Characteristics of vegetarian patties burgers made from tofu and tempeh

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Abstract. Patties burgers are generally made from beef with the addition of seasonings and produced through molding and heating process. This study aimed to development of vegetarian burgers aims by determining the effect of the proportion of raw materials on characteristics of vegetarian burgers. The treatments being tested were proportion of raw materials namely tempeh (100%), tempeh: tofu (50:50), and tofu (100%). The results showed that raw material had significant effect on moisture content, color of raw and cooked burgers, texture, cooking yield and moisture retention of vegetarian burger. Tempeh-based burgers produce more compact texture compared to tofu-based burgers. Tempeh-based burgers have highest texture values, namely 7.51 N hardness, 2.18 mm springiness, 4.75 N gumminess, and chewiness 10.32 mJ. Tofu-based burgers have highest brightness color values, at raw L 71.19 and at cooked L 51.61. The highest moisture content in raw burgers was found in tofu burgers 74.49%, but in cooked burger, tofu burger has lowest moisture content 23.35%. Tempeh burgers has highest cooking yield 78.05% and highest moisture retention 34.84%. The use of tempeh in tofu and tempeh mixed burgers increases value of texture, cooking yield and moisture retention of burger compared to tofu-based burgers.

1. Introduction

Patties burger is one of meat product that usually consumed with burger. It’s made from beef, the other types of meat. For health reasons, environmental sustainability, currently a vegetarian lifestyle or reducing consumption of animal products has become life style today. Consumers now pay more attention to the types of food their consume. Consumers are increasingly concerned about fat consumption and have viewpoint that red meat is high in fat [1], for that sources of vegetable protein as raw material of burger patties have an opportunity to be developed. Tempeh and tofu are sources of soy-based protein that are widely available and consumed in Indonesia. Tempe is a fermented product from soybeans by Rhizopus sp. The growing hyphae and mycelium will form a braid and a tissue structure that covers the soybeans that produce a compact structure of tempeh. Another soybean processed is tofu. Tofu is a semi-solid product obtained from the extraction of soy protein which is coagulated and compacted through a pressing process. Apart from being a source of protein, tempeh and tofu contain many useful bioactive components, namely isoflavones, vitamins and minerals. In addition, tempeh contains bioactive peptides which have biological activities that are beneficial to health [2–5].

Soybean products have been known as field beef, meat that comes from land / planted, because it is a good source of protein and fat for the diet. The textured of soy protein has been used to increase protein
content, water holding capacity and substitute the use of meat [6]. Research on the development of vegetarian burger patties have been reported, some of them are the use of pigeon pea, soybean green beans and red beans tempeh [7–8]. Furthermore, kidney beans, corn and oyster mushrooms also used in producing non-meat patties burger [9]. The use of soybean tempeh as a substitute in making burger patties has also been reported. Tempe and tofu processed from soybeans by different methods have different characteristics. This study aimed to determine the effect of the proportion of tofu and tempeh on the characteristics of vegetarian burger patties.

2. Methods
This research was conducted at the Product Development and Analytical Laboratory of Indonesian Center for Agricultural Postharvest Research and Development, Bogor in January-March 2020. Materials used were tempeh, tofu and additional ingredients namely tapioca, emulsifier and seasonings. The equipment used were weight scale, knife, cutting board, steamer pan, blender, molding, baking pan, aluminum plate, texture analyzer, chromameter, oven, hotplate, breaker glass and desiccator.

The production process of burgers was as follows: Tempeh was weighed and steamed for 15 minutes. Then the tempeh or tofu were blended until smooth. Ground tempeh and/or tofu then mixed with additional ingredients and water. The batter then molded and steamed for 30 minutes. Once it’s cool, then packed and freeze for 12 hours.

The study was designed with a completely randomized design. The treatment was 100% tofu, tempeh: tofu (50:50), and tempeh (100%). The parameters that observed were color using a Minolta CR-300 chromameter, Japan, texture using a texture analyzer, (Brookfield), moisture content using the gravimetric method (AOAC, 2005), cooking yield and moisture retention [10]. Moisture retention and cooking yield were calculated using the following formula:

\[
\text{Cooking yield (\%) = } \frac{\text{Cooked weight}}{\text{Raw weight}} \times 100
\]

\[
\text{Moisture retention (\%) = } \frac{\text{(percent yield \times \% moisture in cooked patties)}}{100}
\]

3. Results and discussion

3.1. Moisture content of raw and cooked patties burger
Moisture content of raw patties burger ranged from 57.42–74.49%, while in cooked burgers ranged from 23.35–49.97%. Based on the analysis of variance, it’s found that the proportion of base materials affected moisture content of raw and cooked patties burger (Table 1).

| Treatment         | Color L Raw  | Color L Cooked | Color a Raw  | Color a Cooked | Color b Raw  | Color b Cooked |
|-------------------|--------------|----------------|--------------|----------------|--------------|----------------|
| Tempeh (100)      | 66.55a       | 50.48b         | 2.91c        | 5.60a          | 17.97a       | 50.48b         |
| Tempeh: Tofu (50:50) | 69.80b       | 44.96a         | 1.70b        | 12.80b         | 20.14a       | 44.96a         |
| Tofu (100)        | 71.19c       | 50.61b         | -2.35a       | 6.28b          | 20.04a       | 51.61b         |

