Study of Tempe Production from Dried Peeled Soybeans

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Abstract. Soybean seeds that will be fermented into tempeh must be peeled by tearing the skin from soybeans that have been previously boiled and soaked in water (for 24-48 hours). Tearing apart causes the seed coat to separate and the seed cotyledon to separate into two. This method is called wet peel, which requires more water, time from energy to separate the skin from cotyledons. In this study, the processing of tempeh made from raw soy peel is dried. Soybeans to be peeled were treated with drying at 50, 60 and 70°C for 12 hours. Tempeh made from dry peeled soybeans compared to the quality of the sensor is tempeh made from raw wet peeled soybeans, and tempeh made from dried peeled soybeans whose soaking process is added with soybean skin. Dry stripping of soybeans that are dried at a temperature of 70°C will produce a better peel than soybeans that are not dried, or which are dried at 50 and 60°C. The yield is 82%, seeds are not peeled 1% and seeds are damaged 1%. However, dry stripping that is done twice on un-dried soybeans can produce peels that are almost as good as soybeans that are dried first at 70°C. This method is more efficient in terms of energy and time used to get dry peel seeds, the process of making tempeh from dried peeled soybeans will save water usage by 40% and time for washing soybeans after soaking as much as 50%. The sensory quality of tempeh made from dry peeled soybeans is the same as tempeh made from wet peeled soybeans as is commonly done by tempeh producers in Indonesia.

Keywords: Tempeh, dry peel, wet peel, tempeh sensory quality

1. Introduction

Soybean seed that will be fermented into tempeh, must be split so that the bark is ripped from regardless of seed meat. Usually this process is preceded by boiling the soybean seed, then soaking it in a boiling water for 24-48 hours. Afterwards, soy is broken down so that the bark is torn and detached from the seeds.

At the making of tempeh, the toughest stage is the separation of the seed bark from the beans after stripping and soybean cleavage. In most of Tempe processing business, this separation is done by stirring the mixture of seeds, seeds that have been split and water is quite a lot in a container (bucket, basket or basin) so that the skin of the seeds tends to be on the top layer, Then the container is tilted so that some water will spill with the skin of seeds. After that the water is added again and the process is repeated until most of the seed bark is wasted. The process of splitting the seed shell like this is referred to as wet stripping [1].

The downside of such a way is that it takes a relatively long time and a lot of energy draining. Because of this, usually Tempe craftsmen do not do perfect skin separation. Skin separation is discontinued if the remaining soy seed skin does not appear too noticeable anymore. In addition, this process results in
a relatively much liquid and solid waste. Soybean seeds that are wasted with seed bark are usually pretty much too.

Another method that is being developed is Dry Stripping using disc mill, screw mill and roll mill peeler. In all types of tools, dry soybeans are used as input, then release the force and curve of the seeds so that they are split in half and the skin is peeled from the seeds. By using a disc mill with a 4.8 mm opening gap, all seeds can be split and peeled [2]. The same results can also be obtained by using a screw mill type machine whose clearance space is 2.5 mm at 386 rpm [3]. The parameters to obtain maximum results do not apply in general but depend on the type and condition of the tool.

Dry stripping against soybeans requires that soybeans should be dried first so that the skin of the seeds becomes more fragile and does not stick firmly to the seeds. The drying temperature is reportedly varied, e.g. 55°C for 20 hours [3] or 104°C for 10 minutes [4]. Tempe producers do not like dry peeled soybeans for making tempeh because the soybean marinade liquid before the soybeans are re-boiled and fermented is less acid which is suspected because in the marinade there is no seed coat enriching the nutrient content of the marinade liquid. This condition causes the quality of tempeh from dried peeled soybeans is not as good as Tempe from wet peeled soybeans [5].

The heat used in drying is used to evaporate material water so that the water content of the material decreases. During drying changes can occur in the material, including shrinkage due to disruption of the balance of tension in the cell wall against pressure in the cell. Evaporation of water will cause pressure in the cell to decrease so that the cell walls will be depressed toward the cells and the material will shrink or shrink. Drying can also cause browning reactions between amino acids and reducing sugars thereby reducing the content and quality of the protein contained in the ingredients. High temperature drying can cause case hardening due to too fast a reduction in surface water content by high temperatures, or due to protein clumping, or the formation of dextrin from starch which will become a massive mass at high temperatures [6]. Protein which can be extracted in the processing of soy milk from raw materials of dried peeled soybeans is lower than soybean milk from raw wet peeled soybeans [7].

