DEVELOPMENT OF TUNA FISH SHREDDER FOR SMALL AND MEDIUM ENTERPRISES
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PENGEMBANGAN MESIN PENCABIK IKAN TUNA UNTUK PEMBUATAN ABON IKAN SKALA INDUSTRI RUMAH TANGGA

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ABSTRACT
This study aims to develop a fish grater machine to produce shredded fish on a household scale. The development of this fish shredder machine considers getting the maximum capacity, a minimum percentage of losses, a maximum percentage of the samples with short grade and middle grade size, and a maximum percentage of the samples with rough grade size with limited sources specified power. The method used in this research is the machine manufacturing and testing approach. Three types of shredder machine teeth (K-type, P-type, and B-type) are the main focus of this research to optimize the quality of the shredded material and the machine's performance. The machine capacity, the percentage of losses, and the optimal quality of the counting size of the developed machine can be achieved using K-type shredder machine teeth. Analysis of variance and the t-test are used simultaneously to determine the optimal performance of this machine. The results of this study suggest that using a K-type shredder machine teeth is the most appropriate shredder machine for shredded fish.

ABSTRAK
Penelitian ini bertujuan untuk mengembangkan mesin pencabik ikan untuk menghasilkan abon ikan skala rumah tangga. Pengembangan mesin pencabik ikan ini mempertimbangkan untuk mendapatkan kapasitas maksimum, persentase susut minimum, persentase maksimum sampel yang dicabik dengan ukuran pendek dan sedang, serta persentase maksimum sampel yang dicabik dengan ukuran kadar kasar dengan daya yang ditentukan sumber terbatas. Metode yang digunakan dalam penelitian ini adalah pendekatan manufaktur dan pengujian. Tiga jenis gigi pencabik (tipe-K, tipe-P, dan tipe-B) menjadi fokus utama penelitian ini untuk mengoptimalkan kualitas cabikan dan kinerja mesin. Kapasitas mesin, persentase losses dan kualitas optimal dari ukuran ikan yang dicabik dari mesin yang dikembangkan dapat dicapai dengan menggunakan mata pencabik tipe-K. Analisis varians dan uji-t digunakan secara bersamaan untuk mengetahui kinerja optimal dari mesin ini. Hasil penelitian ini menunjukkan bahwa menggunakan mata pencabik tipe-K adalah yang paling cocok untuk pembuatan abon ikan tuna.

INTRODUCTION
Tuna has a high protein content, vitamins A and B, omega 3, minerals, and amino acids that are good for growth and intelligence *(Usydus and Szlinder-Richert, 2012; Saleh et al., 2021; Parletta et al., 2013*). The body quickly digests them, which is perfect if humans consume them. In some ports, fishermen throw some fish out in the sea because they have rotted due to the limited facilities and infrastructure owned by fishermen. Another problem is the lack of knowledge of fishermen on post-catch fish handling. They do not understand that handling fresh fish is one of the most critical links in creating diversified fish products. An alternative that can be made to prevent a decrease in fishing income is to innovate the manufacture of processed products such as salted fish, ikan kayu, shredded fish, etc.

Shredded fish is one of the processed foods made from raw fish, which is obtained by boiling, cutting, and frying, then adding spices and herbs so that the shredded meat has a distinctive taste (*Latif et al.*, *2017*; *Rosalina et al.*, *2021*; *Fahmi and Purnamayati*, *2020*).

Shredded fish is classified as processed dry food, so it can be stored for a long time without changing its shape, aroma and taste. Drying and storage is a process that involves a lot of energy (*Sitorus et al.*, *2021*).

In the process of making shredded fish in most of Indonesia, it is still straightforward to use hands, knives, mortar, and hammers to grate the fish that will be transformed into shredded fish (*Putri and Rukmana*, 2021; *Rihayat et al.*, *2019*; *Dewi et al.*, *2020*). Using a manual system to produce shredded materials requires more time and human labour, which will result in high production costs. To solve this problem, a fish shredder machine facilitates shredding to increase production yields and shorten working time. Therefore, this study aims to develop a fish shredder machine for small and medium enterprises considering the aspect of the shredder teeth.

