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EFFECT OF SHOCK LOADING ON FOOD PROCESSING

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ABSTRACT

In the food industry, it is hoping high value-aided product and the increase in efficiency of food processing. On the other hand, we get an experimental result that the load of the shock wave improves an extraction of food, and soften food. But, the safe and high efficiency pressure vessel for the processing is necessary to apply these technologies to the food processing field actually. Therefore, we are planning the development of the pressure vessel for food processing. The fundamental data of the shock loading to food are necessary in order to make suitable vessel. As for these data, it is variety the specifications required by the kind of food and effect to expect.

We report the result that shock wave loading was done to various food.

INTRODUCTION

In the food processing field, static pressure was mainly used for high pressure processing. For example, in the case of meat, experiments were carried out very much by Macfarlane in the 1970's [1]. They reported about the softening of the meat and the effect of the improvement of the water-holding by high pressure processing [2-4]. The following is reported about the meat fiber: High pressure processing makes the structure of the meat change and some of the proteins of that become solubilization. Effect of solubilization of the proteins proceeds as much as time is long as much as pressure is high [5-8].

On the other hand, These technique using shock waves from explosion of explosives or discharge of high current in water results in new industrial development as non-thermal food sterilization[9, 10]. Shock waves from explosion of explosives or discharge of high current in water can get high pressure comparatively easily though action time is short. When an underwater shock wave incidents into food and the structure, it is known to propagate as an incident wave and a reflected wave. An extraction and the softening of food are achieved by the incident wave, the reflected wave, and the difference of impedance in food. Shock wave processing has the possibility to bring the effect for which to be different from the pressure processing by the static pressure. We try to the food processing using an underwater shock wave for several food.

EXPERIMENTAL APPARATUS AND METHOD

The outline of the experiment device is shown in Fig.1. The food samples packed by polystyrene envelope and a detonating fuse (Japan Carlit Co. Ltd., The 2nd kind detonating cord, principal ingredient: PENET, loading density: 1200kg/m^3, outer diameter: 5.4mm, detonation velocity: 6308m/s) were fixed on the wire netting container (see in Fig.2 in the case of pineapple). The wire netting container was put in the water-proof pressure vessel made by steel, and the water-proof pressure vessel was filled with the water. The initiation is made by the No.6 electric detonator (Asahi Chemical Industry Co. Ltd., Japan).

