Available online at
https://journal.rescollacomm.com/index.php/ijqrm/index

International Journal of Quantitative Research and Modeling

e-ISSN 2721-477X
p-ISSN 2722-5046

Vol. 2, No. 2, pp. 75-82, 2021

Production Technology for Adding GDL (Glucono Delta Lactone) to Soy-Based Foods

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Abstract

The technology of adding Glucono Delta Lactone (GDL) to food made from soybeans is gaining popularity because it has many advantages. GDL is an acid that functions to coagulate proteins. GDL is a food additive that is Generally Recognized as Safe (GRAS). GDL has been applied in soy-based products such as tempeh and tofu. The use of GDL in tempeh products can reduce the acidification time of tempeh to 2-3 hours so that the production capacity of tempeh can increase significantly and reduce the amount of water used in the production process. The use of GDL in tofu is as a coagulant which makes the quality of tofu better than other agglomerates. The main objective of this paper is to provides an explanation of the application of GDL to soy-based foods. So, GDL can be used as an innovation to develop soybean-based food industries. It begins from describing about GDL, provides comparison between natural soy-based food and soy-based foods with GDL from study literature. Then moves to the application of GDL in tempeh, the application of GDL in tofu, and Back-Slopping technology.

Keywords: Back-slopping, Glucono Delta Lactone (GDL), Soybean

1. Preliminary

Soybean (Glycine max) is a plant that has long been cultivated in Indonesia (Mariyono, 2019; Malik, A., and Nainggolan, 2020). Soybean is a secondary crop category with a high enough source of vegetable protein to overcome the lack of calories and contains more complete essential amino acids (Naito et al., 1993; Krisnawati and Adie, 2015). Some of the famous processed soy foods are tempeh and tofu. In addition, both are processed food products that have a fairly high level of demand at affordable prices and contain high protein (Ningrum et al., 2018; Adie et al., 2014).

Tempeh and tofu have a long production time. Tempeh has a production time of up to 3 days and tofu has a production time of 12-24 hours. The processing time is long enough to make the quantity of tempeh and tofu production low. However, the high level of demand makes it unable to meet market needs. So, we need innovation so that the processing of tempeh and tofu is faster, namely by adding GDL (Wang et al., 2020; Zheng et al., 2020).

The technology of adding GDL to food made from soybeans is gaining popularity because it has many advantages. GDL is an acid that functions to coagulate proteins and food additive that is Generally Recognized as Safe (GRAS) (Johnson et al., 2003; Ojukwu et al., 2020). GDL has been applied in soy-based products such as tempeh and tofu. The use of GDL in tempeh products can reduce the acidification time of tempeh to only 2-3 hours so that the production capacity of tempeh can increase and reduce the amount of water used in the production process (Yang et al., 2021; Wijaya and Nurjanah, 2015). While the use of GDL in tofu will provide a better quality of tofu (Inggrid and Hananjaya, 2020; Sim et al., 2020; Arii et al., 2021)

The use of GDL in tempeh and tofu did not affect the taste, compactness, texture, and nutrition of both (Jia et al., 2009). However, GDL has a fairly expensive price so that production costs are high. Therefore, back-slopping technology has begun to be developed in the process of making tempeh and tofu is still being tested. Back-slopping technology is the reuse of the remaining GDL solution from the tempeh soaking process. The use of a back-slopping solution can produce tempeh which is no different from the results of the initial soaking of the GDL solution. The application of back-slopping is expected to reduce production costs for using (Wijaya and Nurjanah, 2015). So, that the application of back-slopping technology can increase the quantity, quality, and production benefits for tempeh producers. The main contribution of this research is to provides an explanation of the application of GDL to soy-based foods. So, GDL can be used as an innovation to develop soybean-based food industries.

