ADVANCES IN AGRICULTURAL AND FOOD RESEARCH JOURNAL

HH PUBLISHER

Short Communication

Performance Evaluation of Watermelon Juice Extracting Machine

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Abstract: Watermelon (*Citrullus lanatus*) is a succulent, refreshing fruit that many Malaysians enjoy. They are available all year round in local markets and come in both seeded and seedless varieties. The high-water content of watermelon makes it an excellent choice for quenching thirst and preventing dehydration. Collecting watermelon juice usually requires using a knife to cut the fruit and a blender to puree it. While this method is effective, it can be tedious and require many workers if large quantities of watermelon juice must be collected. In order to cater for this problem, Malaysia Agriculture Research and Development Institute (MARDI) have developed a cost-effective watermelon juice-extracting machine. This study aimed to evaluate the performance of a watermelon juice extraction machine with different sizes of watermelon fruit. The performance evaluation indicators data such as percentage juice yield, extraction efficiency, and extraction loss were collected. The results showed that the watermelon juice extraction machine has an average juice yield, extraction efficiency, and extraction loss of 78.11%, 84.32%, and 1.80%, respectively, with a capacity of 4.43 kg min^{-1}. Therefore, the machine could extract watermelon juice effectively and help the entrepreneur save on production and labour costs. The watermelon juice extraction machine is easy to use, efficient, and cost-effective, which makes it suitable for small-scale businesses.

Keywords: watermelon; juice extraction; performance evaluation

Received: 1st August 2022

Received in revised form: 1st December 2022

Available Online: 30th December 2022

Published: 19th April 2023

Citation: Azizan, S. A., Wan Azman, W. M. F., Rahim A. A., *et al.* Performance evaluation of watermelon juice extracting machine. *Adv Agri Food Res J* 2023; 4(1): a0000350. https://doi.org/10.36877/aafrj.a0000350

1. Introduction

Watermelon (*Citrullus lanatus*) is a water-rich fruit with a hearty flavour that can quench thirst and satisfy hunger. The fruits are usually round or oval and have a hard, green rind with pink, red, or yellow flesh. The watermelon is believed to have originated in southern

Africa and is still grown today (Jarret *et al.*, 1996). Watermelons have recently become popular in other parts of the world and have grown in over 96 countries worldwide (Guner *et al.*, 2008). China, Iran, and Turkey are the world's leading watermelon producers, with an estimated production of 79.28 million tons, 4.06 million tons, and 4.01 million tons, respectively. These three countries also account for over three-quarter of the global output (FAO, 2019). Watermelon is a popular fruit due to its sweetness, refreshment, and nutritional value. These fruits also are a good source of vitamin C, vitamin A, vitamin B, and amino acids, and are also low in calories and fat (Muhammad *et al.*, 2016). Besides, the high levels of lycopene in watermelon, around 48.7 $\mu g\ g^{-1}$ lycopene by weight and also 60% higher than tomatoes, have attracted consumers who prefer their daily intake to be rich in this nutrient (Holden *et al.*, 1999).

According to the Department of Agriculture (DOA), Malaysia produced around 134,000 metric tons of watermelon in 2020. The largest watermelon producer in Malaysia was from Kelantan, Pahang, and Johor, with a crop area of 2,231 ha, 1,992 ha, and 1,168 ha, respectively (DOA, 2021). Although there was a slight decline in crop production from 2019 due to the COVID-19 pandemic, the consumption of watermelon has witnessed a remarkable increase in recent times. All socio-economic classes now consume watermelon, and there are new watermelon-based products such as sports drinks, skincare products, and others. With Malaysia's hot climate, watermelons are sure to remain a staple fruit in the diets of many Malaysians for years to come.

There are several ways to extract juice from watermelons, but the most common method is manually macerating the fruit. The process involves peeling, slicing, and pressing the watermelon to extract the juice (Adekanye & Adelakun, 2017). However, this method is time-consuming, labour intensive, and often yields a low quantity of juice, which makes it impractical to the user, especially for Malaysia’s small to medium-scale entrepreneurs (SMEs). In addition, Malaysia is also experiencing the problem of watermelon dumping, which causes prices to fall and causes losses to entrepreneurs (Safari *et al.*, 2021). In order to address this problem, Malaysia Agriculture Research and Development Institute (MARDI) have developed a cost-effective machine for watermelon juice extraction. The machine mainly operates on the shearing, crushing, and pressing forces through the screw conveyor that can continuously extract watermelon juice from the flesh. This machine is also made from stainless steel 304 and operated using a single-phase motor, making it durable, easy to clean, and simple to operate.

