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Impact of Stroke Length Variation on Speed Efficiency in an Authomatic Tofu Extract Filtering Machine

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Abstract

In the tofu industry, especially at the home-scale "Tahu Pak Muhson," production remains largely manual, with traditional filtering methods. To enhance efficiency, a machine was designed to filter tofu juice, incorporating various crankshaft step lengths to optimize performance. This study aims to assess the impact of different step lengths on filtration time, tofu yield, and quality. Using a descriptive experimental research method with a quantitative approach, the independent variable is crankshaft stroke length (140, 200, 260 mm), while dependent variables include filtration time, yield, and tofu quality. The control variable is a consistent 10kg soybean input. Results indicate that a 260mm stroke length provided the quickest filtration, averaging 524.3 s, compared to 726 s for 140mm and 620 seconds for 200 mm. Yield for the 140mm stroke was 46%, 45.5% for 200mm, and 44.5% for 260 mm. Tofu quality showed minimal variation across different lengths, although the 260 mm stroke length produced tofu with a slightly coarser texture and a faster smell development. The findings demonstrate that step length impacts filtering efficiency and yield, with potential implications for tofu production scalability.

Keywords: *crankshaft stroke length, filtration efficiency, soybean processing, tofu texture, yield*

INTRODUCTION

Indonesia is a diverse country with a rich variety of foods, and its food-related small and medium enterprises (SMEs) are numerous and rapidly expanding. Tofu is one of the most popular foods among consumers due to its nutritional value, ease of digestion, and absorption in the human body. Tofu production has a long history, originating over 2000 years ago in China (Shurtleff & Aoyagi, 2022), and it has become a highly consumed commodity in Indonesia.

Freshly harvested soybeans are immature and have low oil and protein content. Stored soybeans will mature, producing tofu with better colour, denser texture, and lower water content. However, storing for too long can reduce the quality of tofu (Guan et al., 2021). Given its

nutritional richness and positive health benefits, tofu appeals to many consumers (Ballco & Gracia., 2022). The tofu industry has grown from small-scale home-based production to large-scale enterprises, driven by increasing consumer demand and the need for efficiency (Chen et al., 2022).

The small-scale tofu production industry located in Kabupaten Semarang still relies heavily on manual, labor-intensive methods. This traditional approach uses human power as the main energy source, particularly during the soy pulp filtering process, which involves repetitive shaking that can lead to worker strain or injury (Olguin-Maciel, 2020). The process of filtering tofu, using cloth as a filter, is repeated, causing worker fatigue and inconsistency in product quality (Nugroho et al., 2019).

To improve efficiency and product consistency, it is crucial to consider mechanized alternatives to manual filtering. Existing research has discussed mechanization in tofu production, influence of certain mechanical parameters has not been included (Frolov et al., 2019) Such as crankshaft step length, tofu filtering time, yield, and quality remains underexplored. The effects of varying crankshaft step lengths on tofu filtering efficiency. We hypothesize that adjusting the crankshaft step length in an automated tofu filtering machine will enhance processing time, yield, and quality compared to traditional manual methods. By optimizing this parameter, this study provides valuable insights for small-scale tofu producers, potentially improving production efficiency and worker well. Soybean starch extraction has also been carried out using a centrifugal filter system of 0.8 mm thick stainless steel plates bent into a cone shape using a semi-automatic 125µ filter which takes 22.45 minutes, designed using the DFMA Method (Santosa et al., 2021).

The tofu production process itself, especially the results of the filtering process for the final result or small capacity can be done manually plus the dangers to the health of the body such as injury, but it will be more effective and efficient if the process uses a machine. Electric motor as a driving source, so that the axle rotates. Power from the electric motor is transmitted to the axle via a pulley and vanbelt then the axle rotates at a certain speed shaking the shaking frame. One of the previous studies, namely the tofu dregs filtering tool (Gultom et al., 2021) with a rotation speed of 1500 rpm, takes about 4 minutes to separate soybean essence from tofu dregs. The driving motor used is a 3-phase induction motor with 0.5 hp. The storage tube used is made of a plastic drum. The overall dimensions of the filtering tool are 1300 mm x 500 mm x 1200 mm and the cost of making the tool is IDR 3,892,500. Therefore, this is one of the reasons why it is necessary to make a new filtering tool and know the performance of the machine and be more efficient (Amershi et al., 2015).