2. Study Literature

2.1 Definition Of GDL (Glucono Delta Lactone)

Glucono Delta Lactone (GDL) or also known as lactone is a food additive derived from the hydroxycarboxylic acid group of cyclic ester types. GDL is Generally Recognized as Safe (GRAS)[2]. GDL is naturally found in the body of bees and humans. Synthetically, GDL can be made by fermenting corn starch. GDL in the food industry functions as a protein coagulant because it has a strong affinity for water and protein deposits. GDL is commercially available and has been widely applied in the food industry[5]. GDL available in the market has a white fine crystalline form, odorless, and tasteless. In soybean-based food preparations, initially, GDL was only used as tofu coagulation. But now, GDL has been used as an acidifier that speeds up the tempeh fermentation process. GDL is also used in other processed foods such as sausages, yogurt, and various dessert mixes.

2.2 Comparison Between Natural Tempeh Acidification and GDL's Tempeh Acidification

The demand for tempe products both in Indonesia and other countries is quite high. So, it is expected that the amount of production can meet consumer needs but with quality that matches expectations. However, the facts on the ground show that tempe processing is still using the traditional method. This method takes a long processing time and the resulting product sometimes is not uniform. Therefore, an innovation is needed to speed up the tempeh production process and produce uniform quality products, one of which is using GDL. Comparison natural tempeh with GDL can be seen in Table 1.

Table 1. Comparison natural tempeh with GDL

Comparison Criteria	Natural Tempeh	Tempeh With Gdl
Acidification Time	Overnight	2-3 hours
Washing Proccess	Two steps	One step
Acidification Proccess	Not controlled	More controlled
Consistency	Less uniform	More uniform
Nutrition	Not much different	

2.3. Comparison Between Tofu With GDL and Tofu With Other Coagulants

Tofu is the one of soybean products that has long been known in many countries. Tofu has a soft texture and a distinctive aroma and taste. In the tofu processing process, a coagulant is needed, so that the tofu can solidify properly. The agglomerates used are usually acid coagulation (lactic acid and acetic acid), calcium coagulation, or magnesium coagulation. However, the wrong choice of agglomerate will result tofu with less acceptable organoleptic properties. Therefore, a coagulation agent is needed that can produce better organoleptic tofu, namely GDL. Comparison tofu with gdl and tofu with other coagulants can be seen in Table 2.

Table 2 Comparison tofu with gdl and tofu with other coagulants

Comparison Criteria	Tofu with Other Coagulants	Tofu With Gdl
Texture	Coarsed textured (magnesium or calcium coagulants) and brittle (acid coagulants)	Soft and not easy brittle
Aroma	Unpleasant aroma	Pleasant aroma
Taste	Sour (acid coagulant)	Slightly sour
Water holding capacity	Low (magnesium or calcium coagulants)	High
Clotting	Faster (magnesium or calcium coagulants and GDL)	

3. Results and Discussion

3.1 The Application of GDL in Tempeh

Tempeh is a product obtained from fermenting soybean seeds using Rhizopus sp., in the form of a compact solid, slightly grayish-white, and has a characteristic tempeh odor (Christian et al., 2019). Fermentation in tempeh can be done spontaneously or using a starter culture to produce uniform quality. An important process for good tempeh fermentation is acidification both naturally and chemically. Tempe acidification process in Indonesia is done by soaking soybeans that have been boiled at a temperature of 28-31°C until the water is foamy and smells sour. While the chemical acidification process is widely used by countries with subtropical climates by adding acidifying agents to obtain suitable conditions for molds to grow. The natural process of making tempeh can be seen in Figure 1.

