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Manufacturing Method of Okara-Containing Soybean Curd Using Steam Explosion

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Abstract: Development of novel manufacturing method of soybean curd including Okara using steam explosion was attempted. Furthermore, the main contents (i.e. moisture, crude fiber, protein lipid and ash) and rupture stress of the soybean curd produced by novel manufacturing method were investigated. It was able to produce the soybean curd which included a lot of crude fiber by the miniaturization of crude fiber in Okara using steam explosion. By addition of the steam exploded Okara to soybean curd not only the utilization of Okara but also the possibility of the high-nutrition soybean curd production was suggested.

Key words: Steam explosion, soybean curd, Okara, crude fiber, soybean curd residue

INTRODUCTION

Soybean curd residue, known as Okara, is produced from the tofu (i.e., soybean curd) industry in Japan. It was once consumed as a traditional food, but the Okara is just treated as industrial waste with little market value because of its short shelf life (Toole, 1997). Okara is now mainly incinerated like other industrial wastes (Ohno *et al*., 1996). In fact, Okara, generally contains protein up to 25.4-28.4% (dry basis) with high nutritive quality and superior protein efficiency ratio, suggesting that it is a potential source of low cost vegetable protein for human consumption (Toole, 1997; Kasai *et al*., 2004). In Japan, processing industries discharge as much as 800,000 tons of Okara annually (Taka *et al*., 2005). Many trials for using Okara have been reported; however, most of these reports were on its fermentation (Kronenberg and Hang, 1984; Matsuo, 1989), extraction of protein from Okara, utilization fro animal feed or mushroom medium (Wong *et al*., 1996) and extraction of emusionizing polysaccharides from Okara (Yoshii *et al*., 1996; Kasai *et al*., 2004). There are few reports about the method to make effective utilization of Okara as food, because the use of Okara has been difficult fiber content and unsavory texture for eating.

Recently, the steam explosion treatment has been attractive for the degradation and separation of not only structural components, i.e. cellulose, hemicellulose and lignin, but also antineoplastic constituents and antioxidants from plant biomass (Kurosumi *et al*., 2006, 2007). The principle of the steam explosion treatment is the steam hydrolysis at high temperature and pressure, followed by sudden reduction of the pressure for physical treatment of the hydrolyzed product to produce low-molecular weight substances.

In this research, development of novel manufacturing method of soybean curd including Okara using steam explosion was attempted. Furthermore, the main contents (i.e., moisture, crude fiber, protein lipid and ash) and rupture stress of the soybean curd produced by novel manufacturing method were investigated.

MATERIALS AND METHODS

Soybean: Soybeans (Glycine max) from Kanazawa in Japan were used as an ingredient of soybean curd in this study.

Steam explosion: Steam explosion apparatus (Japan Chemical Engineering and Machinery Co., Ltd, Osaka, Japan) consisted of a high pressurized reactor, a steam generator, a receiver and a condenser with a silencing action (Sawada and Nakamura, 2001; Asada *et al*., 2005). The reactor was maintained at a constant temperature. The capacity of the reactor was 1.2 dm^3 and the highest temperature was 275°C (5.5 MPa). A total 50 g of Okara was put into the reactor and then steam-heated at a steam temperature of 160 or 180°C for a steaming time of

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10 or 3 min. A ball valve at the bottom of the reactor was then suddenly opened to bring the reactor rapidly to the atmospheric pressure. The product containing solid and liquid materials was recovered in the receiver.

Manufacturing method of soybean crud: Figure 1 shows that comparison of novel manufacturing method and conventional manufacturing method. The dry soybeans were soaked in water of 30°C for 24 h. The soybeans including the water were divided to soybean milk and soybean milk residue, Okara, by filtration after they were warmed at 90°C for 7 min while it was crushed. Okara have been dumped in the conventional manufacturing method. However, in novel manufacturing method the Okara was added in soybean milk after steam explosion treatment. The steam exploded Okara was mixed with soybean milk enough. Soybean curd was produced by warming at 80°C for 1 h after the coagulant addition to soybean milk. In the conventional manufacturing method, the magnesium chloride which was a salt coagulum was used as a coagulum. In the novel manufacturing method, the glucono-δ-lacton which was an acid coagulum was used to help with progress of the solidification.

Analysis method: Moisture content of soybean curd, crude fiber, protein, lipid and ash were measured. Moisture content was determined by drying the samples 24 h in an oven at 105°C (AOCA, 1996). The crude fiber content of the sample was determined using the modified Henneberg-Stohmann method (McCleary, 2003; Hirayama *et al*., 1970). The protein and lipid content of the sample were determined using the Kjeldahl Method (AOCA, 1996) and the Soxhlet method (Khalil *et al*., 2007), respectively. Ash was measured by plant material mineralization in electric oven at 550°C.

