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Design and Development of Shrimp Paste Mould

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***Abstract*—This shrimp paste mould is a newly designed machine which is used to enhance the traditional production of shrimp paste, and this machine has overcome the problem of moulding the shrimp paste traditionally by the hand. This machine is made from polyethylene because it is a semi-automatic process that involves a lever arm, pushing plate and reservoir, thus it produces uniform quality of shrimp paste cubes. It helps to reduce the time of operation, the risk of injury and increase the hygiene, therefore it is suitable for small scale industries. This machine is light, portable and affordable. It is also a sustainable device as it reduces waste, saves energy and also benefits the local economy, so the device is ready for commercialisation. The machine also benefits both producers and consumers, and it may result in a more efficient and sustainable shrimp paste production process. Subsequently, it is a significant improvement in the industry.**

***Keywords*—Shrimp, Shrimp Paste, Mould, Design, Polyethylene.**

I. INTRODUCTION

Shrimp paste is used as an ingredient in many Malaysian dishes, and shrimp paste is made from small fresh shrimp known as “geragau”. Small fresh shrimp were traditionally fermented and used as a flavouring agent, because they have a strong umami taste that is developed during the fermentation process. The fermentation process in shrimp paste is natural and is influenced by the quality of shrimp and salt content, thus salt is used to inhibit the growth of unwanted microorganisms [1]. Salt is used to inhibit the growth of unwanted microorganisms and encourage the growth of halophilic lactic acid bacteria that ferment the protein into lactic acid [2], therefore the fermentation process requires careful control of salt content [3-6].

Shrimp paste has existed for a long period and raw shrimp paste has a very pungent odour. It must be packed and stored to control its smell because it is very potent [4, 7]. Shrimp paste production in Malaysia is still very traditional, therefore it is often made in small quantities [8]. Nevertheless, there are business operators who have produced and marketed processed shrimp paste, thus making it more accessible. Shrimp paste is very significant in Malaysia, so it is used in many traditional dishes [9]. There is a tremendous demand for several types of shrimp paste and related sauces in Malaysia and abroad. In other ASEAN countries like Brunei, Singapore and Thailand, shrimp paste is also widely used, thus it is a staple ingredient in the region [10-12].

The first step in the production of shrimp paste is to harvest the shrimp as the main raw material, and the raw material used varies from one province to another. The shrimp is then cleaned to remove sand, soil, and small stones, so the shell of big or hard shrimp is removed to get the meat. Fresh shrimp is mixed with pure white good quality salt, because traditionally, the amount of salt used is about 10% of the weight of the shrimp meat [5, 7]. The shrimp mixture was then poured on the canvas mat for sun-drying. When the mixture was half-dried, the shrimp was grounded until it was half-mashed, because a certain texture was required for the next step. A little water was added, and the mixture was poured into a cloth, then the cloth was put in a container and the mixture was pressed as hard as possible with a heavy object, thus making it solid. The fermentation process was done in a suitable and safe place for at least one week. After the fermentation process, the shrimp paste was dried by sunshine until it was nearly dry, and thus it was ready for the next step. The dried shrimp paste was graded, and after grading, the shrimp paste was boxed, labelled and marketed. The period of production of shrimp pastes ranges from 3 weeks, for simple operation, to 8 weeks, for larger shrimp, depending on the equipment used [4].

As aforementioned, shrimp paste is commonly produced manually by hand in small to medium enterprises, and this conventional production method has several shortcomings for workers such as long processing times to produce large quantities of shrimp paste, as the current method produces a limited amount of shrimp paste. Besides, manual production increases the risk of wrist fatigue or injury due to long working hours because the repetitive tasks involved in manual production put a strain on the workers' wrists. The conventional production method raises the issue of low hygiene during the production of shrimp paste, thus highlighting the need for improvement.

Therefore, it is necessary to conduct a study to improve shrimp paste production for small to medium business, so that the production process can be made more efficient and safer. The improvement can be achieved by designing a device that is ergonomic, safe and equipped with helping features or mechanisms to improve the efficiency of shrimp paste production, therefore enhancing the overall production process.

II. MATERIALS AND METHODS

A. User Needs Identification

Identifying user needs is a critical step before advancing to the design concepts of shrimp paste mould. To accomplish this, three primary methods were employed which are questionnaires, observations, and interviews. These sessions were conducted with employees of Belacan Madu Enterprises, located in Kuala Perlis, Perlis. The purpose of this data collection was to gather and analyse user feedback regarding their comfort levels when using manual methods to produce shrimp paste. Belacan Madu Enterprise operates with a workforce of approximately 10 employees. Observations and interviews revealed that the workers face significant challenges in preparing and moulding shrimp paste, especially during periods of high demand. They also reported experiencing minor workplace accidents; however, the injuries were not severe due to the precautions they had implemented. Moreover, the employees expressed fatigue and exhaustion when using the current moulding abilities, which lack assistive features. The moulding abilities commonly used in the workplace were found to be poorly optimised for high-volume and high-quality production, further impairing the challenges faced by the workers.

To substantiate the understanding of user needs, we conducted several online questionnaires with ten participants who routinely mould shrimp paste by hand. The instrument probed key pain points and practices such as frequency of moulding, whether assistance is needed, time taken per batch, experiences with current manual methods or tools, any injuries encountered, difficulties in achieving desired outcomes, and ideas for improvement.

The responses point to an intensive workflow which is eight out of ten reported more than four moulding sessions daily. The autonomy was varied with four participants typically work independently, whereas six rely on help during preparation. Time demands were notable as well with half of the respondents required 20 – 30 minutes per batch using only bare hands, and the remainder needed 30 – 40 minutes. Most of the respondents had not previously used dedicated moulding tools. Although hand moulding was described as manageable for small volumes, scaling to higher output proved substantially more difficult.