The main objective of this study is to evaluate the performance of the developed watermelon juice-extracting machine. This machine should be capable of extracting watermelon juice more quickly and efficiently than manual methods and should be able to handle larger volumes of watermelon fruit. The results of this study can provide valuable information for improving the efficiency and quality of watermelon juice production.

2. Materials and Methods

2.1 Watermelon Juice Extracting Machine Specification

As illustrated in Figure 1, the watermelon juice extracting machine was mainly made from food-grade stainless steel 304 materials and fabricated locally by an appointed fabricator in Pulau Meranti, Selangor, Malaysia. The overall machine size was 780 mm (length) × 320 mm (width) × 860 mm (height). The machine consisted of a frame, hopper, extraction chamber with screw conveyor, watermelon juice, and waste discharge outlet equipped with a 2.0 hp single-phased heavy-duty motor and castor wheels for mobility. The screw conveyor is a simple and efficient way to extract watermelon juice by forcing the watermelon flesh against the inside surface wall of the 0.6 mm perforated cylindrical drum along its passage path. This action extracts the watermelon juice, which was then collected for further processing. The screw conveyor offers several advantages over other juicing methods, including its high efficiency and consistent results. Moreover, it is a gentle juicing process that does not damage delicate watermelon flesh. As such, it is an ideal way to extract watermelon juice commercially.

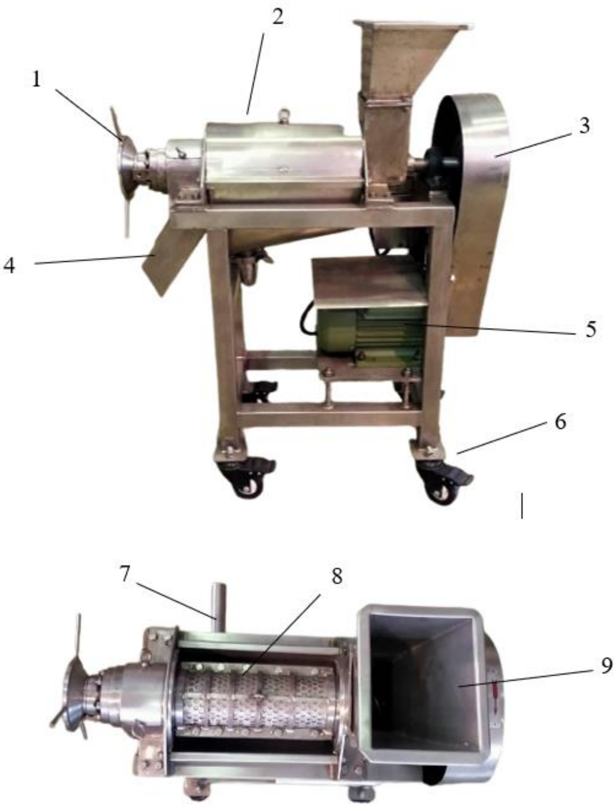

Figure 1. Watermelon juice extracting machine that has been fabricated (side and top view). (1) Screw conveyor opener; (2) Extraction chamber; (3) Gear system; (4) Waste discharge outlet; (5) 2.0 hp single-phased heavy-duty motor; (6) Castor wheel; (7) Watermelon juice outlet; (8) 0.6 mm perforated cylindrical drum; (9) Hopper

2.2. Materials Preparation

The watermelon juice extracting machine performance evaluation was carried out in Food Lab I, Food Science & Technology Research Center, MARDI Serdang. Fresh watermelon fruits (seedless Watermelon: F1 hybrid) as samples were obtained and purchased from Pasar Borong Selangor, Malaysia. The fruits were washed with water and weighed with a digital weigher (DE-A11N, Kern, German), and the watermelon rind was removed manually before experimenting (Figure 2). The initial watermelon, rind, and fruit flesh mass were recorded (Figure 3). In this study, only the watermelon flesh was extracted using the machine (Figure 4).