MATERIALS AND METHODS

Design of fish shredder machine

The driving motor used in this fish shredder machine is an electric motor with engine specifications of 220 V, 0.18 KW, 2.49 A, and 50 Hz. The type of electric motor used is an alternating current electric motor with a rotational speed of 1450 rpm. In the K-type shredder machine teeth (Figure 1a), the material used is a stainless-steel pipe with a thickness of 2 mm, the width of the cylinder is 93.80 mm, and the diameter of the cylinder is 88.10 mm. The weight of the K-type teeth is 498 g. The number of teeth for this type is 654 pieces. In the P-type shredder machine teeth (Figure 1b), the material used is a stainless-steel pipe with a thickness of 3 mm, the width of the cylinder is 93.80 mm, and the diameter of the cylinder is 88.10 mm. The weight of the P-type teeth is 437 g. The number of teeth for this type is 70 pieces. In B-type shredder machine teeth (Figure 1c), the material used is a stainless-steel pipe with a thickness of 3 mm, the width of the cylinder is 93.80 mm, and the diameter of the cylinder is 88.10 mm. The weight of the B-type teeth is 422 g. The number of teeth for this type is 70 pieces.

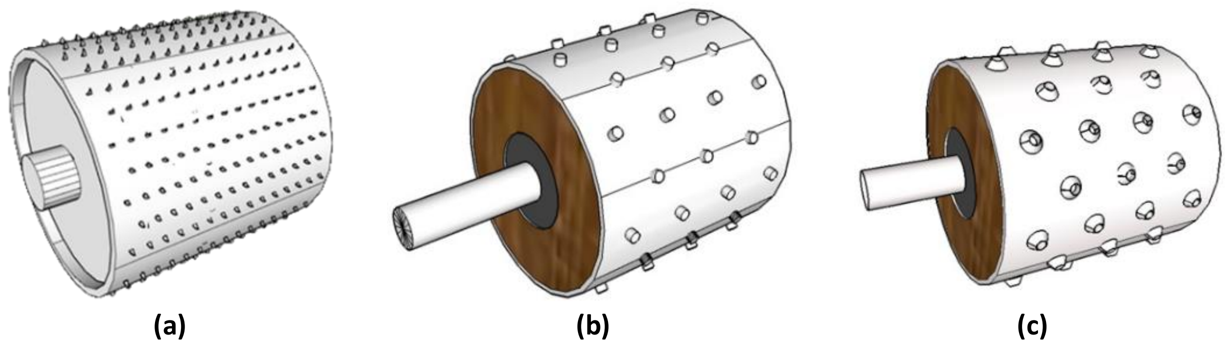

Fig. 1 – Teeth shape for shredder machine (a) K-type, (b) P-type, (c) B-type

Sample preparation

The raw material is the tuna cleaned of dirt, scales, and entrails. Furthermore, the fish is boiled to facilitate the separation of bones from meat. Three replications use 500 g of tuna fish that are fed into the shredder to test its performance. The total tuna fish used was 1500 g for each testing of the tooth shape.

Observation parameters

The performance test of the fish shredding machine is carried out to determine the machine's performance and the quality of the shredding results. In this test, measurements and calculations will be carried out, including the capacity of the machine (*Bulan et al.*, 2019), the percentage of losses, and the uniformity of the shredding results (percentage of the sample that is grated with short, middle, and rough grade). The uniformity of the shredding is then carried out by sieving with a 25 size mesh. The weight of the sample that passes will be compared with the initial weight of the fish before being shredded. Furthermore, statistical analysis, including ANOVA and *t-test*, is carried out on the experimental parameters (*Perdana et al.*, 2021; *Abbey et al.*, *2018*; *Ardiansyah and Sahubawa*, *2020*). All analyses are performed using the MS Excel application.

RESULTS AND DISCUSSIONS

Machine capacity

Table 1 shows the results of the analysis of variance of the capacity parameters using the shredder machine developed in this study and compared to the manual shredding. The results indicate at least one different treatment of the three types of shredding compared to manual shredding.

This can be seen in the *F-value*, which is much higher than the *F-crit*, 98.329 > 4.066. Therefore, more analysis is needed to determine the difference between each treatment in this machine capacity parameter.