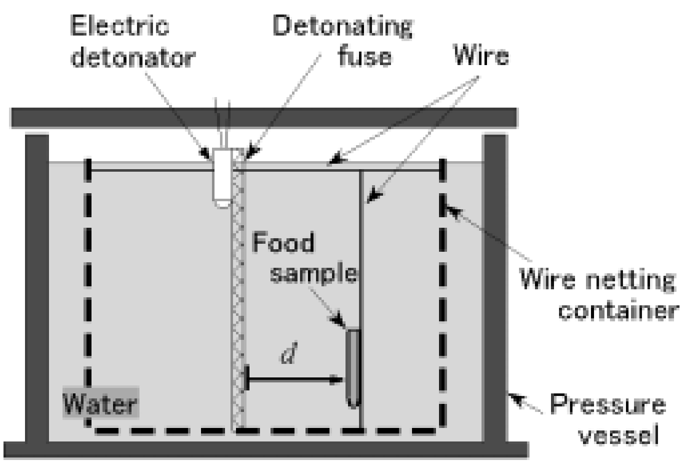


Fig.1 Outline of the experiment device

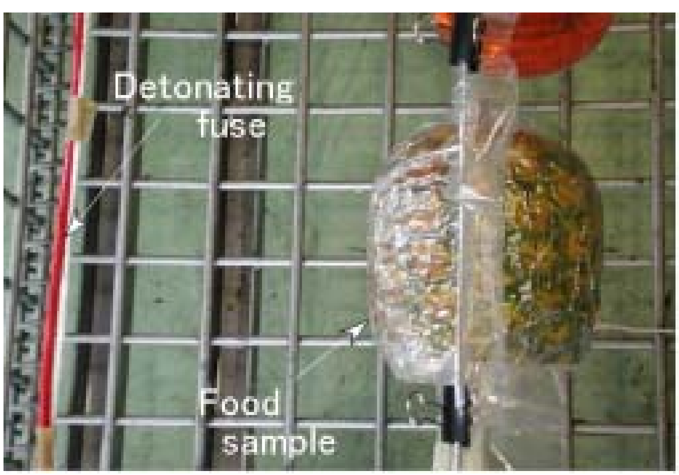


Fig.2 Photograph of experimental set up in the case of pineapple

The relation between the pressure value of underwater shock wave and the distance from the detonating fuse obtained by the pressure measurement is shown in Fig. 3. The pressure measurement of underwater shock wave generated by the detonating fuse was performed at the point's 30mm, 50mm, 70mm, 165mm, 170mm, 300mm, 500mm 1000mm and others from the detonating fuse. The underwater shock wave generated from the detonating fuse attenuates gradually while propagating in water.

RESULTS AND DISCUSSIONS

Softener of pineapple

In this pineapple case, a sample was wrapped in PVDC wrap, and was vacuum packed in PE envelope. The pineapple was shocked at the condition of the pressure level 50MPa.

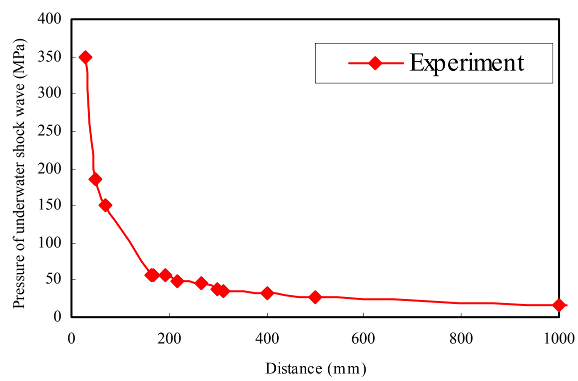


Fig.3 Relationship between pressure of underwater shock wave and distance

Fig.4 Photograph of original pineapple and shocked one

Photograph of pineapple is shown in Fig.4. The left hand side of this photograph shows the original (un-shocked) sample and the right hand side of this photograph shows the shocked sample. It seems that the shocked one is dark and one's color is juicy. When we try to touch shocked sample, it is softly and easily full of juice. Actually, we could eat the part that wasn't usually eaten in the shocked sample. We tried a blank test without telling it to the trial subject. The result that an eaten part was measured in the weight is shown in the Fig.5. The value was calculated in the ratio of the weight of the eatable part to the whole weight. It is understood that eatable parts of food sample increase in about two times by the shock wave processing.