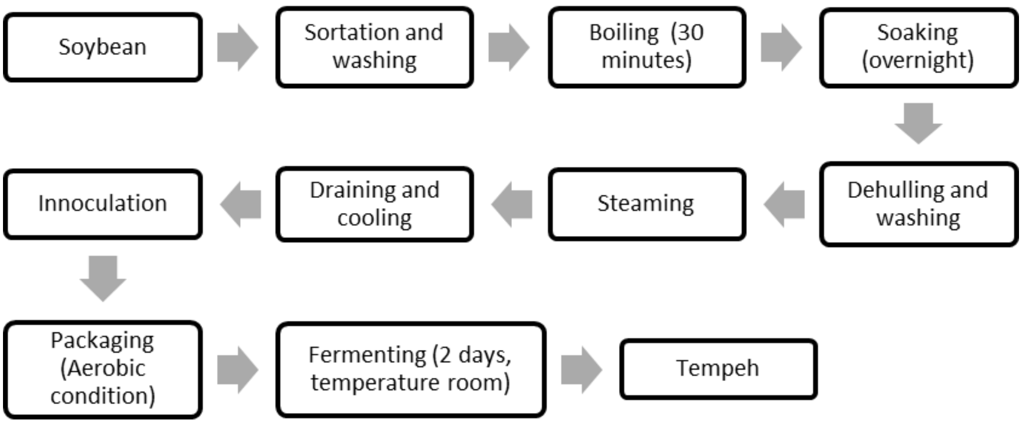

Figure 1 The natural process of making tempeh

However, there are several obstacles in the natural acidification process such as the length of time of production, the consistency of the final quality of tempeh which is less uniform, and the wastewater from the processing is feared to pollute the environment. So that the chemical acidification process began to be developed by adding GDL (Glucono Delta Lactone) to the tempeh making process through the product "Quick Tempe". GDL works by replacing the natural acidification process obtained by soaking soybeans overnight. So, this process can summarize the acidification time of tempeh in just 2-3 hours. This is because the soaking process using GDL can bind water and protein in soybeans so that soybeans can later form mycelium in a short time. In addition, the resulting quality will be more uniform and water use will be reduced.

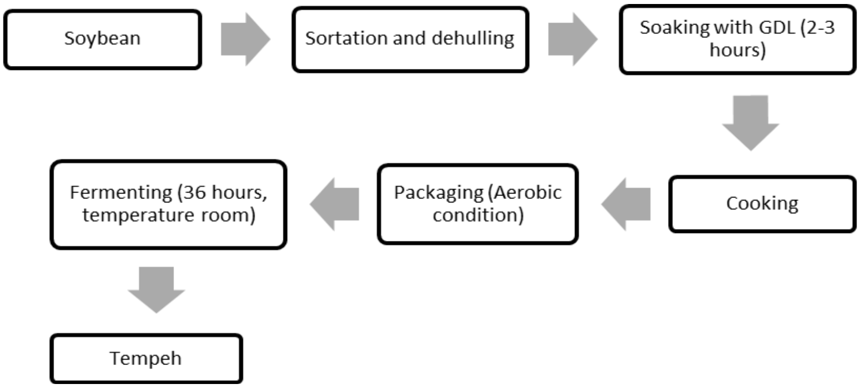

Figure 2 Making Tempeh with GDL (Wijaya and Nurjanah, 2015)

Although the acidification process uses chemicals, this will not affect the taste, compactness, and nutrients contained in tempeh. Controlled acidification can produce tempeh quality with a more stable taste (Wijaya and Nurjanah, 2015). There was no significant difference between tempeh processed using GDL and natural tempeh. In addition, there was no decrease in nutrition between natural tempeh and tempeh processed using GDL (See Figure 2). So, it can be concluded that processing tempeh using GDL saves more time but does not reduce the taste, compactness, and nutrients contained in tempeh. comparison natural tempeh and GDL's Tempeh can be seen in Figure 3. The nutrient content between natural tempeh and GDL’s Tempeh can be seen in Table 3.

Figure 3 Natural Tempeh (Left) and GDL's Tempeh (Right) (Wijaya and Nurjanah, 2015)

Table 3. Nutrient content between natural tempeh and GDL’s Tempeh

Product	Contents (%)			
	Protein	Fat	Carbohydrate	Fiber
Traditional Tempeh	35.30	24.87	28.12	6.30
Tempeh with GDL	39.85	23.20	26.43	6.11

3.2 The Application of GDL in Tofu

Tofu is a product made from the clumping of protein from beans. Tofu has been widely known both in Indonesia and foreign countries (Li et al., 2014). Tofu consists of several types including white tofu, beancurd, hard tofu, silken tofu, kori tofu, sufu, and Thai tofu. Tofu is made using auxiliary materials in the form of coagulants. Coagulants work by precipitating protein and trapping water contained in soybean juice. Then the water is removed from the protein deposits by applying pressure to leave only the protein clumps. The clumps of protein are then referred to as tofu.

