used are connected one by one to the microcontroller to ensure that all components used can be connected and function properly, the test was carried out five times and it was concluded that the test was successful(Basri & Wahira, 2022).

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1
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Sensors TCS-3200 Testing

Table 3.
Sensors TCS-3200 Testing

testing	object	Number of Trials	TCS-3200 Sensor Value			accuracy
			red	Green	Blue	
1stTest	Fresh fruit	Trial 1	472	392	267	Good
		Trial 2	498	401	299	Good
		Trial 3	534	424	308	Good
		Trial 4	525	418	303	Good
		Trial 5	528	420	305	Good
2nd Test	Rotten fruit	Trial 1	147	60	12	Good
		Trial 2	201	112	39	Good
		Trial 3	176	83	28	Good
		Trial 4	159	78	16	Good
		Trial 5	243	124	53	Good

The table 3 is the test results of the TCS-3200 sensor using two conditions, namely fresh fruit and rotten fruit. The fresh fruit test was carried out 5 times with different results. Based on the test results obtained, it was concluded that fresh fruit had a reading value of red above 450, green above 380, and blue above 300. Then in the rotten fruit test the values obtained were red below 450, green below 380, and green blue under 300(Johanes et al., 2022).

IR Sensors Testing

Table 4.
IR Sensors Testing

testing	Fruit Distance with Sensor	Time(s)	accuracy
1stTest	2cm	2	Good
2nd test	2cm	2	Good
3rd test	2cm	3	Good
4th test	2cm	3	Good
5thTest	2cm	2	Good

The table 4 is a test of the IR sensor, this sensor functions to detect passing objects. The application of the IR sensor in this research as the second detector on the fruit after the first detection, the sensor readings are used as a control to open the first door to remove the next fruit. Based on the test results above, it can be concluded that the tool can function properly, it's just that the resulting time lag is different, but it can be said that it is still normal and that is a natural thing(Marlina, 2023).

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Servo Motors MG966r Testing

Table 5.
First servo motor testing

testing	Servo Motor MG966r		Description
	INPUTs	OUTPUT	
1stTest	60°	60°	Success
2nd test	60°	60°	Success
3rd test	60°	60°	Success

Table 6.
Second Servo Motor Testing

testing	Servo Motor MG966r		Description
	INPUTs	OUTPUT	
1stTest	45°	45°	Success
2nd test	45°	45°	Success
3rd test	45°	45°	Success

Tables 5 and 6 above are the results of testing of two servo motors that are used with different functions. The first servo motor was used as a door control where the first fruit was placed. The servo motor will move by 60° then the door will open and the fruit will come out, after the fruit comes out the servo will close automatically. the second servo motor is used as a control for moving rotten fruit, when rotten fruit is detected, the second servo will move 45° then the fruit will be separated from the conveyor. When fresh fruit is detected, the second servo motor will not move so that the fruit remains on the conveyor until the last container(A. M. S. Nugroho et al., 2022).

LCD 20x4 I2C Testing

Table 7.
LCD testing

testing	LCD (Liquid Crystal Display) I2C 20x4		Description
	INPUTs	OUTPUT	
1stTest	Fruit Freshness Sorting Conveyor Prototype	Fruit Freshness Sorting Conveyor Prototype	Success
2nd test	Fresh Pears	Fresh Pears	Success
3rd test	Rotten Pears	Rotten Pears	Success
4thTest	Total Calculation	Total Calculation	Success

The table 7 shows the test results of the 20x4 I2C LCD when applied to the tool. The input column contains information that must be displayed under certain conditions according to the programming that has been done on the microcontroller. The test was carried out 4 times and the results obtained were in accordance with the input given and it was concluded that the test was successful(OO, 2020).

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Stepper Motor Nema 17 Testing

Table 8.
Nema 17 Stepper Motor Testing

testing	Stepper Motor Condition		Condition	accuracy
	Turn Right	Turn Left		
1stTest	✓	-	Succeed	Good
	-	✓	Succeed	Good
2nd Test	✓	-	Succeed	Good
	-	✓	Succeed	Good
3rdTest	✓	-	Succeed	Good
	-	✓	Succeed	Good

Table 8 Shows Tests on the Nema 17 Stepper Motor were carried out with the aim that the motor could rotate right and left properly. Stepper Motor is used as a conveyor drive and the motor will move continuously when the tool has been powered(Soedjarwanto, 2021).

Overall Testing of the Tool

Table 9.
Overall testing of the tool

Object	Number of Attempts	TCS-3200 Sensor Value			Detected colors	Condition of Servo Motor (Fruit Sorting Door)		Description
		Red	Green	Blue		0°	45°	
Fresh Fruit	Trial 1	472	392	267	Fresh	✓	-	Success
	Trial 2	498	401	299	Fresh	✓	-	Success
	Trial 3	534	424	308	Fresh	✓	-	Success
	Trial 4	525	418	303	Fresh	✓	-	Success
	Trial 5	528	420	305	Fresh	✓	-	Success
Rotten Fruits	Trial 1	147	60	12	Rotten	-	✓	Success
	Trial 2	201	112	39	Rotten	-	✓	Success
	Trial 3	176	83	28	Rotten	-	✓	Success
	Trial 4	159	78	16	Rotten	-	✓	Success
	Trial 5	243	124	53	Rotten	-	✓	Success

In the table 9 is a test table of the entire tool where the test is carried out with the input output component of the TCS-3200 sensor and servo motor as a separator. There are two types of pears tested for freshness of fresh fruit and rotten fruit, testing is carried out 5 times with fresh condition results having a red reading value above 450, green above 380, and blue above 300. Then in the rotten fruit test, the values obtained were red below 450, green below 380, and blue below 300. As for the condition of the servo motor on the sorting door, if the fruit is declared fresh, it will remain motionless so that the fruit is straight forward, then if the fruit is declared rotten, the servo door opens so that the fruit will fall down.

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DISCUSSIONS

In this study, the appropriate results were obtained, the TCS-3200 sensor can detect color with good accuracy and can distinguish the type of freshness in pears, but sometimes the color of rotten pears is only half of the fruit, making the TCS-3200 sensor unable to detect it. For future research there are several suggestions, namely by adding several sensors from various sides in order to obtain more accurate results and also types of freshness can be made from half cooked, fresh, raw and rotten.

CONCLUSION

Based on the results of the tests carried out, it can be concluded that: (1) testing of all components to the ESP32 microcontroller was successful and could be connected properly. (2) testing the TCS-3200 sensor using two samples of pear freshness, it was found that fresh fruit for R values above 450; G above 308;B above 300, for the value that rotten fruit R is below 450;G below 380;B below 300. (3) in the IR Sensor test it can be concluded that the sensor can detect fruit that is moving well even though the detection time is still said to be normal and not disturbing tool workflow. (4) in testing the two servo motors, it can be concluded that the servo moves normally according to what is input. (5) on the 20x I2C LCD test it can be concluded that the components can work properly, according to what is input. (6) in the last test performed on the Nema 17 Stepper motor components 3 times, each test was carried out by rotating the motor to rotate right and rotate left. And all tests obtained good results.

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