Based on this background, a study was conducted to study the processing of tempeh using dried peeled soybeans to obtain the same quality of tempeh as tempeh made from wet peeled soybeans. The process studied is how to dry to get a relatively high yield and quality of peeled soybeans, the effect of adding seed coat marinade as a source of additional nutrients for microbes when soybean seeds are soaked before fermentation with molds on microbial growth, and the characteristics of tempeh made from dried soybeans.

This research aims to study the processing of soybean tempeh dried peel in terms of yield and quality of dried peeled soybeans; the amount of water used, and the quality of the tempeh produced.

Results of this research are expected to be a business opportunity for a soybean production skinless soybean to supply it as the main raw material processing tempeh.

2. Method

2.1 Soybean drying
Soybeans (imported from USA and packaged by PT Mabar) commonly used for tofu making and tempeh in West Sumatera placed above the tray (thickness 2 cm), then dried on the dryer type cabinet at 50, 60 and 70°C for 12 hours.

2.2 Dry stripping and seed separation
Soybean is passed in the gap of two discs on the disc mill machine where one of the discs rotates with a speed of 500 rpm. The seeds will experience friction, abrasion and kickback so that the skin is peeled off and the cotyledons are separated. The result of stripping is a mixture of skinless seeds (cotyledon cleavage), skin chips and small piece of seeds. Furthermore, this mixture is dropped vertically on a flow of air that moves almost horizontally to the grain separator (local name: Lumbo) that is commonly used
by farmers when harvesting rice in the fields. Seeds skinless greater density will fall directly to the bottom, while the small pieces of skin flakes and seeds will be thrown follow the flow of air before it falls.

2.3 Tempeh processing
Boiled soybean seeds (ratio of soybean and water = 1: 4, w / v) for 20 minutes (calculated after the water boils), then left to soak in boiling water for 48 hours. After the immersion water is removed and the soybeans are washed until the washing water is clear.

Soybeans that have been clean boiled again (ratio of soybeans and water = 1: 2, w / v) for 20 minutes (calculated after the water boils). After that, the soybeans are drained, then stirred until the temperature is lukewarm (30-35°C). After that added a commercial inoculum (brand Raprima, referred to as "Ragi Tempe") of 2 grams per kg of soybean raw material.

Plastic bags (size 15 x 27 cm) pricked with sewing needles (spacing between 1-1.5 cm), then filled with 400 g of soybeans that have been given inoculum. The bags are flattened, then placed on the shelves the base has a hole for 36 hours.

Whole-skinned soybeans are processed into tempeh in the same way, unless skin is stripped after soybeans are soaked for 48 hours.

2.4 Observation
Observations were made on the results of dry stripping of soybeans, namely the number of peeled soybeans, whole soybeans, soybean bran (a mixture of skin and seed flakes), and damaged seeds.

In the process of dry tempeh processing is also observed the amount of water used for boiling and washing soybeans that have been soaked for 48 hours. Observations were also made on the use of water in the processing of tempeh from wet peeled soybeans. This observation was carried out in the Laboratory and one of tempeh producers in Padang.

Observations on tempeh were made to assess the quality of the sensor with a descriptive sensory test by 4 trained panels who already understood to assess the texture, odor and color of tempeh in accordance with Indonesian National Standards SNI Soy Tempeh 3144: 2015.

3. Results and Discussion

3.1 Effect of drying against the stripping results
Drying of soybeans that will be peeled does not provide significant benefits to the yield if the drying temperature is 50 and 60°C. Drying at this temperature only gives 60 and 69% yield. Whereas without drying, the yield obtained reached 66%.

Drying at a temperature of 70°C will increase the yield to 82%, which is 21% higher than the yield of stripping of soybeans that have been dried at 50°C, or 13% higher than those dried at 60°C.

| Temperature (°C) | Rendemen a) (% | Undivided Seeds b) (% | Bran c) (%) | Broken Beans d) |
|-----------------|----------------|------------------------|-------------|----------------|
| 50              | 61             | 19                     | 15          | 4              |
| 60              | 69             | 12                     | 14          | 5              |
| 70              | 82             | 1                      | 16          | 1              |
| Control e)      | 66             | 14                     | 16          | 5              |

Note: a) percentage amount of "seeds split without skin" results stripping against the amount of "whole seed" peeled, b) The percentage of the number of "skinned beans" stripping the result of the peeled amount of "whole seed", c) The bran is composed of seed bark (7.5% of the whole seed weight) and the cotyledon grains that are detached when the seeds pass through the gap between the two abrasiv discs with rough surfaces. The percentage of "bran" (number of skins and fractions of seeds) of milling against the amount of "whole seed" is peeled, d) The
percentage of the number of "small and splintered seed is still skinned" against the amount of "whole seed" which is peeled, and e) not dried before peeled

Drying at 70°C is also effective in reducing the number of seeds that are not split. If soybeans are not dried or dried only at temperatures of 50 and 60°C, the percentage of seeds not split between 12 and 19%. While the percentage of seeds not split this dropped dramatically to 1% if soybeans are dried at 70°C before peeling dry. Damaged seeds also go down from 4-5% to 1% if soybeans are dried first at 70°C.