Several recommendations received on an assistive device that simplifies moulding while stabilising the paste for cutting and shaping. Participants emphasised higher-throughput capability which are producing many moulded units at once and proposed features such as a built-in input barrel or reservoir, a moulding plate with a secure holder, and a rigid, stable frame. They also stressed modularity by which components should assemble and disassemble easily to support portability.

B. Product Design Specifications

Based on the insights from observations and questionnaire responses, the shrimp paste mould should incorporate several key features. It ought to have detachable sections so the parts can be taken apart for easy storage and to save space. The design should include an effective shaping mechanism to ensure a smooth, efficient moulding process. All materials must be easy to clean to maintain good hygiene. The tool should be straightforward to use so that one person can operate it without needing much assistance. Safety is essential, so every feature must minimise the risk of injury. The main body should be made from lightweight materials such as suitable plastics to make handling easier. A manual operation is preferred to keep the overall weight down. Finally, the dimensions should be optimised for one-handed use, striking a balance so it is neither too bulky nor too small.

The criteria were then taken into a functional analysis with a morphological chart, which mapped out functions based on the product requirements. These functions were further developed through brainstorming, leading to four principal groups for the proposed design which are operation type, material type, handle type, and support type. Each function was explored with at least two specific ideas to broaden the solution option, and different combinations of these ideas were assembled into five distinct design concepts. Figure 1 presents sketch illustrations of these five shrimps paste moulding tool concepts.

Concept A features a premium polyethylene (PE) body with stainless steel components, non-slip feet, and an additional tabletop clamp to keep the press stable during use. No electricity is required, cleaning

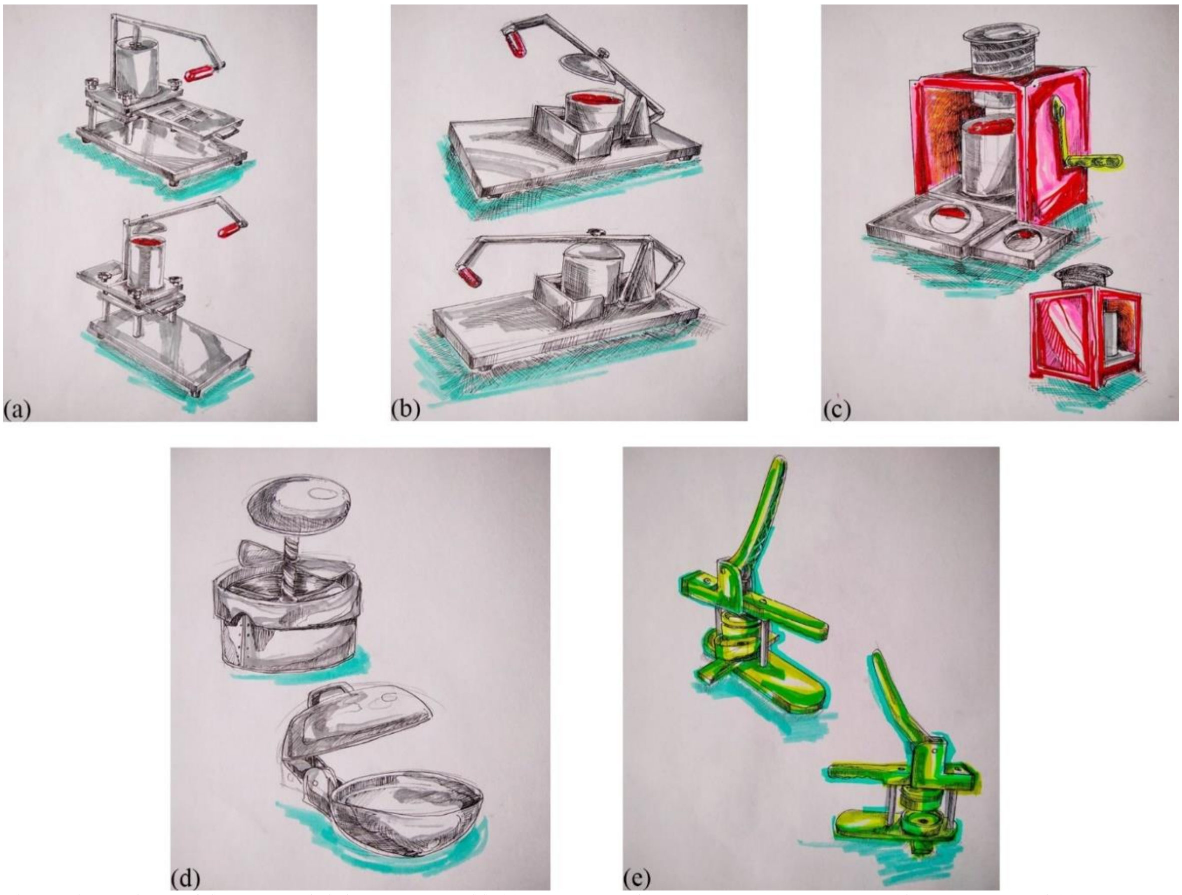


Fig. 1. Five variants of the proposed shrimp paste mould: (a) Concept A, (b) Concept B, (c) Concept C, (d) Concept D and (e) Concept E.

