Design and Build Smart Bowl with Weight Converted to Calories Meter that Integrated with Smartphone

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ABSTRACT
During the COVID 19 pandemic, activities outside the home were limited. Based on research, the obesity number had doubled during the pandemic. In Indonesia itself, several similar studies have also been conducted. As a result, there is an average weight gain of 1 kg in medical students. Then there was also the influence of the COVID 19 pandemic on physical activity and weight gain. Moreover, during the pandemic, several studies have shown that there is a relationship between an increased risk of death for people who are overweight when infected COVID 19. This research proposes the design and manufacture of a calories scale that is integrated with the application and is able to control daily calories for achieving an effective diet. This device is intended to measure the calories intake per serve. The bowl-designed is unique and allows the user to consume the food from it. Some testing was acquired to gain error percentage. The weight measurement was 1.74% in error average. Some kinds of food are also tested to understand the accuracy of the device to detect food calories. Also, a calorie intervention intake feature has been tested. The result was validated and functioned well

Keywords: *load cell, bowl, calories meter, dietary*

1. INTRODUCTION

One of the unstable entropy parameters in humans is body weight. Under normal circumstances, when a person consumes food with balanced nutrition for their needs, body weight will develop according to age. However, in abnormal circumstances, changes in body weight may not be in accordance with age, can be faster or vice versa. Therefore, body weight must be monitored regularly. So that if there is excess or deficiency, nutrition intervention can be given immediately [1].

Gaining an ideal body weight is everyone's hope. However, during the COVID 19 pandemic, activities outside the home were limited. Based on research by Samantha J Lange conducted in the United States, obesity numbers had doubled during the pandemic [2]. In Indonesia itself, several similar studies have also been conducted. As a result, there is an average weight gain of 1 kg in medical students [3]. Then there was also the influence of the COVID 19 pandemic on physical activity and weight gain [4][5].

Overweight can cause several complication diseases that lead to degenerative diseases. For example cardiovascular disease, such as heart attack and stroke. Besides that, being overweight also causes diabetes, neuromuscular diseases such as osteoarthritis, and cancer [6]. Moreover, during the pandemic, several studies have shown that there is a relationship between an increased risk of death for people who are overweight when infected COVID 19 [7][8].

Several methods have been offered by dietitians to reduce excess weight by some patients, such as calories diets, exercise, medication, and others. According to M. J. Frans et al., an average weight loss of 5 to 8.5 kg (5% to 9%) was observed during the first 6 months of the intervention involving a low-energy diet and/or weight loss medication with

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weight loss. at about 6 months [9]. Therefore, a diet by eating the right number of calories is one of the best methods for achieving ideal body weight.

Several calorie meter devices and systems have been researched [10][11]. However, from those researches there is no food control per serving according to each user's body mass index (BMI). This research proposes the design and manufacture of a calories scale that is integrated with the application and is able to control daily calories for achieving an effective diet. In addition, this bowl-design device design allows food to be consumed directly from the device.

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2. METHOD

The method research conducted through several methodological stages, that were, literature study, system model and design, build the system, and testing and data analysis. Based on some literature [10][11], we proposed a new approach system that could provide a more effective diet system. We combined the previous research [12] that could generate a calories control per serving according to the user's BMI with the bowl-designed device.

2.1. System Design

The block diagram of smart-bowl is shown in Figure 1. The ESP32 microcontroller converted the weight from the load cell sensor which has been processed by the HX711 signal conditioner. Then the data results were displayed on the ST7789 IPS display screen. The button was used to enter the manual input type of food. The ESP32 also sends and receives data from and to smartphones. Smartphones are used to decide the type of food, then the chosen option would be sent to a microcontroller so it can detect and convert the weight of the food to its calories.

The 3D hardware design of the smart-bowl device is shown in Figure 2. The design of this calories scale resembles a bowl, so the users can consume calories directly from the scale. This bowl is also designed to be waterproof and washable, so the electronic components inside are safe. Moreover it does not need an additional container such as a plate. On the front there is an LCD that can display the results of weight detecting the calories that are weight-converted from microcontroller

2.2. Calories Control per Serving Algorithm

A person with proportional body shape that measures their height and weight is considered to have a normal body mass index. Here the formula for measuring the normal body weight:

$$ideal\ body\ weight = 0.9 \times \{body\ height\ (cm) - 100\} \times 1kg$$
$$ideal\ body\ weight = 0.9 \times \{body\ height\ (cm) - 100\} \times 1kg \quad (1)$$
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$$ideal\ body\ weight = 0.9 \times \{body\ height\ (cm) - 100\} \times 1kg \quad (2)$$

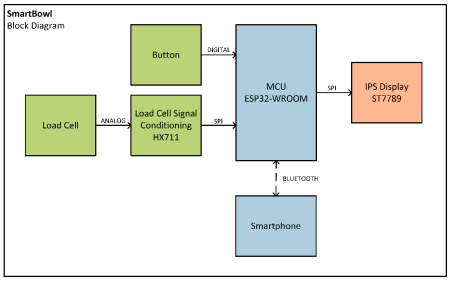

Figure 1 Block diagram for smart-bowl system

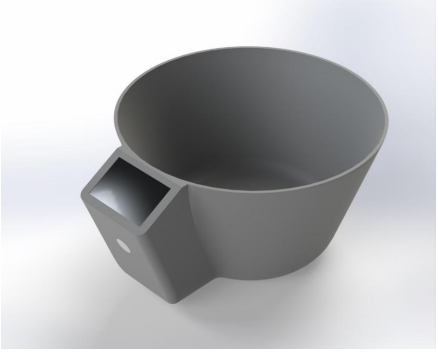

Figure 2 3D design of smart-bowl hardware

$$\text{ideal body weight} = 0.9 \times \{\text{body height(cm)} - 100\} \times 1\text{kg}$$

Formula (2) is used for male and females that have height under 160 cm and 150 cm respectively [13].