Soybean is classified as dicotyledon which consists of two cotyledons. Both of these cotyledons are wrapped and held by the seed coat. If the seed coat is torn (for example by using two abrasive discs as in this study), the two cotyledons will be easily separated when the seeds are passed in the gap between the two rapidly rotating abrasive discs. Under normal dry conditions (moisture content of about 14%), the seed coat is firmly attached to the two cotyledons. If drying is done, the skin will be drier and brittle, cotyledon volume shrinkage will also occur due to reduced moisture content of the seeds so that a gap is formed between the skin and cotyledons so that the skin is more easily torn when it gets friction by an abrasive disk on a peeling machine. However, this drying effect on ease of seed coat is torn and peeled from the seeds, only appear when the seeds have been dried at a temperature of 70°C for 12 hours where the water content of the seeds drops to 8.9%. At drying with lower temperatures (50 and 60°C) the moisture content of the seeds soybeans only dropped to 11.1 and 10.7%.

| Drying Temperature (°C) | Before Drying | After Drying |
|-------------------------|---------------|--------------|
| 50°C                    | 14, 2         | 11, 1        |
| 60°C                    | 14, 2         | 10, 7        |
| 70°C                    | 14, 2         | 8, 9         |

Byproducts of dry stripping is flakes seeds and skin that is separate from the seed without stripping the skin when the result is dropped vertically in a stream of air moving horizontally. This by-product is referred to as bran. The percentage of this bran of the number of whole soybeans to be peeled reaches 14 to 16%. The drying process of soybeans to be peeled does not significantly reduce the amount of bran produced.

3.2 Effect of 2 times stripping
Drying that lasts 12 hours (720 minutes) requires a lot of energy. The higher the temperature, the more energy needed for drying. But drying at higher temperatures is advantageous because it will have a lot of reduced unpeeled beans (whole seeds) during the stripping process (1%, see Table 1). Meanwhile, the stripping process takes place in a relatively short time, which is 10 minutes to 50 kg of soybeans so that the energy needed for this stripping is lower than the energy for drying. Based on the fact, the effort has been made to eliminate the drying process on soybeans that will be peeled, by stripping two times. After the seeds are peeled and the bran separated, the stripping is peeled once more. It turns out this way, it can reduce the amount of intact seeds that are not peeled to 1.2% (close to the amount of whole seed in the dried soybean stripping at a temperature of 70°C), but slightly lower the yield to 80% (also approaching a stripping yield on soybeans that are dried at a temperature of 70°C).

| Stripping  | Yield (%) | Undivided seeds (%) | Bran (%) | Broken Beans (%) |
|------------|-----------|---------------------|----------|-----------------|
| 1 timea)   | 82%       | 1.0%                | 16       | 1.0%            |
| 2 timesb)  | 80%       | 1.4%                | 17       | 1.6%            |

Note: a) The stripping is done 1 time against soybeans that have been dried at 70°C for 12 hours for 12 hours and b) The stripping is done 2 times against soybeans which are not given the treatment of drying before peeled.
3.3 Water usage
The use of water for the processing of tempeh from wet peel is quite large. Observation on one of tempeh factory in Padang which do wet stripping, indicating that soybean processing as much as 4 sacks or 200 kg per day requires more than 10,000 litres of water. This water is used for 2 times boiling soybeans, washing and skin separation. The results obtained from laboratory experiments did not differ much from the water demand in the tempeh industry.

Table 4 Water consumption per kg of soybeans on tempeh processing made from wet peel soybeans

| Process Stage                  | Water supplies (liter) |
|-------------------------------|------------------------|
|                               | Tempeh Factory in Padang (as example) | Laboratory experiments |
| 1st boiling                   | 4.0                    | 4.0                     |
| 2nd boiling                   | 3.0                    | 3.0                     |
| Introductory Wash             | 6.7                    | -                       |
| Skin separation and washing   | 39.2                   | 45.4                    |
| Amount                        | 52.9                   | 52.4                    |

Experiments in the laboratory for the processing of dried tempeh peel showed that less water consumption, i.e. only 28.2 liters per kg of soy. Dry peel soybeans do not need water for the separation of the skin from the seed (cotyledons) because the separation of the skin has been done with the air blowing after dry peeled soybeans. Thus, the processing of tempeh using dry peel soy can save water from about 52 liters to 28 liters, or water usage savings of more than 40%.