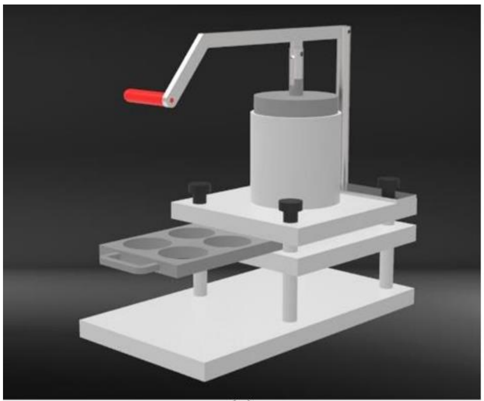
Table I. Concept screening results for all design options.

No.	Selection Criteria	Concept A	Concept B	Concept C	Concept D	Concept E	Competitor (Reference)
1	Save operating time	+	0	+	0	0	0
2	Easy to operate	+	+	+	0	0	0
3	Easy to clean	+	+	0	+	+	0
4	User friendly	+	0	-	+	0	0
5	Safe	0	0	-	0	0	0
Sum +'s		4	2	2	2	1	0
Sum 0's		1	4	1	3	4	6
Sum -'s		0	0	2	0	0	0
Net Score		4	2	0	2	1	0
Rank		1	2	5	3	4	0
Continue?		Yes	Yes	No	Revise	No	No

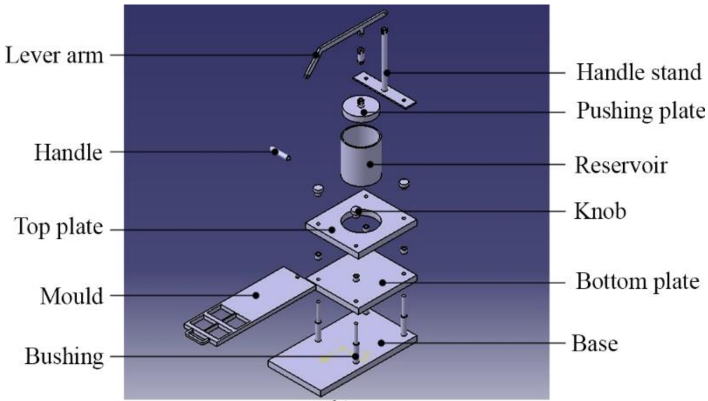
can be done with water, and the food-grade PE parts help prevent rust. As shown in Fig. 1(a), the mould is replaceable. The concept also includes ergonomic handles for straightforward operation by pressing the lever downward, removing the mould, and a clean round shape is produced. Then, for Concept B (Fig. 1(b)), the body of this shrimp paste moulding mechanism is made of stainless steel. Its moulding method follows Concept A to meet user objectives and ensure comfortable use. Certain moulding components perform distinct functions. The overall dimensions are 550 mm in length and 180 mm in width. The frame is designed specifically for forming shrimp paste, allowing the clamp press to compress the paste within the mould during shaping. After each cycle, the mould is lifted to begin the next. The unit stands on four small feet, each fitted with anti-slip rubber pads to keep the device steady during operation. Ergonomic handles enable simple operation by pressing the presser down, then removing the mould, and a round shape is

Table II. Concept screening results for all design options.

No.	Parameter		Concept A		Concept B		Concept D	
	Selection Criteria	**Weightage (%)**	**Rating**	**Weightage Scoring**	**Rating**	**Weightage Scoring**	**Rating**	**Weightage Scoring**
1	Save operating time	14	4	0.56	5	0.70	3	0.42
2	Easy to operate	25	4	1.00	3	0.75	4	1.00
3	Easy to clean	22	5	1.10	3	0.66	5	1.10
4	User friendly	12	5	0.60	4	0.48	4	0.48
5	Safe	10	5	0.50	5	0.50	4	0.40
Total Score			3.76		3.09		3.40	
Rank			1		3		2	
Develop?			Yes		No		No	



(a)



(b)

Fig. 2. (a) 3-D isometric view and (b) Exploded view of the shrimp paste mould.

produced. The body of the shrimp paste mould is also made of stainless steel for Concept C. This concept consists of a few key parts. The handle, shaped in an L configuration, is moved by hand to drive the shaft connected to the mould (Fig. 1(c)). A rotating transmission shaft transfers power and torque to compress the raw material. Each leg is fitted with an anti-slip rubber screw, which helps stabilise the mould and prevents movement during use. On the other hand, Concept D is made from an aluminium alloy (Fig. 1(d)). It uses a push-style handle, which differs from the earlier designs and keeps the layout simple. The unit measures 254 mm in length, about 203 mm in width including the handle, and 127 mm in height. The mould is adjustable, allowing precise control over paste thickness from thin to thick as required. Thickness is set by turning the locking nut clockwise to raise it to the desired setting, with adjustment available up to 41 mm. The handles include fixed springs that press the plate into the mould during operation, functioning like a clamp to form a round shape. Anti-slip rubber pads are fitted to the base to stabilise the mould and prevent movement during use. Meanwhile, for Concept E, the body of the shrimp paste moulding tool is made of PE. The overall layout is similar to Concept B, with a long, trapezoidal body (Fig. 1(e)). A pressure is applied to the top handle to push the raw material into the mould clamp. Interchangeable mould containers allow adjustment of the paste's final shape and thickness. The design is straightforward and visually clean, and the handle includes an integrated grip for better control.

Guided by the finalised user requirements, the proposed concepts were compared using the defined criteria and two methods which are concept screening and concept scoring. For screening, user needs were translated into a selection matrix, and a current market product was set as the benchmark. Concepts were then marked with "+", "–", or "0" to indicate performance better than, worse than, or equal to the benchmark. Net scores were calculated from the number of "+" marks to determine the rankings, with the highest score placed first and the lowest last. A subsequent review highlighted areas for refinement across all options. As summarised in Table I, the screening results led to the removal of Concepts C and E from further consideration. Concepts A, B, and D emerged as the preferred possible options.

