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REDESIGN OF A MANUAL TOFU PRESS TO REDUCE SETUP TIME IN AN INDONESIAN FOOD MSME

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ABSTRACT

Small food-processing enterprises frequently experience productivity losses not because of inadequate production capacity, but because of non-value-added activities embedded in routine operations. This study examines production waste at a small enterprise producing beef-stuffed tofu in Indonesia and proposes improvements to its tofu pressing process. Value stream mapping, process activity mapping, and cause-and-effect analysis were used to identify sources of non-value-added time. Waiting accounted for 133.1 min, or 90% of the identified waste; setup of the existing tofu press took approximately 31 min per production cycle. To address these losses, the study proposes a screw-driven press with an integrated handwheel, alongside 5S workplace organization. The proposed changes are estimated to reduce press setup time from 31.0 to 19.8 min (approximately 36%) and production lead time from 543.6 to 526.3 min (3.18%), without changing value-added processing time. The study demonstrates that lean improvement in small food enterprises does not necessarily require high-cost automation; targeted equipment redesign and workplace organization can reduce non-value-added time while maintaining the core production process.

Keywords: Lean Manufacturing; Value Stream Mapping; Tofu Press; 5S; Set-Up Time; MSME

1 INTRODUCTION

The competitiveness of small-scale food enterprises depends not only on investment in machinery and labor but also on the efficient use of existing resources. Research on food-processing small and medium-sized enterprises (SMEs) indicates that lean manufacturing can improve operational performance, particularly productivity and quality, through process improvement (Dora, Kumar and Goubergen, 2013). In this context, standardized work practices and systematic workplace organization offer opportunities to address operational inefficiencies without relying solely on capacity expansion (Hu *et al.*, 2015). Recurring activities such as waiting, searching for tools, unnecessary material handling, and prolonged equipment setup can consume production time without directly adding value to the product. Although production targets may still be achieved, their attainment alone does not demonstrate that the underlying process is efficient. Identifying and reducing these activities can shorten production lead time and improve labor utilization, making waste reduction an important priority for resource-constrained enterprises (Hu *et al.*, 2015).

Lean manufacturing offers a systematic framework for improving operational efficiency by identifying and reducing waste while preserving customer-defined value. Its five core principles comprise specifying value from the customer's perspective, identifying the value stream, establishing continuous flow, implementing pull-based production, and pursuing perfection through continuous improvement. Within this framework, value stream mapping (VSM) provides an integrated representation of material and information flows, enabling the analysis of both value-adding and non-value-adding activities across the production process. Its relevance to the food sector is supported by a systematic review of 24 agri-food studies, which identified lead time as the most frequently applied performance indicator and documented reductions in lead time across several applications. These findings indicate that VSM can support targeted process improvements by revealing waste hotspots and opportunities to improve production flow (De Steur *et al.*, 2016).

This study was conducted at Tasuba, a tofu-processing micro, small, and medium-sized enterprise (MSME) located in Sleman Regency, Indonesia. Beef-stuffed tofu, the enterprise's highest-demand product, is manufactured daily at an average output of approximately 112 boxes. Tasuba employs a make-to-stock production strategy in response to relatively stable demand, making the timely and efficient completion of daily production essential. The production process consists of soybean preparation, tofu production, filling with a beef mixture, boiling, cooling, and vacuum packaging. Preliminary observations revealed that, despite a routine production sequence, work procedures and designated storage locations for tools had not been consistently standardized.

Baseline measurements indicated a production lead time of 543.6 minutes per production cycle, including 396.3 minutes of value-adding activities. The remaining 147.3 minutes comprised non-value-adding activities and necessary but non-value-adding activities with potential for improved efficiency. Assessment against the seven categories of lean waste identified waiting, unnecessary motion, and transportation as the sources of time-related waste. Waiting was the predominant category, accounting for 133.1 minutes, or approximately 90% of the total identified waste time. Unnecessary motion and transportation accounted for 10.3 minutes (approximately 7%) and 3.9 minutes (approximately 3%), respectively. These baseline findings established waiting as the principal focus of subsequent improvement efforts.