The purpose of the study is changes in stroke length affect the speed of the filtering process and the quality of the tofu produced. The benefits of this study provide recommendations for optimizing the stroke length of the automatic tofu extract filtering machine so that it can increase the efficiency of the filtering speed, maintain product quality, and reduce energy consumption, which ultimately increases productivity and operational efficiency in the tofu manufacturing industry.

METHOD

Research Time and Location The research was conducted at Tofu MSMEs and the Mechanical Engineering Laboratory at Universitas Negeri Semarang (UNNES), Central Java, as well as at the tofu MSMEs Bergas Kidul, Semarang Regency. Equipment and Materials

Equipment, A relatively stable balance between soybean extraction quality and flavour compound release can be achieved under soaking conditions of 25 °C and pH 9 (Li et al., 2019). The tools used in this research included an automatic tofu extraction filtering machine, a stopwatch, a collection container, and a scale. Materials The primary material was soybeans, which were processed into soybean pulp after undergoing a grinding procedure. Research Stages The experimental procedures involved multiple stages to evaluate the performance of the automatic tofu filtering machine. Key parameters assessed included: The step length of the crankshaft in each variation, the filtering time required for a single filtration process, the yield of the filtering process, and the weight of the residual pulp from the filtration process. Each of these stages is demonstrated schematically in Figure 1, showing the specific workflow and variations in step length used in the filtration experiments.

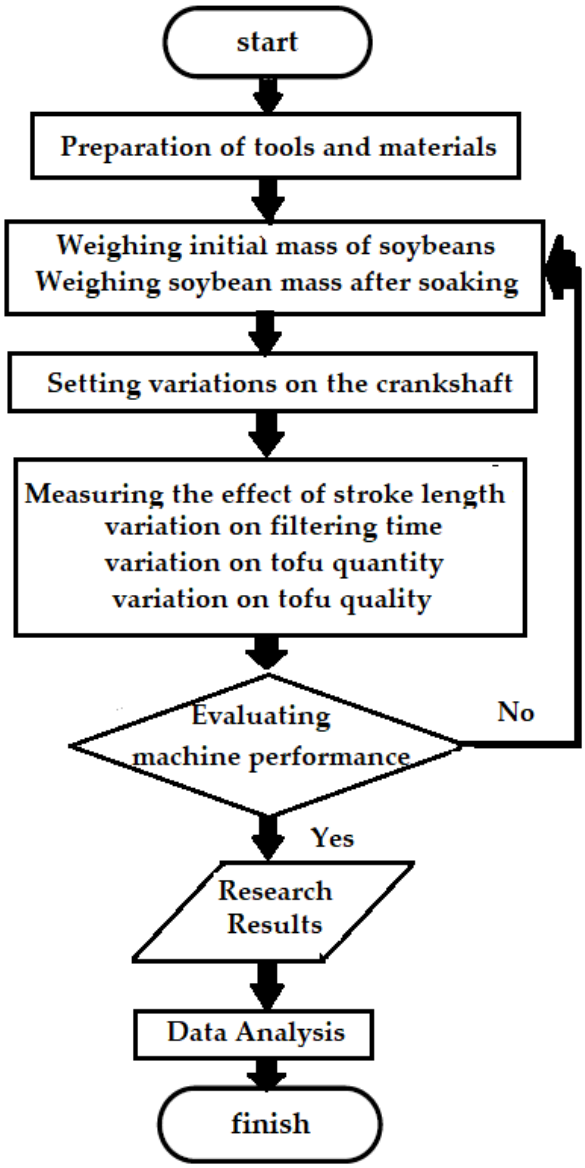

Figure 1. Flowchart the flowchart for the Procedure to Use the Automatic Tofu Extract Filtering Machine

RESULT AND DISCUSSION

Specification

The crankshaft of the machine consists of two types of shafts: a circular shaft and a main shaft. The circular shaft is made from an iron plate, with a diameter of 260 mm and a thickness of 10 mm, and is connected to the main shaft through a drilled hole designed to accommodate a 25 mm diameter, 108 mm long spi (spline). The main shaft, constructed from steel, has a length of 300 mm and a diameter of 20 mm, with hook holes at both ends to enable easy attachment (Brown et al., 2018).