Table 1

Analysis of variance of machine capacity parameters

Source of variation	Sum of square	Degrees of freedom	Mean squares	F	P-value	F-critical
Between groups	458.123	3	152.708	98.329	1.183×10^{-6}	4.066
Within groups	12.424	8	1.553			
Total	470.55	11				

The results of the *t-test* on the capacity parameters for using this machine compared with manual shredding are presented in Figure 2. In general, the shredding capacity using the machine developed in this study was significantly greater, eight times higher than that of manual shredding. Additionally, the use of the K-type teeth resulted in a significant difference (p<0.05) in engine capacity performance compared to the use of the P- type and B-type teeth. However, using P-type and B-type teeth did not differ significantly (p<0.05) on the machine capacity achievement. This *t-test* indicates that the use of P-type and B-type can be used equally well to achieve the maximum capacity for making fish floss. In addition, the use of K-type teeth should be avoided so that the machine can work optimally.

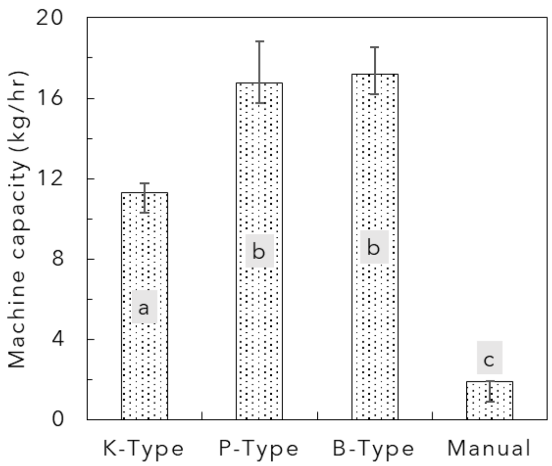

Fig. 2 – The results of the *t-test* on the machine capacity parameter compared with manual shredding

Percentage of losses

Table 2 shows the results of the analysis of the percentage of variance of losses using the shredder machine developed in this study and compared to the manual shredding. The results indicated at least one different treatment among the three types of shredding compared to manual shredding. This can be seen from the *F-value*, which is much higher than the *F-crit*, namely 12.804 > 4.066. Therefore, further analysis is needed to determine the difference in each treatment in the parameter percentage of losses from this machine.

Table 2

Analysis of variance to a percentage of losses

Source of variation	Sum of square	Degrees of freedom	Mean squares	F	P-value	F-critical
Between groups	15.237	3	5.079	12.804	0.002	4.066
Within groups	3.173	8	0.397			
Total	18.41	11				

The results of the *t-test* on the percentage of losses parameter using either the machine or manual shredding are presented in Figure 3. This shows statistically that any type of shredder teeth can be used for this developed fish shredding machine without affecting the percentage of losses. In general, the percentage of losses using the machine designed in this study is significantly greater than manual shredding, 5.5 times. Furthermore, the use of shredder teeth of all types in this study did not produce a significant difference (p<0.05) in the percentage of losses. However, to subjectively minimize the percentage of losses by observing the average percentage of losses from using the three types of shredder teeth, it can be recommended to use a shredder teeth of type K-type > P-type > B-type.

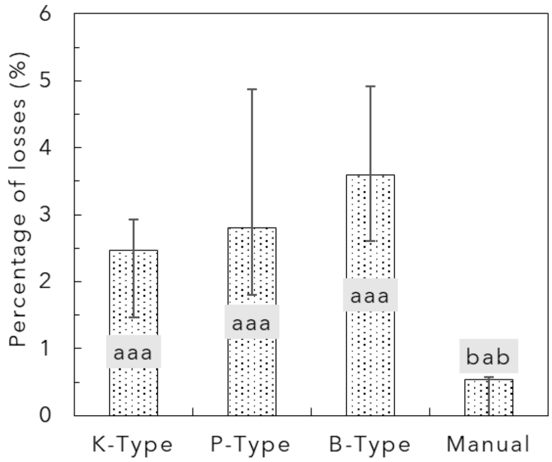

Fig. 3 – The results of the *t-test* on the percentage of losses from machine shredder parameter compared with manual shredding

Percentage of the sample that shredded with size short grade

Table 3 shows the results of the analysis of the variance percentage of the sample shredded with short grade size using the shredder machine developed in this study. The results indicate that at least one treatment differs from the three types of shredder teeth treatments in the percentage of the sample that is shredded with short grade size. This can be seen in the *F-value*, which is much higher than the *F-crit*, 11.523 > 5.143. Therefore, more analysis is needed to determine the difference between each treatment in the sample percentage more significant with the short-grade parameter size.