Baseline observations identified cooling and tofu-press setup as the largest contributors to the recorded waiting time, accounting for 52.8 minutes and approximately 31 minutes per production cycle, respectively. Cooling was not selected as an immediate improvement priority because it coincided with the operators' approximately one-hour rest period. Press setup, by contrast, was performed four times per production cycle, entirely within active working hours, and was therefore selected for further analysis. The existing press employed a scissor-jack mechanism that required operators to retrieve and assemble the mould cover, jack base, jack, and crank handle before applying pressure. Operators also reported that the mechanism frequently became difficult to operate under the wet conditions of the production area. According to the business owner, lubricating grease was not applied because of concerns about potential product contamination.

Additional inefficiencies were associated with inconsistent workplace organization. Gloves, packaging materials, and certain food ingredients lacked clearly designated and consistently maintained storage locations. The average time required to locate packaging materials and gloves was approximately 3.2 minutes and 3.0 minutes, respectively. Although relatively brief, these activities recurred during daily production and contributed to non-value-adding time. The 5S methodology provides a structured approach to addressing such conditions through sorting, setting in order, cleaning, standardizing, and sustaining workplace practices. In the present study, 5S was therefore selected to establish designated storage locations, improve the accessibility of frequently used items, and standardize workplace organization.

Previous research on tofu-press design has investigated pneumatic actuation (Efendi *et al.*, 2024). Such approaches provide useful design precedents, but their suitability depends on the resources and operational requirements of the enterprise. For Tasuba, the principal requirements were straightforward operation, maintainability, cleanability and independence from compressed-air and electronic control systems.

The practical contribution of the present study is therefore the integration of value-stream analysis, workplace organization, and the redesign of a manual tofu press to address the enterprise's specific operational constraints. The proposed design incorporates a mould cover coupled to the threaded shaft and a visual reference intended to guide pressure application. These features are intended to reduce component handling and setup time while providing operators with a more consistent operating reference.

Accordingly, this study aims to identify the principal causes of recorded waiting time in beef-stuffed tofu production, develop improvement proposals through 5S implementation and manual press redesign, and estimate the resulting changes in production lead time using future-state value stream mapping. The scope is limited to reducing non-value-

adding activities and improving the efficiency of necessary supporting activities, while preserving the core processing operations that determine product characteristics.

2 MATERIAL AND METHODS

2.1 Study design and data collection

A quantitative study was conducted at an Indonesian food MSME. Scope ran from raw-material preparation to packaging; meat grinding was excluded because it is performed by an external party. Primary data came from direct observation, stopwatch time study, photographic documentation and informal interviews with the owner and operators, the latter used to understand why work is done as observed. Each activity was timed 10 times. Data uniformity was checked with control limits at 95% confidence (k = 2) and sample adequacy at 95% confidence and 10% precision, following standard work-measurement practice (Niebel and Freivalds, 2002). All observations lay within the control limits and the required number of observations (N′) was below the number taken (N), so the data were judged sufficient. Mean times per activity were arranged in actual process sequence, including supporting activities such as fetching tools, waiting, set-up and moving product, because these seldom appear in daily production records.

2.1.1 Lean approach

A current-state value stream map was developed to describe material and information flows (Rother and Shook, 1999). Process activity mapping (PAM) was then used to classify activities as operations, inspections, delays, transportation or storage (Hines and Rich, 1997).

Activities were further classified as:

- Value-added (VA): activities that contribute to the product characteristics required by customers.
- Non-value-added (NVA): activities that do not add to customer-defined value and can be targeted for elimination.
- Necessary non-value-added (NNVA): activities that do not directly add value but remain necessary under the existing process configuration (Hines and Taylor, 2000).

Activities were subsequently assessed against the seven lean-waste categories. Necessary process time was distinguished conceptually from immediately avoidable waste. The category with the largest recorded time contribution was selected for further investigation. Potential causes were organized using a cause-and-effect diagram under human, machine and method-related factors.

2.2 Improvement design

Two complementary improvement packages were developed. The first applied 5S principles to workplace organization. Proposed measures included red tagging, point-of-use storage, labelled containers, cleaning checklists, shared housekeeping standards and a simple owner-led audit (Hirano, 1995; Mazur, Dosta and Idzikowski, 2024). The second addressed press setup through equipment redesign. The design process incorporated information gathering, functional analysis, generation of alternatives, evaluation and design development, and drawing on value-engineering and engineering-design principles.