Reducing calories intake by 500 – 1000 kcal/day in 1 week can reduce 0.5 -1 kg. For example, if a person has 61 kg and he is expecting to reduce weight to 54 kg, so it becomes 61 - 54 kg = 7 kg. It takes approximately 7-14 which is the calories reduction is about 500 kcal -1000 kcal [13]. From those formulas, we proposed an algorithm in Figure 3. If the user will consume food that exceeds the calories limit that is allowed to be consumed, a warning notification will appear in the smartphone. The application in smartphones was built in the android operating system.

2.3. System Testing

The proposed research was tested by 3 kinds of testing; weight measurement testing with metal weighing scale, calories testing with 10 kinds of food, and calories intervention testing.

Table 1. Weight testing in smart-bowl

Reference (gram)	Measured weight (gram)	Error (%)
10	10.00	0.00
20	19.80	1.00
30	30.00	0.00
50	51.00	2.00
70	70.00	0.00
80	76.00	5.00
90	92.00	2.22
100	106.20	6.20

3. RESULT AND DISCUSSION

First test was to calculate the smart-bowl measurement weight error percentage. The metal weighing scale was used as reference. The result is shown in Table 1. The smart-bowl can measure food with an error of 1.74% in the range between 10-200 grams. The error could be caused by placing food on the surface because the load cell has higher accuracy in the centre point, while the food can be spread around the centre.

Second test measured the calories measurement error percentage from each type of food that was filled into a smart-bowl. The result is shown in Figure 3. The reference calories were acquired by using a standard weight scale. Then the measured weight was converted to each type of food calories.

Table SEQ Table * ARABIC 2. Average error calories measurement testing

	White Rice	Red Rice	Bread	Wheat	Fried Tempeh	Fried Tofu	Fried Chicken	Carrot	Tomato	Eggplant
Error (%)	1.47	2.13	1.82	0.95	3.57	2.45	1.46	1.46	2.41	2.89

The reference calories that have been used were 20, 50, 100, 150, and 200 kcal. The error percentage of each food is shown in Table 2. As shown in Table 2, the highest error percentage was gained by fried tempeh, while the lowest error was gained by wheat.

Using the same analysis with first testing, the load cell detects weight if it lies in the middle zone of the device. In this testing, fried tempeh was placed scattered inside the bowl. This can be caused by using a regular load cell sensor, which is not designed for spherical load [14].

The last testing was calories intervention intake. The system will alert the user if the device detects an excessive amount of calories. The result is shown in Table 3. The calories intervention intake testing validated that the software was functioning as expected.

The calories daily intake is about 2200 kcal per day, which means calories per serve is around 700 kcal. If a person wants to lose body weight, the decreasing amount of calories around 1000 kcal must be done. Number of calories threshold depends on the eating rate.

If the number of calories that lays in the device is the right number, there would not be a warning sign in the application. On the other hand, if the amount of calories is higher than allowed to consume detected, a warning sign would be triggered.

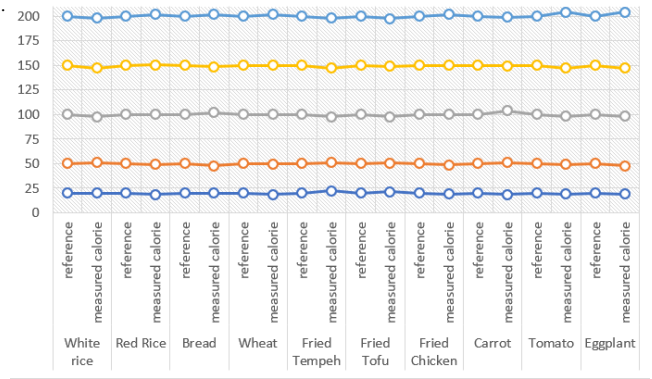

Figure 3 Calorie measurement testing from each type of food

Table 3. Calories intervention intake testing

Eating rate	Feature	Testing	Expected result	Result
2 times a day	Right amount of calorie	calorie<=600kcal	No warning	valid
	Excessive number of calorie	calorie>600	Warning appeared	valid
3 times a day	Right amount of calorie	calorie<=400kcal	No warning	valid
	Excessive number of calorie	calorie>400	Warning appeared	valid

4. CONCLUSION

Several conclusions can be obtained from the result and discussion from proposed research testing. This device is intended to measure the calories intake per serve. The bowl-designed is unique and allows the user to consume the food from it. Some testing was acquired to gain error percentage. The weight measurement was 1.74% in error average. Some kinds of food are also tested to understand the accuracy of the device to detect food calories. Also, a calorie intervention intake feature has been tested. The result was validated and functioned well.

AUTHORS' CONTRIBUTIONS

A.F.F. conceived of the original idea and designed into a concept. I.Y.H. designed the nutritional equation in application on android. A.F.F. and L.K. conceived and planned the hardware and software of the device. A.A.B. and N built, developed, and tested the design system into a real and functional device.

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