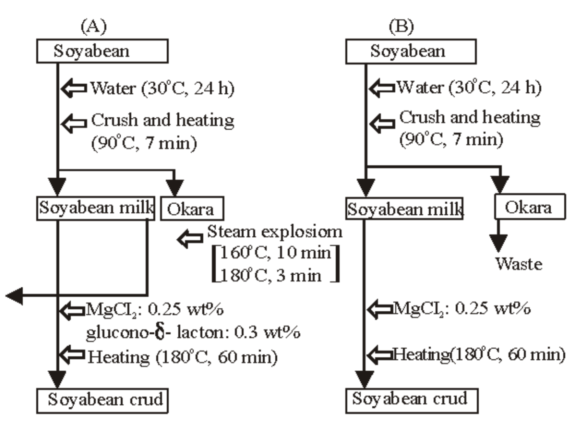

Fig. 1: Comparison of novel manufucturing method and condintional manufucturing method

RESULTS AND DISCUSSION

Figure 2 shows that effect of steam explosion in amount of crude fiber in Okara. The amount of crude fiber in Okara I was about 15.3 g/(100g-Okara). The amounts of crude fiber in Okara II and Okara III were about 7.4 g/(100g-Okara) and 11.4 g/(100g-Okara), respectively. It is thought that the reason why the amount of crude fiber in Okara decreased by steam explosion was hydrolysis reaction by high temperature steam and miniaturization by rapid depressurization. It seemed that a part of the Okara was solubilized to water. It is thought that the reason why amount of crude fiber in Okara II decreased more compared to that of Okara III is because the hydrolysis for the long time at low temperature was effective to a low molecule of the crude fiber.

Table 1 shows that comparison of main contents and rupture stresses of soybean curds. The remarkable difference was not confirmed to amount of water included in each soybean curd and it was about 90 (g/100 g). The amounts of crude fiber in soybean curd added Okara II and Okara III were 0.18 (g/100g) and 0.26 (g/100 g), respectively. The amount of crude fibers in the soybean curds with Okara II and Okara III were 6 times and 9 times, respectively more than the soybean curd without Okara. When untreated Okara was added in soybean milk, it was not solidified by the coagulum. It is thought that this is because grain size of crude fiber included in Okara was large. Therefore, it was able to produce the soybean curd which included a lot of crude fiber by the miniaturization of crude fiber in Okara using steam explosion. In addition, it is thought that the crude fiber miniaturized by steam explosion became the water-soluble fiber and effects by this water-soluble fiber such as the prevention of a sudden rise of blood glucose level after meal and the inhibition of cholesterol absorption may be expected. The remarkable difference was not confirmed to amount of protein included in each soybean curd and it was about 4.6 (g/100 g). The amount of lipid in soybean curd including Okara II was less than that including Okara III. It is thought that this is because a part of the lipid was dismantled by heat. However, compared to soybean curd without Okara the amount of lipid in soybean curd with Okara II was rich. By novel manufacturing method using steam explosion, production of the soybean curd that amounts of crude fiber and lipid were rich in comparison with the soybean curd which it produced by conventional manufacturing method was enabled. The rupture stresses of soybean curds including Okara II and Okara III were about 5.56 and 5.18 kPa, respectively. Because the rupture stress of soybean curd produced by conventional manufacturing method was 10.15 kPa, the soybean curd

Table 1: Comparison of main contents and rupture stresses of soyabeam curd

	Contents (g/100 g)					Rupture stress
	Moisure	Curd fiber	Protein	Lipid	Ash	(kPa)
Soyabeam curd including Okara II	88.80±0.22	0.18±0.01	4.60±0.25	2.82±0.17	0.61±0.02	5.56±0.45
Soyabeam curd including Okara II	87.13±0.47	0.26±0.02	4.57±0.11	2.58±0.25	0.58±0.02	5.182±0.47
Soyabeam curd	90.04±0.01	0.03±0.01	4.55±0.28	2.54±0.03	0.76±0.03	10.15±0.78

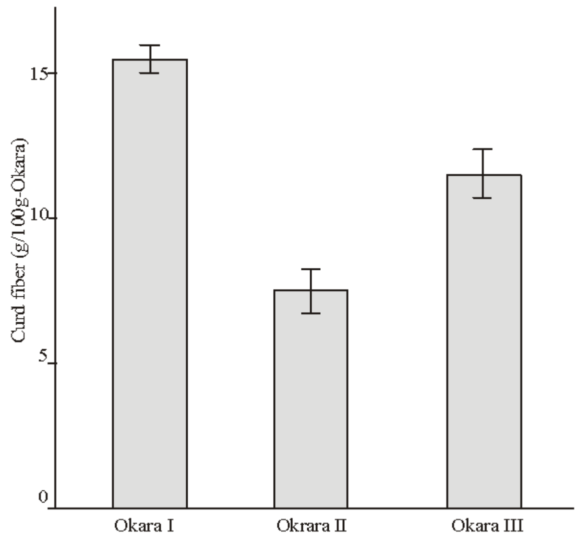

Fig. 2: Effect of steam explosion on amount of crude fiber in Okara. Okara I: Untreated, Okara II : Seam exploded at a steam temperature of 160°Cand a streaming time of 10 min, Okara III: Steam exploded at a steam temprature of 180°C and a streaming time of 3 min

produced by novel manufacturing method was very tender soybean curd. Because Okara doesn't occur as waste by using novel manufacturing method, it is thought that this manufacturing method is the green manufacturing method that can reduce waste disposal treatment costs.

CONCLUSION

It was able to produce the soybean curd which included a lot of crude fiber by the miniaturization of crude fiber in Okara using steam explosion. By addition of the steam exploded Okara to soybean curd not only the utilization of Okara but also the possibility of the high-nutrition soybean curd production was suggested.

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