Two alternatives were compared qualitatively in consultation with the owner and operators. Evaluation criteria included anticipated cost, ease of operation, corrosion resistance, drainage and maintainability. The assessment was not a formal-weight multi-criteria analysis. The selected design was modelled in SolidWorks. Mould dimensions were retained from the existing production equipment. Anthropometric values were used as preliminary dimensional inputs. The original source and representativeness of the Indonesian anthropometric dataset must be specified before submission. A virtual manikin was used for preliminary Rapid Upper Limb Assessment (RULA), following McAtamney and Corlett (McAtamney and Corlett, 1993). The assessment represents a simulated posture rather than measured operator exposure. Applied force, repetition and variation in operator body dimensions require subsequent field assessment

2.3 Future-state estimation and statistics

Future-state times were constructed from the baseline activity sequence by retaining unchanged activities and removing or replacing activities targeted by the proposals. The revised press sequence replaced the jack-related tasks with a handwheel-turning task assigned a duration of 0.4 min per production cycle. Because the press had not been fabricated, this duration was treated as a scenario assumption rather than an observed operating time. The empirical or engineering basis for the 0.4-min assumption should be reported explicitly. The estimated 5S benefit was derived from the searching and handling activities considered removable under the proposed storage arrangements. No post-

implementation measurements were available. Accordingly, the analysis used descriptive comparisons rather than hypothesis tests of intervention effectiveness. VA activities were retained unchanged in the future-state scenario.

2.4 Preliminary economic assessment

Fabrication cost was estimated from a bill of material (prices from online marketplaces) and machining and welding services priced with the provincial tariff regulation. A simple payback period was computed as investment divided by annual maintenance saving; net present value and internal rate of return were outside the scope of this study.

3 RESULTS AND DISCUSSION

3.1 Current state and waste identification

Current-state mapping showed six process groups: raw-material preparation, tofu making, *beef-stuffed tofu* making, boiling, cooling and packaging, totaling 543.6 min (9.1 h). Tofu making was longest (246.6 min) because it includes grinding, coagulation, pressing, cutting and frying, but long duration is not itself waste: these operations transform the material and are VA. PAM classified 396.3 min (73%) as VA, 140.7 min (26%) as NNVA and 6.7 min (1%) as NVA. The small NVA share can mask the fact that some NVA activities, such as searching for gloves and packaging plastic, recur every day, whereas NNVA is large because it includes set-up, transfers and cooling that are presently required.

Table 1: Recapitulation of identified waste in the production process

Waste type	Time (min)	Share (%)
Waiting	133.1	90
Motion	10.3	7
Transportation	3.9	3
Total identified	147.3	100

Waiting represented approximately 90% of the total time assigned to these categories. However, these total included activities that were considered necessary under the existing process, including cooling and equipment preparation. It should therefore not be interpreted as wholly removable time. Cooling accounted for 52.8 min, while press setup accounted for approximately 31.0 min across four pressing operations. Other contributors included steam equipment preparation, boiling-water preparation, oil heating and shorter delays. Cooling was not prioritized because it coincided with the operators' rest period and no validated intervention was available to shorten it without affecting the process. Press setup occurred during active working time and offered a more direct opportunity for redesign.

3.2 Potential causes of prolonged press setup

The cause-and-effect analysis (Figure 1) attributes the waiting to the man, machine and method factors. Under *man*, skills differ among operators and there is no routine training, so set-up time varies by person. The *machine* factor was dominant, where the scissor jack needs many turns to build pressing force. It often sticks because cooking oil is substituted for grease, which is withheld to avoid contaminating the product; and the plain-iron parts corrode in the damp environment. The jack has failed before, forcing the operators to borrow a press from another table. Under *method*, tasks are carried out strictly in sequence, no standard time or pressing pressure exists, and pressure depends on operator's effort and estimation, so the result is inconsistent. The improvement therefore centered on the press mechanism and material, with 5S as a supporting measure for work-area order.