The tofu filtering machine is powered by an electric motor as its primary driving component. The motor, type AE 71M2-4, has a power output of 0.5 hp and operates at 1,400 RPM. This motor offers several advantages, including a lightweight design, quieter operation, and ease of availability in the market, making it an efficient choice for this application.

The tofu filtering machine is powered by an AE 71M2-4 electric motor with a power rating of 0.5 hp and a rotational speed of 1,400 RPM. This motor offers several benefits, including a lightweight design, quieter operation, and easy availability in the market, making it an ideal choice for driving the machine efficiently.

The filtering machine is equipped with an NMRV 050 gearbox with a ratio of 20. This gearbox offers several advantages, including gear-damping capabilities, a compact design that saves space, and strong mechanical durability. It is also pre-filled with synthetic oil, enabling universal installation without requiring adjustments to the lubricant levels.

These specifications highlight the careful selection of components that optimize the performance and efficiency of the tofu filtering machine. The combination of a robust crankshaft, an efficient electric motor, and a space-saving gearbox contributes to the overall functionality and reliability of the machine in the tofu production process.

The machine system designed to increase the speed of tofu production produces tofu with a softer texture than pressed tofu, due to the absence of a physical pressing process, the use of a special coagulator, and the content of soluble dietary fibre (Yang et al., 2020). Soybean milk obtained from a machine equipped with a 100 mesh sieve hole is 35%, the yield is used to determine the sieve size that produces the most solids and is very fine (Karyadi et al., 2015).

Variation in Step Length

The step length refers to the distance or length covered by the swing of the soy milk filtering machine. The distance obtained for each variation of the crankshaft results in different step lengths, as shown in Table 1. The results of testing different crankshaft variations, each producing a distinct step length. The 70 mm variation resulted in the shortest step length of 140 mm, while the 130mm variation produced the longest step length of 260mm. The 100 mm variation yielded a step length of 200 mm. The optimal or most effective step length for filtering soy milk was found in the 100 mm variation, as this length provided a more stable filtering performance compared to the other two crankshaft step length variations.

The comparison of time obtained for each step length also showed significant differences. The fastest filtering time occurred with a step length of 260 mm, averaging 524.3 seconds. This variation filtered the soy milk quickly and produced an average soy pulp weight of 8.9 kg.

The second result, with a step length of 140 mm, had the slowest time compared to the other two step lengths. This step length had an average filtering time of 736 seconds and produced an average soy pulp weight of 9.2 kg.

The third result, with a step length of

200mm, showed that this step length had an average filtering time of 620 seconds per process. The 200mm step length produced an average soy pulp weight of 9.1 kg.

The yield of tofu was consistent across all step lengths, with an average of 8 tofu moulds per process. The 200 mm step length was considered optimal because it provided more stable and efficient filtering. The results from the 260 mm and 140 mm step lengths showed nearly identical final weights. However, for the 260 mm step length, the longer stroke caused more pulp to spill out during the filtering process, while the 140 mm step length, with its shorter stroke, resulted in incomplete filtration of the soy pulp.

The manual filtering process for tofu production. Starting with an initial soybean mass of 10 kg, the soybeans increased to 20 kg after soaking. The manual filtering took 380 seconds, leaving 9.8 kg of soybean pulp, and resulting in a final yield of 8 moulds of tofu. Table 2 compares the filtering times between manual filtering and machine filtering, showing that the manual process was faster, with an average time of 380 seconds. This difference can be attributed to two factors the electric motor used was 0.5 hp, which did not generate a fast enough swing motion. Also, the holes in the screen or foot valve that draw in the soy slurry were too small, causing inefficient suction. The average time difference between manual filtering and machine filtering was 144 seconds. Despite this, using a machine was more effective in terms of labour, as it helped prevent injuries. The soy pulp produced by the machine was of good quality, and the resulting pulp was relatively dry. Soybean milk obtained from a machine equipped with a 100 mesh sieve hole is 35%, the yield is used to determine the sieve size that produces the most solids and is very fine (Colletti et al., 2020).