Concepts A, B, and D advanced to concept scoring to verify their advantage over the existing design. Each selection criterion was rated on a 1–5 scale for which 1: Poor, 2: Ok, 3: Fair, 4: Good, 5: Excellent, and assigned a weight (%) reflecting its importance to overall functionality. Table II summarises the scoring for all three concepts. Concept A recorded the highest weighted total and was chosen for further development, with minor adjustments made to refine specific features.

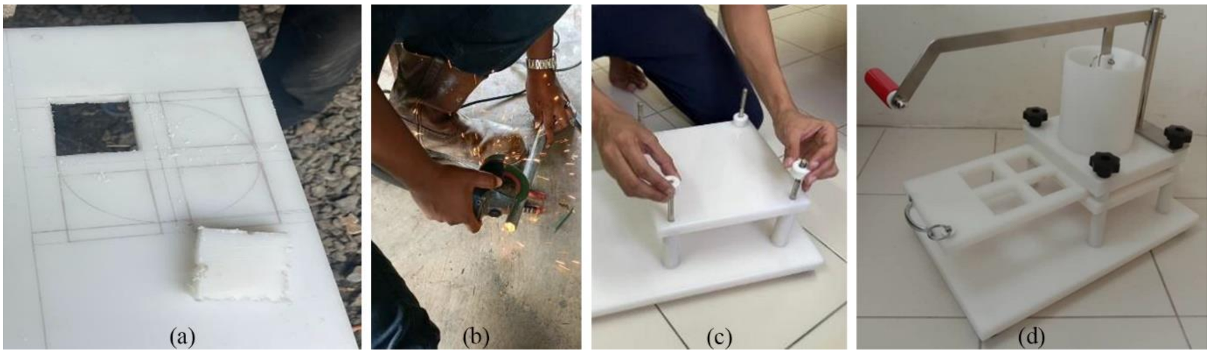


Fig. 3. Main fabrication steps and the completed prototype. (a) Layout and cutting of the PE boards. (b) Cutting and shaping of the bushings. (c) Assembly of the base and bottom plate. (d) Fully assembled prototype, including the lever arm, reservoir and mould plate.

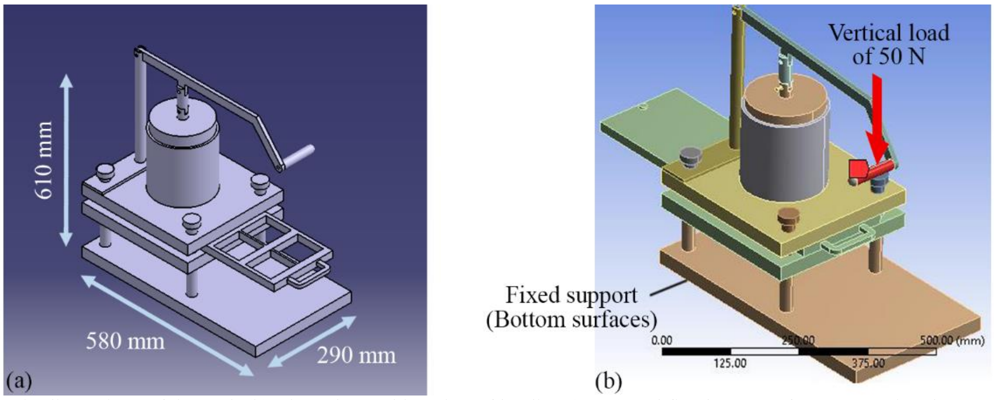


Fig. 4. (a) Main dimensions of the tool. (b) The value and location of loading (50 N) and fixed support for computational strength analysis.

Table III. The properties of materials applied in the analysis.

Material	Elastic Modulus (GPa)	Poisson's Ratio	References
PE	0.334	0.40	Callister *et al.* (2020) [13]
Stainless steel	193	0.29	Callister *et al.* (2020) [13]

C. 3-D Design and Prototype Fabrication

The finalised design was built as a full 3-D model in CATIA, using CAD tools such as revolve, extrude, extruded cut, mirror, and shell to generate the individual parts. Once the components were created, they were assembled into the complete digital model. The choice of dimensions for the shrimp paste mould drew on published ergonomic data to keep the design user-friendly. Figure 2 shows the result, with both an assembled view and an exploded view of the mould.

The design organises the tool into three functional zones: a filling section for the paste, a press handle, and a shaping mould. It uses three main plates which are the top plate, bottom plate, and base. They can be detached and reassembled easily. Bushings and knobs are fitted to these plates to lock the assemblies in place and keep them steady during operation. The mould includes guides to keep the formed paste from slipping out, and several rounded elements come together to create a reservoir for storing the shrimp paste. Above the reservoir sits the handle, supported by a stand and paired with a pushing plate for smoother pressing. Overall height is set for comfortable, ergonomic use, and all edges are softened to avoid hazards. The main body is made of PE to keep weight down for easier handling and storage, while the handle and lever arm are stainless steel for durability. Food-grade PE was selected for the main body due to its impact resistance, machinability, low adhesion to the paste, and resistance to moisture and salt, while stainless steel was used for the lever and high-load components because of its high strength, fatigue and corrosion resistance, and compatibility with standard metal-fabrication processes. The unit measures 290 mm wide, 580 mm long, and 610 mm tall as shown in Fig. 4(a).

After exporting the 3-D files from CATIA in the required format, the models underwent a detailed check before a mock-up was built for initial functional testing. The work then moved into prototype fabrication, combining metalworking with assembly to produce the working unit. Figure 3 exhibits the key fabrication steps and shows the completed prototype.