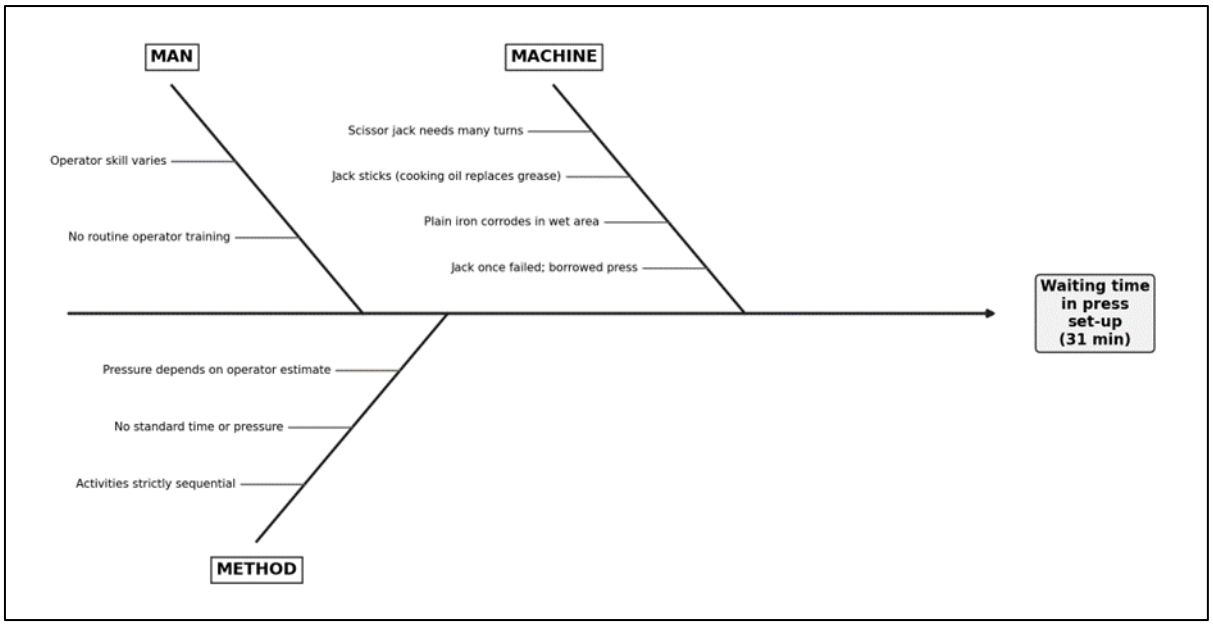


Figure 1: Cause-and-effect diagram for waiting time in tofu-press set-up

3.3 Redesign of the tofu press

The existing press is an iron frame with a wooden mould (Figure 2). After the curd is poured and wrapped in cloth, the operator places a lid, a jack base and the jack, then tightens the jack with a wrench. Over 10 observations, total set-up for the four pressings per cycle averaged 31 min. Tightening the jack alone took 8.1 min in total, and the four preparatory steps (lid placement, fetching the base, the jack and the wrench) took a further 3.6 min.

The information phase yielded three requirements: a pressing mechanism integrated with the frame, resistance to a wet production environment, and ease of operation. FAST translated these into the basic function of forming firm tofu by squeezing the curd, producing pressing force and keeping the pressure consistent. Force is generated by turning a handwheel that drives a threaded spindle; consistency is supported by a line marked on the mould wall as a visual limit for the lid position. Two alternatives were generated (Table 2). Alternative 1 was selected after discussion with the owner and operators. Its material cost is higher, but stainless steel suits the wet environment, is easier to clean and needs no repainting, and the handwheel can be turned continuously without repositioning the hands.

Table 2: Design alternatives and evaluation

Aspect	Alternative 1 (selected)	Alternative 2
Handle	Handwheel	T-handle
Mould lid	Connected to spindles, removable by bolts	Separate loose lid
Material	Stainless steel	Plain iron
Drainage	Distributed holes in base and lid	Single downward channel
Cost	Higher	Lower
Ease of use	Continuous turning; no extra step per cycle	Hand repositioning; lid adds a step
Durability	Corrosion-resistant, easy to clean	Iron prone to rust



Figure 2: Existing tofu press (iron frame, scissor jack, wooden mould)



Figure 3: Selected design (3D model): stainless-steel frame, threaded spindle and handwheel

The selected design has an overall frame height of 162.69 cm and a press-plane height of 106.82 cm (Table 3). The 5th-percentile standing height keeps the handwheel reachable for shorter operators, and the 50th-percentile elbow height avoids a work surface that is too low for taller operators or too high for shorter ones. The spindle is mounted on the main frame and connected to the mould lid, so the lid moves vertically and stays guided and level as the handwheel turns. The existing press has no force sensor, and neither does the new design; the study therefore does not claim numerically measured pressure. The line on the mould wall acts as a simple visual control: when the lid reaches the same line, the operator has a consistent positional reference without adding electronics to maintain. Drainage holes in the base and lid let whey leave from several sides. The lid remains detachable by bolts for washing, because sanitation must not be sacrificed for set-up speed.