Table 3

Analysis of variance of the sample shredded with short grade size

Source of variation	Sum of square	Degrees of freedom	Mean squares	F	P-value	F-critical
Between groups	185.761	2	92.880	11.523	0.009	5.143
Within groups	48.362	6	8.060			
Total	234.123	8				

The results of the *t-test* on the percentage of parameters in the sample that is shredded with a short grade size is presented in Figure 4. In general, there is a difference between the use of brittle tooth type on the achievement of the percentage of the sample that is higher with short grade size. The K-type shredded teeth were significantly different (p<0.05) in achieving the percentage of the sample that is grater with a short grade size against the P-type teeth. However, the K-type and B-type teeth did not significantly affect the achievement of the percentage of the sample that was shredded with short grade size. In addition, using P-type teeth also did not have a significant effect achieving the percentage of the sample that was shredded with short grade size. Therefore, from the point of view of the percentage of the sample that is shredded with a short grade size, the use of K- type and B-type is the best option. But when the two are compared, the K-type teeth option is the best.

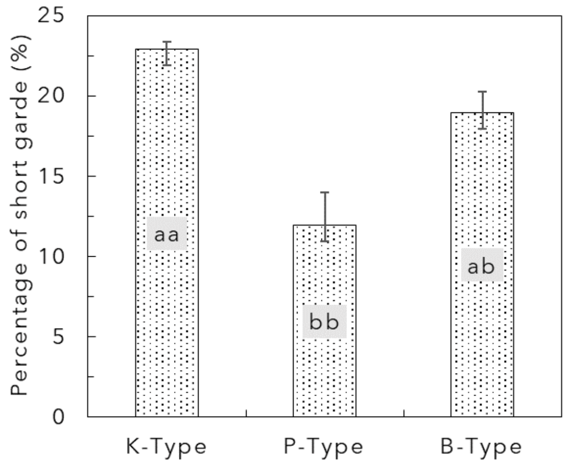

Fig. 4 – The results of the *t-test* on the percentage of the sample that is shredded with short grade size

Percentage of the sample that shredded with size middle grade

Table 4 shows the results of the analysis of the variance percentage of the sample that is shredded with middle grade size using the shredder machine developed in this study. The results indicate that at least one treatment differs from the three types of shredder teeth treatment in the percentage of the sample that is shredded with middle grade size. This can be seen in the *F-value*, which is much higher than the *F-crit*, which is 78.613 > 5.143. Therefore, further analysis is needed to determine the difference between each treatment in the percentage of parameter of the sample shredded with a middle grade size.

The results of the *t-test* on the percentage of parameters in the sample that is shredded with a middle grade size is presented in Figure 5. In general, there is a difference between the use of the type of shredder tooth and the achievement of the percentage of the sample that is shredded with middle grade size. The K-type teeth were significantly different ($p<0.05$) in achieving the percentage of the sample that was shredded with a short grade size against the P-type and B-type teeth.

However, the P-type and B-type teeth did not significantly affect the achievement of the percentage of the sample that was shredded with a middle grade size. Therefore, from the point of view of the percentage of the sample that was shredded with a middle grade size, the use of K-type teeth is optimal.