Table 5 Use of water per kg of soy on the processing of tempeh made from dry peel soybeans

| Process Stage                  | Water supplies (litre) |
|-------------------------------|------------------------|
| 1st boiling                   | 4.0                    |
| 2nd boiling                   | 3.0                    |
| Washing after soaking         | 21.2                   |
| Total                         | 28.2                   |

3.4 Time for soybean wash
Washing the wet peeled soy lasts quite a long time. At the time of washing is also done at the same time the separation of the skin. In the tempeh industry used as a research sample, washing the peeled soybeans is done by placing soybeans in a bamboo basket, then the basket is put into a tub full of water until the upper lip of the basket is under the surface of the water, and water enters the basket. The basket is shaken so that some of the seed coat floats, then the basket is tilted so that the water from the basket flows out carrying a portion of the seed coat. This process is repeated 10-15 times for 10 minutes until most of the soybean skin is separated. After 4-5 times the skin is removed, the liquid that is discharged from the basket is clear enough which indicates that the residual acidic acid during the soybean immersion has been previously washed or discharged. Thus, if the soybeans that are washed in the tub are soybeans from dried peel, then the washing time will be reduced by half (50%).

3.5 Sensory quality of tempeh
Tempe sensory quality is based on SNI Soybean Tempe 3144: 2015 where tempeh is required to have a compact texture, uniform white color and distinctive odor of tempeh. In this study, 3 types of tempeh were made, namely made from 1) soybean without skin boiled and soaked without the skin included, 2) soybean without skin boiled and soaked with its skin wrapped in gauze; and 3) whole soybeans boiled and soaked, then peeled and washed clean before inoculation with mold inoculum. Descriptive tests conducted by trained panelists showed that tempeh that was peeled dry had sensory quality as good as wet peeled tempeh. Tempeh from dried peeled soybeans that are boiled and soaked without the skin, or the skin, also has the same sensory quality.
Table 6. The quality value of sensory beans\(^a\) made from soybean peel wet and dry

| Treatment | Texture\(^b\) | Color\(^c\) | Smell\(^d\) |
|-----------|--------------|------------|------------|
| Wet Peel  | 3            | 3          | 3          |
| Dry Peel  |              |            |            |
| 1) Seed coat is not included during boiling and soaking | 3          | 3          | 3          |
| 2) The seed coat is wrapped in cloth, then included during boiling and soaking | 3          | 3          | 3          |

Note: a) The assessment is based on a descriptive sensory test by 5 trained panels that agreed to the test attributes and testing method based on SNI Tempe soybean 3144:2015. Tests conducted on 10 examples of Tempe from each treatment, b) Textures rated 3 (compact, if pressed and thinly sliced no parts are removed, as well as indirect slices break if given a mild pressure or pull), the value 2 (compact, if pressed and sliced, no parts removed, but the slices will be immediately broken if given a mild pressure or pull) and a value of 1 (not compact, if pressed or sliced, there is a detached part), c) Color is rated 3 (mycelium is white evenly and thick enough, and there is no sign of spore growth and other colors, except the surface color of nuts), the value 2 (the mycelium is white, less evenly and less thick), and the value 1 (mycelium grows thin, and uneven), and d) Smell is rated 3 (the typical smell of tempeh, without any smell of ammonia), the value 2 (typical smell of Tempe, but there is little smell of ammonia), and the value 1 (typical smell of tempeh, but the smell of ammonia quite unnoticeable).

4. Conclusion
Dry stripping of soybeans dried at 70°C will produce a better peel than soybeans that are not dried, or which are dried at 50 and 60°C. Dry stripping of soybeans dried at 70°C, yielding 82% yield, 1% unpeeled seeds and 1% damaged seeds. Dry stripping carried out twice on un-dried soybeans can produce peels that are almost as good as soybeans which are dried in advance at 70°C. This method is more efficient in terms of energy and time used to get dry peel seeds. The process of making tempeh from dried peeled soybeans will save water usage by 40% and time for washing soybeans after soaking as much as 50%. Sensory quality of tempeh made from dried peeled soybeans is the same as tempeh made from wet peeled soybeans as is commonly done by tempeh factories in Indonesia.

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