Table 3: Anthropometric dimensions used in the design

Design element	Basis	Dimension (cm)
Overall frame height	D1 standing height, 5th percentile (165.19) − 2.5 cm allowance	162.69
Press-plane height	D4 elbow height, 50th percentile (104.32) + 2.5 cm allowance	106.82
Mould length × width	Existing production mould (not anthropometric)	70.4 × 58.6

RULA on the manikin yielded upper arm 2, forearm 1, wrist 1 and wrist twist 1 (posture A = 2), neck, trunk and leg each 1 (posture B = 1), a wrist-and-arm score of 3 and a final score of 3, which corresponds to action level 2 (investigate further): acceptable posture with continued monitoring and no urgent redesign. Trunk and neck scores of 1 indicate that the frame and work-plane heights allowed an upright posture. No RULA measurement was available for the existing press, so the comparison with it is qualitative, based on observation and interviews; this is a limitation of the ergonomic evidence.

3.4 Effect on set-up time

Table 4: Press set-up steps before and after redesign (mean time per cycle, min)

Step (before)	Before	Step (after)	After
1. Fetch cloth	0.3	Fetch cloth	0.3
2. Place and smooth cloth	6.6	Place and smooth cloth	6.6
3. Pour curd onto press board	5.5	Pour curd onto press board	5.5
4. Level curd	3.8	Level curd	3.8
5. Cover curd with cloth	3.3	Cover curd with cloth	3.3
6. Fetch and place lid	2.4	Turn handwheel	0.4
7. Fetch jack base	0.5	–	0
8. Fetch jack	0.5	–	0
9. Fetch wrench	0.2	–	0
10. Tighten jack with wrench	8.1	–	0
Total	31.0		19.8

Set-up time fell by an estimated 11.2 min (36.1%), from 31.0 to 19.8 min. The largest change replaces jack tightening (8.1 min) with handwheel turning (0.4 min); the preparatory steps of fetching the lid, base, jack and wrench disappear because the mechanism is integrated into the frame. The gain therefore comes not from asking operators to work faster but from changing mechanism and sequence so that unnecessary steps do not occur. Conceptually this resembles set-up reduction in the SMED tradition, although no formal internal/external-element analysis was performed here.

To test the reduction, step-level observations were summed per observation. The raw-data means were 31.14 ± 0.54 min before and 19.93 ± 0.35 min after (mean difference 11.21 ± 0.31 min). The Shapiro–Wilk test on the paired differences gave $p = 0.584$, supporting normality. The paired t-test gave $t(9) = 115.42$, $p < 0.001$, and the Wilcoxon signed-rank test agreed ($W = 0$, $p = 0.00195$, the smallest two-sided exact value attainable with $n = 10$). These tests should be read with caution. The post-improvement values were constructed by removing or replacing steps in the baseline observations rather than measured on a built device, so the test confirms that the estimated reduction is consistent across observations but is not field evidence of the actual effect.

3.5 Suitability for the MSME context

A pneumatic press can accelerate pressing but needs a compressed-air source and extra components. At Tasuba, the aim was not to maximize pressing force but to simplify set-up. A manual spindle press is cheaper to procure, easier to maintain and independent of compressors or controllers, while the handwheel gives continuous rotation and the connected lid reduces manual stacking points (lid, base and jack in the old tool), which previously could shift and produce uneven pressure. Stainless steel was chosen for the main parts because the press operates in a wet environment next to food. Based on interviews, maintenance of the existing press was estimated at IDR 2,060,000 per year (jack replacement three times a year, mould corner walls four times, whole wooden mould twice), and total spending over two years at about IDR 5,720,000 including a frame replacement.

Because the investment reduces cost rather than generating revenue, the annual maintenance saving was used as the cash-flow term, giving a payback of 2.12 years against an estimated service life of 5–10 years reported by sellers of similar presses. This is a preliminary figure: it ignores the time value of money, has not been checked against supplier and workshop quotations in Sleman, and counts neither the value of the time saved nor any residual value of the old equipment.