D. Strength Analysis and Functionality Testing

Structural strength was assessed using a 3-D linear static finite element analysis (FEA). Because the tool's main role is to resist the pressing action during moulding, a downward vertical load representing the moulding force was applied to the handle surface and evaluated in the simulation (Fig. 4(b)). The geometric model of the mould was exported as an IGS (.igs) file and analysed in ANSYS. Material behaviour was defined as isotropic, homogeneous, and linearly elastic. The elastic modulus (E) and Poisson's ratio (v) used in the study are provided in Table III. FEA, a standard numerical technique in engineering, was used to carry out the computational assessment.

A handle load of 50 N was selected to represent a moderate hand push or grip force, consistent with laboratory studies of tool-hand interaction which use grip forces up to 75 N and push forces of 25 – 75 N, including a commonly studied level of 50 N [14]. For the boundary conditions, all ground that contacting bottom surfaces of the moulding tool were fixed to prevent any translation or rotation. The model was meshed with four-node solid tetrahedral elements, applied uniformly to every part, with particular attention to critical regions to maintain accuracy and consistency. Contacts between components were modelled as perfectly bonded, thereby representing rigid, non-slipping connections between all mating parts. Automatic meshing method was used and generated 75,291 nodes and 24,697 elements. A brief mesh refinement study (coarse-medium-fine) has been performed and showed that further refinement beyond the selected mesh changed the maximum von Mises stress and deformation by less than 5%, indicating that the chosen mesh density is adequate for the present analysis. Although a full mesh-size sensitivity analysis was not carried out, preliminary trial meshes were adjusted until the stress and deformation fields showed consistent patterns and the peak von Mises stress remained well below the material yield strength. Therefore, the selected mesh is considered reasonable for the comparative and design-verification purposes of this work. A more comprehensive mesh convergence study could be considered in future extensions of this analysis. The structural performance of the mould model under the specified loading was evaluated by the peak equivalent von Mises stress (MPa) and the maximum deformation (mm).

The finished prototype was evaluated in trials to assess both ease of use and moulding performance. Its performance was compared with that of the same operator performing the task using the traditional bare-hand method. The main outcome measure was task completion time, comparing the prototype-assisted method with the conventional approach. All trials were performed by a single operator (25 years old) with 5 years of prior experience in shrimp paste moulding. The same operator conducted all trials for both the conventional method and the proposed tool to eliminate inter-operator variability and focus on the basic performance of the tool itself.

E. RULA Ergonomic Assessment

The Rapid Upper Limb Assessment (RULA) method was applied to evaluate workers' exposure to ergonomic risk factors associated with upper extremity musculoskeletal disorders. This assessment tool examines the biomechanical demands and postural loads placed on the neck, upper limbs, and trunk during work tasks. Once the data for each work location were obtained, a corresponding scoring table was used to combine the relevant risk factor variables into a single value that reflects the level of musculoskeletal disorder risk.

III. RESULTS AND DISCUSSION

A. Strength Analysis Results

The findings of 3-D linear static finite element analysis reported the peak values and spatial distribution of equivalent von Mises stress and total deformation generated in the model. Also, colour contour plots were used to illustrate these fields, marking the most critical zones in red and the least critical in blue. As a widely accepted numerical technique, FEA is routinely used to solve problems arising in mathematical modelling across science and technology [15-18].

Under the vertical loading applied to the handle, the analysis revealed that the maximum stress, measuring 21.02 MPa, occurred at the middle region of the lever arm, as illustrated in Fig. 5(a). Overall, the structure exhibited adequate capacity to withstand the applied vertical load, with a minimal risk of failure under normal operating conditions, as the maximum stress value was significantly lower than the yield strength of stainless steel (215 MPa) [19]. In terms of structural safety, the calculated safety factor for the moulding tool is 10.2, as determined in Eq. (1), indicating that the design can withstand loads more than ten times greater than the maximum expected operating load. Areas around the reservoir compartment and the lower sections showed only minor stress. By contrast, the lever region carried higher stresses, largely because the structure's bending resistance increases under the applied load.

$$\text{Safety Factor} = \frac{215\ MPa}{21.02\ MPa} = 10.2 \tag{1}$$

The deformation analysis showed a maximum value of displacement of 0.5558 mm at the handle's edge, as illustrated in Fig. 5(b). This amplified deflection at the handle tip stems from elevated bending stresses generated by the applied load. To reduce the risk of excessive deformation and potential structural failure, users should moderate the pressure exerted on the handle, since greater applied force correspondingly increases the likelihood of deformation.

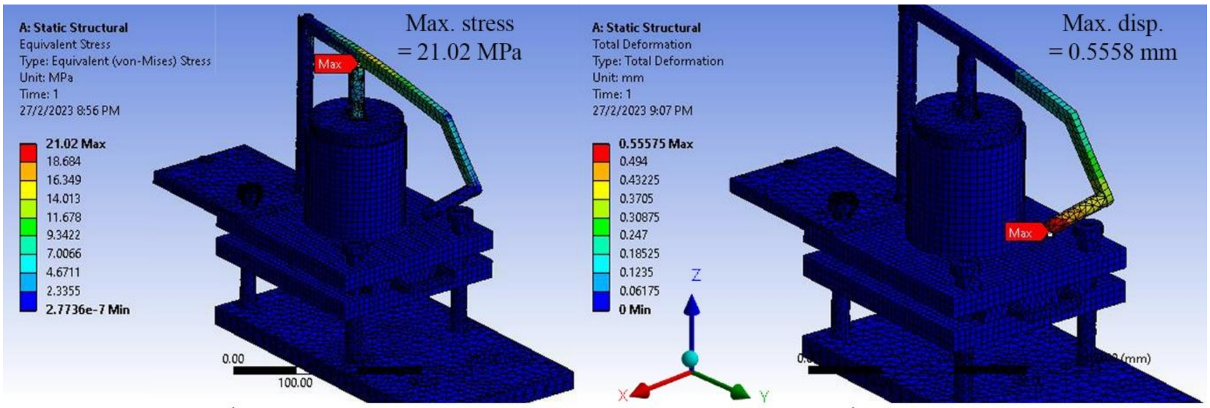
B. Prototype Functional Analysis Results