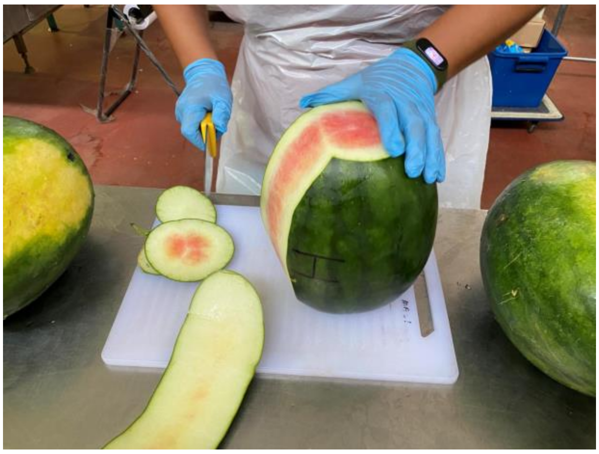

Figure 2. Watermelon rind removal process

Figure 3. Watermelon flesh and rind weighing process

Figure 4. Watermelon extracting process using the machine

2.3. Performance Evaluation

Performance evaluations are the key when determining the efficiency of a juice extraction machine. To conduct the test, a known quantity of watermelon flesh was poured into the hopper. The flesh in the hopper was then transferred to the extraction chamber by the screw conveyor, where the flesh was crushed and filtered with a 0.6 mm perforated cylindrical drum. The machine was left to run until the watermelon flesh had been entirely fed and extracted. The mass of fruit fed into the machine, the mass of juice extracted, and the mass of the residual waste was recorded. From the values obtained, the juice yield, extraction efficiency, extraction loss, and extraction capacity were calculated using Equations (1) to (4) used by Tressler and Joslyn (1961).

$$Juice\ yield, J_y = \frac{W_{JE}}{W_{JE} + W_{RW}} \times 100 \quad (1)$$

$$Extraction\ efficiency, E_e = \frac{W_{JE}}{XW_{FS}} \times 100 \quad (2)$$

$$Extraction\ loss, E_l = \frac{W_{FS} - (W_{JE} + W_{RW})}{W_{FS}} \times 100 \quad (3)$$

$$Extraction\ capacity, E_C = \frac{W_{JE}}{time}\ (kg\ min^{-1}) \quad (4)$$

where $\boldsymbol{W_{JE}}$ is mass of juice extracted in kg, $\boldsymbol{W_{RW}}$ is mass of residual waste in kg, $\boldsymbol{W_{FS}}$ mass of feed sample in kg and x is juice constant of fruit in decimal.

2.6. Statistical Analysis

Using the Statistical Analysis System (SAS 9.0) computing tool, experimental data were analysed using Analysis of Variance (ANOVA).

3. Results and Discussions

The MARDI watermelon juice extracting machine was successfully tested, and the mean evaluation values for five replications were presented in Table 1. The result showed that this machine has an average watermelon juice yield of 78.11%. The extraction efficiency, extraction loss, and extraction capacity were 84.32%, 1.80% and 4.43 kg min $^{-1}$, respectively. The result obtained was compared with other findings.

Adekanye and Adelakun (2017) evaluated a portable watermelon juice-extracting machine. The result showed that the maximum juice yield, extraction efficiency, and extraction capacity were 86%, 87.80%, and 49.04 kg hr $^{-1}$, respectively. Aviara *et al.* (2013) have developed and evaluated a multi-fruit juice extractor, and the result reported for peeled watermelon were 89.53%, 96.6%, and 2.90% for juice yield, extraction efficiency, and extraction loss, respectively. For the manual juice extractor fabricated by Eyeowa *et al.* (2017), the result obtained for watermelon juice in terms of juice yield, extraction efficiency, and extraction loss was 57%, 71.3%, and 2.5%, respectively. The comparison showed that the MARDI watermelon juice extracting machine was able to extract watermelon juice like the others (above 80%). The values vary due to the fruits' physiology and species, maturity stage, post-harvest handling, mode of operation being manual or motorised, size of the machine, operator handling, and others (Odewole *et al.*, 2018).

Table 1. Mean values of watermelon juice extractor evaluation (*n*=5)

Parameters	Mean	SD
Mass of watermelon without rind W_{FS}, kg	11.20	1.89
Mass of extracted juice W_{JE}, kg	8.60	1.56
Mass of residual waste W_{RW}, kg	2.39	0.32
Time taken, min	2.55	0.54
Juice yield, %	78.11	1.12
Extraction efficiency E_e, %	84.32	1.30
Extraction loss E_l, %	1.80	0.52
Extraction capacity C, $kg\ min^{-1}$	4.43	0.58

n = numbers of replicate

4. Conclusions

A cost-effective watermelon juice-extracting machine was designed and fabricated by MARDI for small and medium enterprises in Malaysia. This machine was developed to extract the juice using the compression and shear principles of a screw conveyor. The machine has an average juice yield, extraction efficiency and extraction loss of 78.11%, 84.32% and 1.80%, respectively with the capacity of 4.43 kg min^{-1}. By applying the use of this machine technology in the processing of watermelon extraction, the government's objective through the National Agro-Food Policy 2.0 (DAN 2.0) can be achieved.

Funding: This work was funded by MARDI with research grant number P-RM521.

Acknowledgements: The authors would like to acknowledge the financial support by MARDI and team members whose contribution to stimulating suggestions, encouragement and coordination of this project.

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