Table 5: Estimated fabrication cost and simple payback of the proposed press

Item	Cost (IDR)
Materials (SS304 plate, stainless hollow frame, Tr30×10 spindle, Ø180 mm handwheel, 6206 bearing, small parts)	3,870,000
Fabrication services (turning, welding, cutting, milling and drilling)	493,750
Total fabrication cost	4,363,750
Annual maintenance of existing press (assumed annual saving)	2,060,000
Simple payback period	2.12 years (≈ 25 months)

3.6 5S proposal

The 5S proposal addresses problems the press cannot solve. *Seiri* uses red tags on broken, unused or surplus items, and groups needed items by frequency of use. *Seiton* places gloves, packaging plastic, ingredients and small tools in labelled racks or boxes near the point of use, directly targeting the searching times of about 3.0 min (gloves) and 3.2 min (packaging plastic). *Seiso* adds a daily cleaning checklist for floors, work surfaces, machines and racks, important because the process uses much water and floors become slippery. *Seiketsu* converts the clean and tidy condition into a shared standard, and *Shitsuke* sustains it through a simple 1–5 audit by the owner. Reported experience with 5S suggests that gains are greatest when organization is supported by standardization and sustained habit. Applying 5S is expected to reduce NVA time from 6.7 to about 0.6 min (about 91%); this too is an estimate from re-observation, not a post-implementation measurement.

3.7 Future-state map

The future state retains every core activity, so VA time stays at 396.3 min. NNVA falls from 140.7 to about 129.5 min, mainly through the shorter press set-up, and NVA falls from 6.7 to about 0.6 min. Table 6 shows the effect by process stage and Table 7 the contribution of each proposal.

Table 6: Process time in current and future state (min)

Process stage	Current	Future
Raw-material preparation	0.5	0.5
Tofu making	246.6	235.2
Beef-stuffed tofu making	110.2	107.3
Boiling	75.6	75.6
Cooling	52.8	52.8
Packaging	57.9	54.9
Production lead time	543.6	526.3

Table 7: Contribution of each proposal to time reduction (min per cycle)

Proposal	Target waste	Reduction
Press redesign	Waiting	≈ 11.2
5S	Motion / searching	≈ 6.1
Combined	Production lead time	17.3 (3.2%)

Tofu making fell from 246.6 to 235.2 min, essentially from press set-up; beef-stuffed tofu making fell by 2.9 min through less searching for gloves and tools, and packaging by 3.0 min once packaging plastic had a fixed place. Raw-material preparation, boiling and cooling were left unchanged because no sufficiently strong intervention was developed. Overall lead time falls by 17.3 min per cycle (3.2%). Although small as a percentage, the saving comes entirely from time that

previously added no value, and across a cycle that produces about 112 boxes can serve as buffer when a stage runs late or as time for *Seiso* cleaning. The result supports the view that lean in an MSME need not rely on large-scale automation: VSM and PAM select the activity that absorbs time, and the remedy is matched to the cause. At Tasuba neither measure suffices alone, since 5S would not remove the press set-up delay and a new press would not remove searching time.

3.8 Limitations and product-quality testing

The press has not been fabricated, so post-improvement times are estimates from the changed steps and re-observation, the RULA assessment comes from simulation, and no pressing-pressure or product-quality data exist. Quality testing should follow Indonesian National Standard SNI 3142:2018 for tofu, which sets requirements for organoleptic condition, absence of formalin, maximum moisture content of 92% (mass fraction), minimum protein of 3.5%, maximum acid-insoluble ash of 0.1% and limits on metal contamination. The standard does not give a quantitative texture parameter even though texture is a key attribute for consumers. Once a prototype exists, a comparative test of tofu from the existing and proposed presses, under equivalent raw-material and process conditions, should include gravimetric moisture content, instrumental texture analysis, sensory evaluation and dimensional measurements to assess cycle-to-cycle consistency, analyzed with an independent-samples *t*-test or a non-parametric alternative.

4 CONCLUSION

Waste in the beef-stuffed tofu process at the studied MSME is dominated by waiting (133.1 min, 90% of identified waste). Press set-up, about 31 min per cycle across four pressings, was the most addressable part and was traced to the scissor-jack mechanism, its unsuitability for wet food environments, differences in operator skill and an unstandardized, sequential method. A manual stainless-steel press with an integrated threaded spindle, handwheel, attached removable lid, distributed drainage and a visual pressure mark was designed, and is estimated to reduce set-up time from 31.0 to 19.8 min (36.1%). A 5S programmed aimed at searching time is estimated to cut NVA time from 6.7 to 0.6 min. Together, they reduce production lead time from 543.6 to 526.3 min (17.3 min, 3.2%) without changing VA time. The estimated fabrication cost of IDR 4,363,750 and a simple payback of about 2.12 years suggest the investment is worth considering for the enterprise.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Disclosure of conflict of interest

The authors declare no conflicts of interest regarding this manuscript.

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