Improvement of Extracted Volume of Sugarcane using Underwater Shock Wave

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ABSTRACT

The productivity improvement of food is necessary because the rate of food self-sufficiency of Japan is low. And then, the high efficient food processing is developed in Japan. On the other hand, the ratio of the production of sugarcane is high in the primary industry in Okinawa Prefecture. The rate of profit in the sugar manufacturing by sugarcane is lower than other primary industry goods, because the production cost is high. In this research, the sugar manufacturing method by sugarcane in high efficiency was developed using underwater shockwave. In this paper, to crush hard food like sugarcane, the pressure vessels of three dimensional oval structure is proposed. It is clear that the effect of the improvement of the juice extraction rate using the pressure vessel.

INTRODUCTION

In Japan, most sugar is produced with the sugar beet and sugarcane. In the agricultural output of Okinawa Prefecture, the proportion of the production of the sugarcane that becomes the raw material of raw sugar is very high. However, the price of the raw sugar made from sugarcane is higher than that of general sugar. To achieve economy independent of Okinawa, the reduction in the sugar manufacture cost of sugarcane is requested. The general process of manufacture of raw sugar is compressed four and five times using the roller, after the raw material of sugarcane is crushed. (Fig.1)

On the other hand, the food processing technology by the underwater shock wave has been developed in Okinawa National Technical College. The food crushing technology of this device has the advantage
compared with the current technology. Various foods are crushed using this device, and, the effect has been verified\textsuperscript{1}. In this research, the effect of the sugarcane compression improvement is verified with an underwater shock wave crushing device. In this report, the relation between the frequency of the shock wave and the extraction rate of the compression liquid is clarified.

**Design of pressure vessel of disintegrator of sugarcane**

We have developed the various pressure vessel of disintegrator using the shock wave.

Figure 2 shows the pressure vessel of disintegrator of the batch type. This device was developed by Kumamoto University. The inside of this device is a cylinder pipe made of the stainless steel. The crushed sample is enclosed with the polyethylene container beforehand. And, the container is set in the pressure vessel of disintegrator, and sealed up with the lid of the stainless steel. This device can crush a lot of sort of sample using the polyethylene container. However, it is not suitable for continuousness and a large amount of crushing.

On the other hand, the pressure vessel of disintegrator for the milling flour is developed in Okinawa National College of Technical\textsuperscript{2}. The crushing object is rice, and continuous processing is a possible design. Figure 3 shows the structure of the pressure vessel of disintegrator for the milling flour. Figure 4 shows the photograph of an upper, lower unit of this device. To enable continuous processing, the silicone hose is set up in this pressure vessel of disintegrator. Moreover, the durability is improved more than the batch type for continuous processing. The pressure vessel of disintegrator is made by the aluminum block using machining. An internal structure is 3D oval because of the crushing energy improvement. The inside is filled with water, and rice passes the silicone hose (in air). It is confirmed that rice powder manufactured by rice using this pressure vessel of disintegrator.

![Fig.2 Pressure vessel of disintegrator of the batch type](image1)

![Fig.3 Pressure vessel of disintegrator for the milling flour](image2)

![Fig.4 Picture of disintegrator for the milling flour](image3)

![Fig.5 Picture of sugarcane](image4)

The purpose of this research is crushing of sugarcane. Figure 6 shows the photograph of the general sugarcane. The diameter of general sugarcane is 30mm-40mm and length are 3m or more. The pressure vessel of disintegrator of the batch type cannot continuously be crushed.

Moreover, the diameter of the hose of the disintegrator for the milling flour is small. Then, the suitable disintegrator for crushing food that the
diameter is fat, and long (like a sugarcane) is developed. Figure 6,7 shows the picture of the disintegrator for sugarcane. To improve energy similarly for the milling flour, the lower side of this device is an oval structure. The aluminum blocks of the cube (Internal shape is a cylinder) are connected using the M20 bolt.

A fat, long food can be crushed by passing the silicone hose of 40mm (inside diameter) through the aluminum block.

CRUSHING EXPERIMENT AND EVALUATION METHOD OF SUGARCANE

Figure 8 shows the flow of the experiment method. At first, the part of the node is removed and cut. The sugarcane taken out is cut into the vertical direction, and one side is compressed. The other part crushes by the shock wave and is compressed. The effect of the compression improvement using the underwater shock wave is verified by comparing the juice extraction. Figure 9 shows the picture of the juice extraction sugarcane device. Sugarcane is set in the device, and the juice extraction is extracted by compression using oil pressure. The compression pressure is constant and the juice extraction is calculated by the following expressions.

\[ R = \frac{M_1}{M_0} \times 100 \]  

\( R \): Juice extraction Ratio(%)  
\( M_0 \): Mass of sugarcane (before compression) (g)  
\( M_1 \): Mass of bagasse (g)  
\( t \): Number of shockwave(0 is untreated)

On the other hand, the percentage of moisture content of each bagasse is measured.

RESULT OF JUICE EXTRACTION AND DISCUSSION

Figure 10 shows the relation of the number of the shock wave and juice extraction ratio. The horizontal axis is the number of the shock wave and the vertical is juice extraction. The line of the length of each plot is the scattering of each experiment. The effect of the improvement of 19% (5 shock waves) and 7% (1 shock waves) is able to be confirmed by this graph. It is clear that juice extraction is improved by the number of the shock wave increasing. If the number of the shock wave is more increased, the maximum juice extraction efficiency is clarified. Moreover, the charging time of the shock wave is about 5sec. It is necessary to clarify the most efficient experimental condition by the relation between amount of crushing per hour and the juice extraction.

Next, the percentage of moisture content of sugarcane (Untreated) and Bagasse (Only compression, shock wave and compression) is measured.
Untreated 75.68%
Only compression 68.73% (+6.95%)
shock wave and compression 66.20% (+9.48%)

It is clear that the percentage of moisture content improve 3.5% by crushing using the underwater shock wave. The production of sugarcane in the Okinawa prefecture is about 1 million ton. If these improvements can be built to the unrefined sugar production system, a big economic effect is expected. Figure 11, 12 shows the SEM image of sugarcane and bagasse. The existence of the hole can be confirmed by the section photograph of bagasse to the cell wall. Thus, it is thought that juice extraction improved by the effect of destroying the cell wall using underwater shock wave.

CONCLUSION

We designed and produced the pressure vessel of disintegrator, and able to confirm that the continuous crushing is possible. It is clear that the percentage of moisture content and juice extraction ratio improve by crushing using the underwater shock wave. Moreover, the mechanism of improvement effect juice extraction is clarified from the SEM image.

REFERENCES