Before usability testing, the user's familiarity with the shrimp pastes moulding tool matters because safe, effective operation depends on basic setup and cleanliness. The process typically involves placing the tool on a stable, level surface and assembling the prepared components into a functional unit. Clean, debris-free working areas especially the mould tray help ensure consistent results. In practice, the moulding sequence runs from loading the prepared paste into the reservoir, positioning the pushing plate, adjusting the mechanism, pressing the handle, and then sliding out the mould tray to retrieve the formed pieces. Since the device is intended for one-handed use, the tasks inherently carry some risk in which lapses in handling or attention to safety can lead to minor injuries or cause the tool to drop. Careful use therefore reduces the likelihood of accidents and supports reliable outcomes.

Figure 6 presents the time, in seconds, needed to complete the paste moulding during usability testing, comparing the conventional approach with the proposed moulding tool. The testing measured the time required to mould 12 pieces of shrimp paste using both the traditional method and the proposed mould prototype. Using the new tool reduced the duration of the shrimp paste moulding task by about 50% relative to moulding by hand, indicating a substantial improvement in efficiency. With the tool, the task took about 15 minutes, whereas the conventional method took roughly 30 minutes. Figure 7 compares the moulding process using the traditional method with the process using the proposed tool.

As the main objective of this study is to form the shrimp paste into a consistent shape, the dimensions of the paste mould are of primary importance. In current practice, the standard size for rectangular shrimp paste is 130 mm × 60 mm, while the commonly used round paste has a diameter of 100 mm. In this work, the proposed forming tool was designed exclusively for the rectangular paste configuration. As a result, the tool produces shrimp paste blocks with the final dimensions of 110 mm × 55 mm. This indicates a small deviation from the conventional rectangular paste size which can be considered acceptable.

The prototype uses food-grade PE and stainless steel, which are widely applied in food-processing equipment. In this study, the focus is on design, strength, and usability, and did not carry out formal regulatory certification of the specific materials used. For future industrial use, the mould components would need to be sourced from suppliers that provide food-contact declarations of conformity and used with documented cleaning and maintenance procedures to ensure compliance with relevant food-safety regulations.



Maximum stress = 21.02 MPa Maximum stress = 0.5558 mm

(a) (b)

Fig. 5. The areas of peak (a) stress (21.02 MPa) and (b) deformation (0.5558 mm) in the shrimp paste mould model.

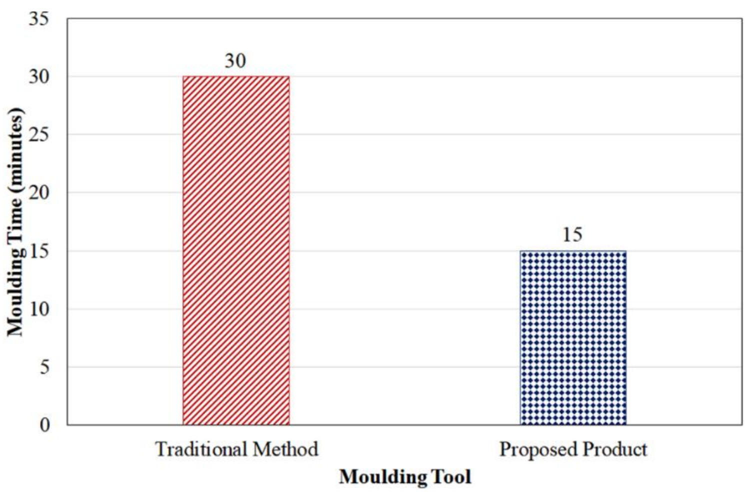


Fig. 6. Comparison of moulding times recorded between the traditional method (30 minutes) and proposed product (15 minutes).

(a) (b)

Fig. 7. Shrimp paste moulding process using (a) traditional method and (b) proposed moulding tool.

The functionality testing revealed several concerns related to performance and safety in the proposed mould. Sharp corners on the stainless-steel lever arm pose a risk to users, suggesting a need to round the edges or add protective coverings. The tool also lacked adequate grip on the work surface, leading to slipping during operation. This can be improved by adding high-quality rubber to the base to increase tool stability. Assembly quality emerged as another weakness in which some tool parts did not seat securely, leaving the structure loose. Refining the attachment method and tightening design tolerances would improve the tool's overall rigidity and structural integrity.

The ergonomic analysis was also conducted to evaluate and compare the risk factors associated with the traditional method and the proposed prototype. A RULA ergonomic assessment sheet was used to analyze and compare the findings between the two methods. The results showed that the prototype achieved a score of 4, while the conventional moulding approach scored 6, indicating higher risk. In practical terms, the proposed tool demonstrates better ergonomic performance than the manual method.

The usability tests indicate that the proposed shrimp paste moulding tool can markedly improve the efficiency of moulded paste preparation. Although it delivers notable time savings over the conventional approach, the shortcomings noted earlier still require refinement to meet performance goals. Resolving the safety issues, improving surface grip, and strengthening the assembly will raise both usability and reliability, positioning the tool as a more effective option for users.