Some of the coagulation materials that can be used are tofu or sioko, vinegar acid, tofu (whey), pure calcium sulfate, and GDL (Tseng and Xiong, 2009). However, not all coagulants will produce good quality tofu. Acid coagulants such as lactic acid and acetic acid produce low yields tofu with a brittle and slightly acidic texture. Meanwhile, calcium or magnesium chloride coagulant produces tofu with good flavor, faster clotting, but coarse-textured tofu due to low water holding capacity. So, we need a type of coagulant that can produce tofu with better texture, flavor, and aroma. After conducting various studies, the right coagulant was obtained, namely Glucono Delta Lactone (GDL).

Glucono Delta Lactone (GDL) in the tofu production process works as an acid-type coagulant. The reason why GDL is appropriate to be used as a coagulant is because it has a high water-holding capacity and the resulting tofu has a soft, gel-like texture and is not easily brittle. Tofu that is processed using GDL also produces a slightly sour taste and no unpleasant aroma. Some of these reasons make tofu with GDL coagulant preferred by the public. So, it can be concluded that tofu that is coagulated with GDL will produce tofu with much better quality than tofu that is coagulated using other coagulants (Li et al., 2021).

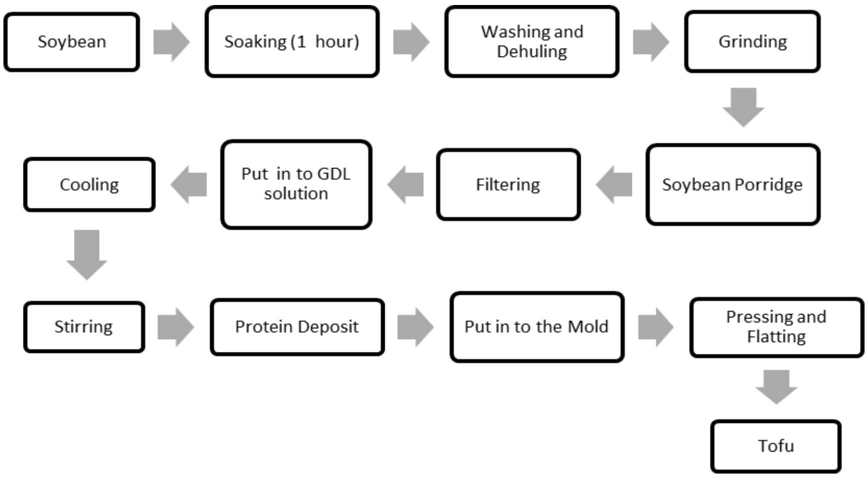

Figure 4 Tofu Making with GDL (Source: Interview Result)

3.3 Advantages and Disadvantages of the Use of GDL in Soy-Based Foods

The use of GDL in food made from soybeans certainly has advantages and disadvantages. In tempeh, the excess use of GDL will shorten the soy acidification time to only 2-3 hours. The water used is less because the washing process is not carried out many times so that it can prevent environmental pollution. In addition, acidification using GDL will make the taste and results more uniform because the acidification process is controlled. Although processed using chemical acidification, the nutrients and compactness produced are not much different from tempeh produced by natural acidification.

The advantage of using GDL in tofu is that it can produce a better-quality tofu. Tofu that is processed using GDL will have a softer and stronger texture. In addition, the use of GDL in tofu will not affect the nutrition, color, and aroma of tofu so that the organoleptic quality of tofu is guaranteed. This causes tofu processed with GDL coagulant to be preferred by the public. It can be concluded that the excess use of GDL in processing tempeh and tofu will shorten processing time, but the resulting product still has good quality and even increases in several aspects.