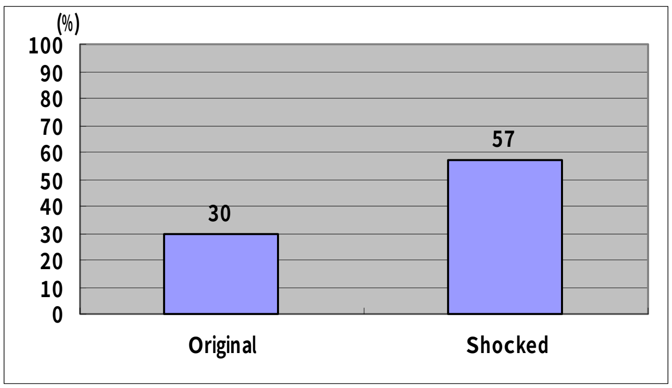


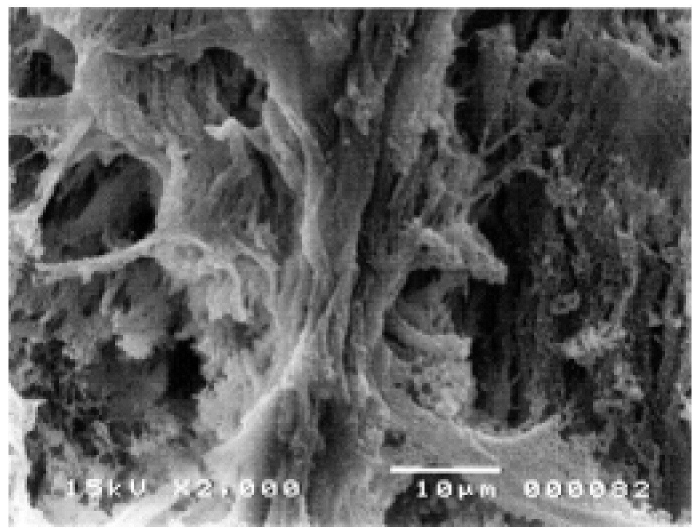
Fig.5 Ratio of eatable part weight to whole weight

(a) Before

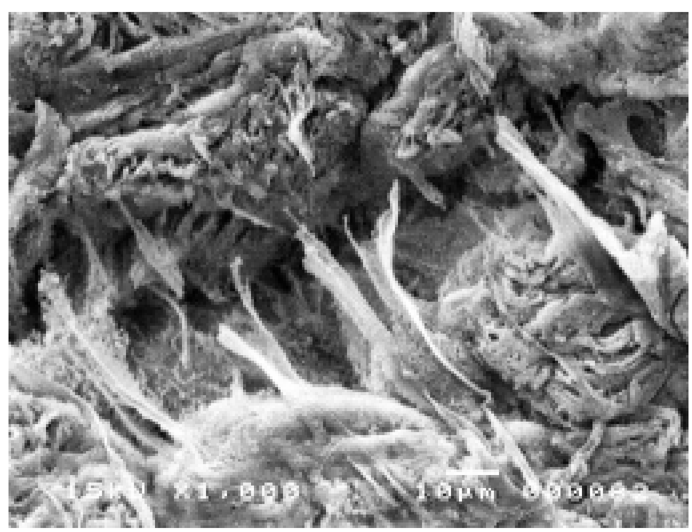
(b) After
Fig.6 Photograph of beef for steak

Softener of beef for steak

Beef for steak was shocked at the condition of the pressure level 50MPa. The way of the pack is the same as the case of pineapple. Figure 6 (a) and (b) shows the photographs of beef for steak before and after the application of shock wave respectively. Though a color seems to change a little, the difference is hardly seen in appearance. We tried to take a SEM photograph to see the condition of the fiber. Figure 7 shows the SEM photograph. Figure 7 (a) shows the original material and (b) shows the shocked material. It seems that fiber is cut off in the case of shocked sample (Fig. 7(b)). In order to investigate eating quality, both of samples were grilled on the same condition and were eaten by four test subjects on the blank. All four test subjects said that the food sample which processed a shock wave is soft, and eats easily.



(a) Before



(b) After
Fig.7 SEM photograph of beef for steak

(a) Before

(b) After
Fig.8 Photograph of ginger

Softener of ginger

The ginger cut into proper size was put into the test pressure vessel made by Polycarbonate, which has nominal volume 100ml. In this case, the ginger was shocked at the condition of the pressure level 50MPa. It seems that the shocked one is dark and one's color is juicy, like a case of pineapple. Figure 8 (a) shows the original material and (b) shows the shocked material. We couldn't squeeze un-shocked ginger though we could squeeze shocked ginger by hand. Since the smell of shocked ginger was very strong, it was found that an inside extract came out well.

Improvement extractability of coffee beans

In this coffee beans case, a sample was wrapped in plastic wrap, put into the test pressure vessel made by Polycarbonate. These were shocked at the condition of the pressure level 100MPa. Photograph of food sample is shown in Fig.9. The left hand side of this photograph shows the original (un-shocked) sample and the right hand side of this photograph shows the shocked sample. There is no change in the appearance at first glance. But, very small crack is in innumerably throughout the shocked beans Both of original and shocked beans were put into room tenperature water in order to investigate extractability.