C. RULA Ergonomic Assessment Results

The RULA ergonomic assessment results indicated an improvement in postural risk when the proposed shrimp paste mould was used, compared with the conventional manual method. The mould-assisted method obtained a RULA score of 4, whereas the manual technique yielded a score of 6. According to RULA interpretation guidelines, this reduction in score suggests that the proposed mould lowers the overall risk of developing work-related musculoskeletal disorders, particularly in the upper limbs and trunk. In practical terms, the mould appears to promote more neutral working postures and reduce excessive or sustained joint loading.

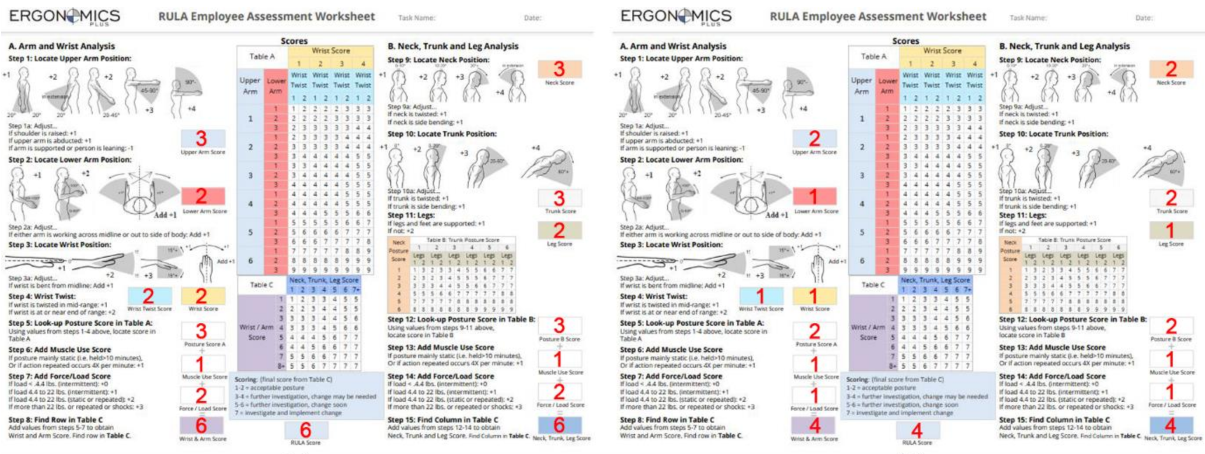
Although the new tool reduces ergonomic risk to a more acceptable level, it does not completely eliminate it. Some residual risk remains, indicating that further design refinements such as optimising handle dimensions, working height, or force requirements may be warranted in future iterations. Additional evaluation under different working conditions and with a larger group of operators would also help to confirm the robustness of these findings. The comparative RULA scores for both the manual method and the shrimp paste mould are summarised in Fig. 8.

D. Production Feasibility

The shrimp paste mould was designed with simple geometries, PE, and standard stainless-steel components so it can be fabricated using common workshop processes such as cutting, drilling, and basic machining. No motors, sensors, or electronics are required, which simplifies assembly, cleaning, and maintenance. These design choices make the tool well suited for small-batch or mass production using CNC cutting jigs, and potentially moulded plastic parts if demand increases. The bill of materials is dominated by PE panels, steel bars, and standard fasteners, suggesting that unit costs can be kept relatively low and accessible for small and medium shrimp-paste producers. A detailed cost analysis was beyond the scope of this work, but future studies should quantify production cost, payback period, and labour savings compared with the fully manual method.

E. Limitations

A major limitation of this study is that the usability test was conducted with only one operator. Consequently, the inter-operator variability could not be assessed, or statistical comparisons could not be performed across multiple participants. Future studies will involve a larger number of operators with varying levels of expertise to evaluate generalisability and to perform robust statistical analysis of tool performance.



(a) (b)

Fig. 8. The score of RULA ergonomic assessment for (a) manual method and (b) proposed mould.

IV. CONCLUSION

The findings from design development, structural simulation, and usability testing point to a shrimp paste mould that performs well in practice. The analysis showed both mechanical stress and overall deformation stayed within acceptable thresholds, indicating the tool can handle expected loads during use. Taken together, the results support the design's structural integrity and durability under typical operating conditions.

The revised moulding mechanism focuses on efficient shaping of the shrimp paste while integrating key safety features and ergonomic considerations. These updates improve the user experience and reduce the risk of problems such as accidents or operational slowdowns. By targeting these areas, the design addresses shortcomings often seen in conventional moulding methods.

The new shrimp paste mould addresses the main shortcomings of the conventional approach and delivers a safer, more ergonomic, and more efficient way to produce large batches of moulded paste. The design improves both accessibility and usability in typical moulding settings, representing a meaningful step forward in assistive mould design.

The functional trials and ergonomic assessment highlight several directions for further improvement. The sharp edges on the stainless-steel lever should be rounded or fitted with protective covers to minimise the chance of hand injury during repetitive use. The current base can also be enhanced by incorporating higher-friction rubber pads or a broader footprint so that the unit remains stable even when operators apply higher forces to the handle. Besides, the fastening and alignment of key joints can be refined by tightening dimensional tolerances and using more robust attachment hardware, which would reduce looseness in the structure and improve long-term rigidity under repeated loading. Future refinement could also consider adjusting the handle geometry and working height to bring the RULA score closer to the lowest risk category. This may include minor alterations to lever length, grip diameter, and the relative position of the reservoir so that operators can maintain more neutral wrist and shoulder postures during extended moulding sessions. Evaluating these design changes with a larger and more diverse group of users from small and medium enterprises would provide stronger evidence on comfort, fatigue, and productivity.