Table 4

Analysis of variance percentage of the sample shredded with middle grade size

Source of variation	Sum of square	Degrees of freedom	Mean squares	F	P-value	F-critical
Between groups	2985.093	2	1492.546	78.613	0.000050	5.143
Within groups	113.916	6	18.986			
Total	3099.009	8				

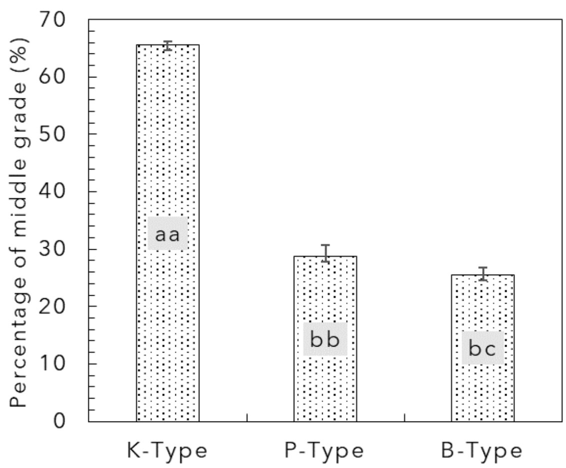

Fig. 5 – The results of the *t-test* on the percentage of the sample that is shredded with middle grade size

Percentage of the sample that was shredded with rough grade size

Table 5 shows the results of the analysis of the variance percentage of the sample shredded with rough grade size using the shredder machine developed in this study. The results indicate that at least one treatment differs from the three types of teeth treatments in the percentage of the sample that is shredded with rough grade size. This can be seen in the *F-value*, which is much higher than the *F-crit*, which is 158.927 > 5.143. Therefore, further analysis is needed to determine the difference between each treatment in the percentage of parameter of the sample shredded with rough grade size.

The results of the *t-test* on the percentage of parameters in the sample that is shredded with rough grade size are presented in Figure 6. In general, there is a difference between the use of the teeth type on the achievement of the percentage of the sample shredded with middle grade size. The K-type teeth were significantly different (p<0.05) in achieving the percentage of the sample shredded with a short grade size against the P-type and B-type teeth. In addition, the P-type teeth also significantly influence the achievement of the percentage of the sample shredded with rough grade size against the B-type teeth. Therefore, from the point of view of the percentage of the sample shredded with rough grade size, using K-type teeth is optimal.

Table 5

Analysis of variance percentage of the sample shredded with rough grade size

Source of Variation	Sum of square	Degrees of freedom	Mean squares	F	P-value	F-critical
Between groups	4148.570	2	2074.285	158.927	6.359×10^{-6}	5.143
Within groups	78.311	6	13.052			
Total	4226.881	8				

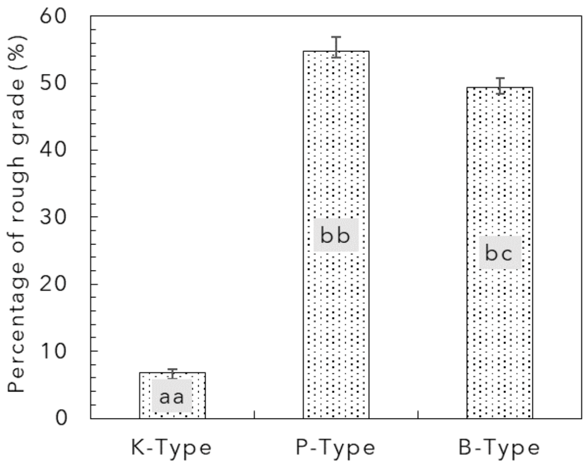

Fig. 6 – The results of the *t-test* on the percentage of the sample that shredded with size rough grade

CONCLUSIONS

A fish shredding machine for small and medium enterprises has been successfully designed and its performance tested. The developed machine has a capacity in the range of 11.29±0.46 kg/hr to 17.21±1.31 kg/hr with optimization on the K-type shredder teeth. The parameter percentage of machine loss is at a maximum of 3.60±0.60%. The best percentage of the sample shredded with a short grade size was achieved using K-type teeth, which was 22.92±1.97%. The best percentage of the sample shredded with middle grade size was performed with K-type teeth, namely 65.67±2.02%. The best percentage of the sample shredded with rough grade size was achieved using K-type teeth, namely 6.80±1.99%. On the basis of these parameters, the results of this study conclude that using a K-type shredder tooth is the most appropriate for developing a fish shredder machine for tuna fish.

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