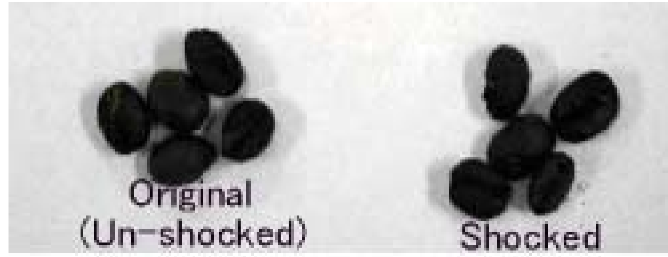


Fig.9 Photograph of coffee beans

(a) After 1hour in water (b) After 6hours in water
Fig.10 Result of extractability test of coffee beans

(a) Before (b) After
Fig.11 Photograph of the green tea

Figure 10 (a) is a photograph after an hour and (b) is a photograph after six hours, respectively. It is understood that an extractability rises very much by the shock wave processing.

Smashing the green tea

The Japanese green tea was shocked at the condition of the pressure level 100MPa. Photograph of green tea is shown in Fig .11 (a) and (b). Test sample was smashed very well. It can

Fig.12 Photograph of original unshelled walnut

be processed without injuring flavor because it is non-heat-processing fundamentally.

Smashing the walnut

We tried smashing of the walnut by the shock wave. The unshelled walnut was used in experiment (see in Fig.12). In this case, unshelled walnuts was whole put into the test pressure vessel made by polycarbonate, and a shock wave was processed. Figure 13 shows the photograph of shocked material. Figure 13 (a) is photograph of shoked material in the case of 50MPa, (b) is photograph of shoked material in the case of 70MPa and (c) is photograph of shoked material in the case of 100MPa. As strength of shock wave becomes small, it is understood that particle size becomess big. This result suggested the possibility that it is useful for smashing of the various size and unshelling by controling the strength of the shock wave.

CONCLUSIONS

Experiments for several food samples on food processing by shock wave were carried out, in order to get fundamental data for development a pressure vessel for shock wave processing. In the case of a shock wave processing, as for the condition of 100MPa or under, softening and the improvement of the extraction were seen.

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(a) In the case of 100MPa

(b) In the case of 70MPa

(c) In the case of 50MPa

Fig.13 Photograph of shocked walnuts

REFERENCES

[1] J. J. Macfarlane, 1985, "Developments in Meat Science-3", Ed. R. Lawrie, Elsevier Applied Science Publishers, Barking.
[2] J. J. Macfarlane, 1973, J. Food Science, 38, 294.
[3] P. E. Bouton, P. V. Harris, J. J. Macfarlane and J. M. O'shea, 1977, Meat Science, 1, 307.

[4] J. J. Macfarlane, I. J. Mckenzie, R. H. Tuerner and P. N. Jones ,1984, Meat Science, 10, 307.
[5] J. J. Macfarlane, and D. J. Morton, 1978, Meat Science, 2, 281.
[6] A. Suzuki, M. Watanabe, K. Iwamura, Y. Ikeuchi and M. Saito, 1990, Agric. Biol. Chem., 54, 3085.
[7] J. J. Macfarlane, 1974, Food Science, 39, 543.
[8] A. Suzuki, N. Suzuki, Y. Ikeuchi and M. Saito, 1991, Agric. Biol. Chem., 55, 2467.
[9] Acim M. Loske, Ulises M. Alvarez, Claudia Hernandez-Galcia, Eduardo Catano-Tostado, and Fernando E. Prieto, " Bactericidal effect of underwater shock waves on Escherichia coli ATOC 10536 suspensions " Innovative Food Science & Emerging Technologies 3, 2002, pp.321-327.
[10] Ulises M. Alvarez, Achim M. Loske, Eduardo Castano-Tostado, and Fernando E. Prieto, " Inactivation of Escherichia coli O157:H7, Salmonella Typhimurium and Listeria monocytogenes by underwater shock waves ", Innovative Food Science and Emerging Technologies 5, 2004, pp.459-463.