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AUTHOR CONTRIBUTIONS

Muhammad Ikman Ishak: Experimental Design, Methodology, Investigation, Formal Analysis, Validation, Visualization, Testing, Data Analysis, Implementation, Validation, Writing – Original Draft Preparation, Review & Editing, Manuscript Refinement.
Muhammad Izhar Ali: Experimental Design, Investigation, Conceptualization, Testing, Data Analysis, Writing – Review & Editing, and
Noor Alia Md Zain: Methodology, Investigation, Data Analysis, Implementation, Visualization, Testing, Data Analysis, Writing – Review & Editing.

CONFLICT OF INTERESTS

No conflict of interests was disclosed.

ETHICS STATEMENTS

All participants provided informed consent prior to participation.

REFERENCES

[1] K. J. D. Abedelazeez *et al.*, "Microbial Characterization of Belacan (Fermented Shrimp Paste) and Its Potential as a Plant-Growth Promoting Agent of Oyster Mushroom (Pleurotus ostreatus)," *J. Biochem., Microbio. and Biotechnol.*, vol. 12, pp. 57-60, 2024.

[2] T. H. Tengku Abdul Hamid and N. Fatin Amysya, "Lactic Acid Bacterium With Antimicrobial Properties From Selected Malay

Traditional Fermented Foods," *Int. J. Life Sci. and Biotechnol.*, vol. 4, pp. 13-24, 2021.

[3] P. Hajeb and S. Jinap, "Fermented Shrimp Products As Source of Umami in Southeast Asia," *J. Nutrit. & Food Sci.*, vol. 01, pp. 1-5, 2013.

[4] J. Pongsetkul, S. Benjakul, K. Vongkamjan, P. Sumpavapol and K. Osako, "Microbiological and Chemical Changes of Shrimp Acetes Vulgaris during Kapi Production," *J. Food Sci. and Technol.*, vol. 54, pp. 3473-3482, 2017.

[5] H. Helmi *et al.*, "Dynamic Changes in The Bacterial Community and Metabolic Profile during Fermentation of Low-Salt Shrimp Paste (Terasi)," *Metabolites*, vol. 12, pp. 118, 2022.

[6] Y. J. Cha and D. Yu, "Health Benefits and Functions of Salt-Fermented Fish," *J. Ethnic Foods*, vol. 11, no. 34, pp. 1-17, 2024.

[7] Y. Narzary, S. Das, A. K. Goyal, S. S. Lam, H. Sarma and D. Sharma, "Fermented Fish Products in South and Southeast Asian Cuisine: Indigenous Technology Processes, Nutrient Composition, and Cultural Significance," *J. Ethnic Foods*, vol. 8, no. 1, pp. 33, 2021.

[8] J. P. Tamang *et al.*, "Fermented Foods in A Global Age: East Meets West," *Compreh. Rev. in Food Sci. and Food Safet.*, vol. 19, pp. 184-217, 2020.

[9] M. S. A. Karim, S. S. A. Rashid, N. Adzahan and A. A. Camillo, "Consumers Perspective Towards Malaysian Traditional Food: Sambal Belacan (chilli Shrimp Paste), A Preliminary Investigation," *Universiti Putra Malaysia Institutional Repository*, 2011.

[10] Y. B. Kim, Y. S. Choi, S. K. Ku, D. J. Jang, H. H. Ibrahim, K. B. Moon, "Comparison of Quality Characteristics Between Belacan From Brunei Darussalam and Korean Shrimp Paste," *J. Ethnic Foods*, vol. 1, pp. 19-23, 2014.

[11] Stefanny and F. H. Pamungkaningtyas, "Shrimp Paste: Different Processing and Microbial Composition Across Southeast Asia," *IOP Conf. Series: Earth and Environ. Sci.*, vol. 1169, pp. 012089, 2023.

[12] A. Lestido-Cardama, R. Sendón, J. Bustos, M. T. Nieto, P. Paseiro-Losada, A. Rodríguez-Bernaldo de Quirós, "Food and Beverage Can Coatings: A Review on Chemical Analysis, Migration, and Risk Assessment," *Compreh. Rev. in Food Sci. and Food Safet.*, vol. 21, pp. 3558-3611, 2022.

[13] W. D. Callister and D. G. Rethwisch, *Materials Science and Engineering: An Introduction*, John Wiley & Sons, 2020.

[14] D. Pan *et al.*, "The Relationships Between Hand Coupling Force and Vibration Biodynamic Responses of The Hand-Arm System," *Ergonom.*, vol. 61, pp. 818-830, 2018.

[15] M. I. Ishak, R. Daud, S. Noor, C. Y. Khor and H. Roslan, "Assessment of Stress Shielding Around A Dental Implant for Variation of Implant Stiffness and Parafunctional Loading using Finite Element Analysis," *Acta Bioeng. Biomech.*, vol. 24, pp. 147-159, 2022.

[16] M. I. Ishak, M. Abdul Kadir, E. Sulaiman and N. Kassim, "Effects of Different Zygomatic Implant Body Surface Roughness and Implant Length on Stress Distribution," *Proc. 2010 IEEE Conf. on Biomed. Eng. and Sci.,* Kuala Lumpur, Malaysia, pp. 210-215, 2010.

[17] M. A. M. Nawi *et al.*, "The Effect of Multi-staged Swirling Fluidized Bed on Air Flow Distribution," *IOP Conf. Series: Mater. Sci. and Eng.,* vol. 864, pp. 012194, 2020.

[18] J. S. Tan *et al.*, "Effect of Solder Joint Width to The Mechanical Aspect in Thermal Stress Analysis," *IOP Conf. Series: Mater. Sci. and Eng.*, vol. 551, pp. 012105, 2019.

[19] "Properties and Selection: Irons, Steels, and High-Performance Alloys," *ASM Handbook*, vol. 1, ASM International, 1990.