In the variation of the axis and stroke length, the axis and stroke length of the machine are set at three variations: 70 mm and 140 mm, 100 mm and 200 mm, and 130 mm and 260 mm. Each variation results in changes in the time and quality of tofu. On the other hand, the average production time is shorter as the stroke length increases, from 736 seconds for a stroke length of 140 mm to 524.3 seconds for a stroke length of 260 mm. This shows that increasing the stroke length can speed up the production process.

Table 1. Results of Screening Against Time, Dregs, and Tofu Quality

Variation Axis (mm)	ofStroke Length (mm)	Average Time (s)	Average (kg)	weightTofu Quality
70	140	736	9,2	a smooth or fine texture.
100	200	620	9,1	a smooth or fine texture.
130	260	524,3	8,9	a coarse or rough texture

Table 2. Soybean Extract Filtration Time

Stroke Length (mm)	Filtering Time (min.)
Manual	6,33
140	12,23
200	10,31
260	8,76

Table 3. Results of Soybean Extract Filtration Yield

Step Length (mm)	Initial Weight (kg)	Final Weight (kg)	Residue Yield (%)	Tofu Yield (%)
140	20	9,2	46 %	54%
200	20	9,1	45,5 %	54,5%
260	20	89,6	44,5 %	55,5%

Yield

Yield is a comparison between the final product obtained and the raw materials used. The yield value is based on the dry weight of the raw material. The yield in soybean milk extraction can be determined using the following equation.

$$Rd = \frac{B\ output}{B\ input} x\ 100\% \qquad (1)$$

Table 3 shows that the yield values of soybean milk tend to vary with each crankshaft stroke length. These differences occur because each stroke length results in different swing speeds. At a stroke length of 140 mm, a yield of 54% was obtained, while a stroke length of 200 mm resulted in a yield of 54.5%, and a stroke length of 260 mm produced a yield of 55.5%. For the soybean pulp residue, a yield of 46% was achieved at a stroke length of 140 mm, 45.5% at 200 mm, and 44.5% at 260 mm. Differences in water content in tofu are closely related to the levels and fractions that influence the gel-forming properties) and will ultimately affect the recovery of the results, besides protein, the tofu yield is also determined by the ratio of beans and water (Ginting et al., 2021). Yield, protein content and protein solubility of soymilk were increased by 24%, 44.4% and 94.6% respectively by microwave-assisted extraction (Varghese & Pare, 2019).

Tofu Quality

The quality of tofu produced typically exhibits varying textures. The shape and texture do not differ significantly compared to the manual filtering process. However, the filtration process of soybean milk using different crankshaft variations affects its texture. A 260 mm stroke length results in a slightly coarser tofu texture because the soybean pulp passes through the filter too quickly, causing some pulp to spill out of the filtering cloth. This leads to the tofu spoiling more quickly due to the mixing of the pulp with the filtered extract. The quality and chemical properties of tofu are constructed to determine the soybean breeding index to produce high-quality soybean seeds for tofu production (Wang et al., 2020). Tofu production made with a short soaking time still pays attention to the quality of the final product if other ingredients are added to reduce the production time (Han et al., 2022). Properly treated recycled water and optimal machine stroke length settings can help maintain the quality of the tofu produced. With consistency in texture, water content, and product cleanliness, the tofu industry can maintain the quality standards expected by consumers (Soenandi et al. 2022)

CONCLUSION

It can be concluded that the step length in the soybean filtration process affects both the quantity and quality of tofu and pulp. A step length of 260 mm resulted in the highest tofu yield (55.5%), but the best pulp yield occurred at 140 mm. While the tofu quality in terms of texture and shape was similar across all step lengths, the 260 mm step caused a rougher tofu texture and faster spoilage due to excessive pulp spillage and mixing with the filtered water, which negatively affected the tofu's quality.

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