While the disadvantage of using GDL is the selling price on the market. GDL in the market has a fairly expensive price. This causes producers to prefer to process products with natural acidification and coagulation to save production costs. In addition, the use of GDL with the wrong amount will damage the quality of the resulting product. So, we need an innovation using GDL which is more cost-effective but product quality is guaranteed.

3.4 Opportunities and Challenges of using GDL

The use of GDL in the manufacture of tofu and tempeh has great opportunities. Currently, in Indonesia, there are around 81 thousand tempeh-making businesses that produce 2.4 million tons of tempeh per year. Based on the SUSENAS data in 2015 released by BPS, the average consumption of tempeh per person per year in Indonesia is 6.99 kg and tofu 7.51 kg (Zheng et al., 2020). So, the use of GDL will be needed to meet market demand. The use of GDL in the manufacture of tempeh will produce a product with less waste-water, uniform product quality, and shorter production time. In addition, we already know that tempeh which is processed using a GDL acidifier has been selected as one of the 100 Indonesian innovations in 2008 with a product called "Quick Tempe". So this will be an opportunity for tempeh industries that still use natural acidification processes to switch to chemical acidification processes using GDL.

The use of GDL as tofu coagulation has been applied for quite a long time. However, there are still many manufacturers who choose to use other coagulants than GDL. This is because other types of coagulants have lower prices. Even though it is cheaper, the tofu produced is of poor quality. Such as brittle texture, mushy, unpleasant, and sour so that it is not liked by the public. Based on this, GDL began to be used as tofu coagulation and the resulting product had a better quality. Tofu that is processed using GDL coagulant has a soft, strong texture, no unpleasant aroma, and a slightly sour taste so that it is preferred by the public.

The various opportunities available certainly have their challenges. The challenge for using GDL experienced by producers is the relatively expensive price of GDL compounds. This causes many tempeh producers to choose to use a natural acidification process even though it takes time. Meanwhile, tofu producers choose to use other coagulants and even hazardous materials such as formalin so that the tofu produced is better organoleptically. The challenges faced by manufacturers then create new technology, namely back-slopping.

Back-sloppping is a technology in the form of reusing the remaining GDL solution from soaking which can be used in the next tempeh production proccess. The use of back-slopping aims to save the cost of using GDL from tempeh production, but with the concentration of the solution that must be optimized. After testing, the results obtained tempeh which has a quality that is not much different from "Quick Tempe". The application of back-slopping technology can also reduce 4.8 percent of the total production cost of "Quick Tempe" compared to without the application of back-slopping and can increase the total profit by 49.9 percent compared to natural acidification tempeh (Wijaya and Nurjanah, 2015). Although the use of back-slopping technology has been tested in tempeh production, this technology has not been tested in the tofu production process. So that in the future it is hoped that this technology can be tested in the manufacture of tofu.

4. Conclussion

Soybean is one of the important crops that has been processed into various products including tempeh and tofu. They both have a fairly high demand but the processing process is quite long, 3 days for tempeh and 12-24 hours for tofu. So, we need an innovation that aims to produce tempeh and tofu faster but the quality produced is better. The innovation is the use of GDL in the process of making tempeh and tofu. GDL in the tempeh production process functions as a substitute for soaking soybeans for one night to 2-3 hours and fermentation for only 36 hours. Tempeh produced has uniform quality and compactness but does not reduce the nutrients in it. Whereas in tofu, the use of GDL will result in a better quality of tofu, namely soft texture, strong, not unpleasant aroma, and slightly sour taste so that it is preferred by the public.

Although GDL has a high chance of processing tempeh and tofu, there are also have drawbacks. The price of GDL in the market is quite high so that it will increase production costs that are burdensome for producers. Therefore, an innovation was carried out, namely back slopping technology, where the remaining of soaking GDL solution was reused in the next tempeh production process. It has been proven that there is no significant difference between tempeh processed using back-slopping and "Quick Tempe". In addition, it can reduce production costs by 4.8 percent and increase profits by up to 49.9 percent. However, the back-slopping technology in tofu has not yet been tested. So that in the future it is hoped that back-slopping technology will be tested on tofu.

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