Description: The same letter in the same column behind mean value showed no significant difference (P > 0.05)

In Table 1 it could be seen that the highest moisture content of raw patties burger was found in tofu burgers, but when it has cooked, its moisture content became the lowest one. Tofu is obtained from the extraction, coagulation and pressing proses of soybeans, tofu has moisture content ranges from 75–77%, while the moisture content of tempeh ranges from 63–65% [2,4]. Therefore, raw tofu patties burger has highest water content. Whereas in cooked patties burger, tofu burger patties had the lowest moisture content, this due to the structure of tofu was less compact so that more water has evaporated from the product. According to the previous research, tempeh has a dense and compact texture that comes from the
mold mycelium R. oligosporus [11]. Meanwhile, the structure of tofu is not compact therefore the lost of water was in line with the heating process.

3.2. Color of raw and cooked patties burger

The lightness of raw burger patties ranges from 66.55–71.19. The highest lightness was on tofu patties burger and the lowest was on tempeh patties burger. The results of variance analysis showed that the treatment had significantly affect to the lightness of patties burger. In the other side, the lightness of cooked patties burger was ranged from 44.96 to 50.61. The results of variance analysis showed the treatment had a significantly effect. The lightness of tofu ranges from 83.13–85.10 while the lightness of tempeh ranges from 72.28–75.47 [4]. And then the redness level (a) of raw burger patties ranged from -2.35–2.91 while the cooked ones ranged from 5.60–12.80.

### Table 2. The means of color intensity L, a, b raw and cooked patties burger

| Treatment          | Color L | Color a | Color b |
|--------------------|---------|---------|---------|
|                    | Raw     | Cooked  | Raw     | Cooked  | Raw     | Cooked  |
| Tempeh (100)       | 66.55<sup>a</sup> | 50.48<sup>b</sup> | 2.91<sup>c</sup> | 5.60<sup>a</sup> | 17.97<sup>a</sup> | 50.48<sup>b</sup> |
| Tempeh: Tofu (50:50)| 69.80<sup>b</sup> | 44.96<sup>a</sup> | 1.70<sup>c</sup> | 12.80<sup>b</sup> | 20.14<sup>a</sup> | 44.96<sup>a</sup> |
| Tofu (100)         | 71.19<sup>c</sup> | 50.61<sup>b</sup> | -2.35<sup>a</sup> | 6.28<sup>a</sup> | 20.04<sup>a</sup> | 51.61<sup>b</sup> |

Description: The same letter in the same column behind mean value showed no significant difference (P> 0.05)

Furthermore, the yellowness level (b), it ranges from 17.97–20.14 for raw burgers and 44.96–51.61 for cooked burgers. In this study, tofu patties burger has the highest yellowness. The color of cooked burger is influenced by the composition of the ingredients used. Maillard reaction, which is the reaction between amino acids and reducing sugars, produces a yellow color in the fried products so that yellow and red color intensity of burger patties increases after the frying process.

3.3. Texture of raw and cooked patties burger

The hardness of raw burger patties ranged from 162.17–759.17, while cooked burger patties had a hardness value of 2.25–7.51. The results of the analysis of variance show that the proportion of raw material treatment affects the characteristics of produced patties burger. The highest hardness was found in 100% tempeh and the lowest was in 100% tofu. The compact structure of tempeh results in higher hardness compared to tofu. The bulk density of tempeh ranges from 0.6–0.65 g/ml, while the bulk density of tofu ranges from 1–1.06 g/ml [2, 12]. This indicate that the texture of tempeh is more compact than tofu.

Furthermore, the springiness value of raw burger patties ranged from 1.74–1.97, while those for cooked burgers ranged from 1.83–2.18. Highest springiness on the tempeh burger. The results of the analysis of variance showed that the treatment had effect on the springiness value of cooked burgers. The springiness value describes the product's ability to return to its initial position after the first compression until the second compression starts [13]. The compact texture of tempeh actually produces higher elasticity than tofu.

### Table 3. The means of raw and cooked patties burger texture

| Treatment          | Hardness (N) | Springiness | Gumminess | Chewiness |
|--------------------|--------------|-------------|-----------|-----------|
|                    | Raw          | Cooked      | Raw       | Cooked    | Raw       | Cooked    |
| Tempeh (100)       | 759.17<sup>b</sup> | 7.51<sup>b</sup> | 1.74<sup>a</sup> | 2.18<sup>b</sup> | 436.97<sup>b</sup> | 4.75<sup>b</sup> | 7.42<sup>b</sup> | 10.32<sup>c</sup> |
| Tempeh: Tofu (50:50)| 505.00<sup>ab</sup> | 6.60<sup>c</sup> | 1.55<sup>a</sup> | 1.86<sup>e</sup> | 216.70<sup>a</sup> | 4.05<sup>b</sup> | 3.31<sup>c</sup> | 7.54<sup>b</sup> |
| Tofu (100)         | 162.17<sup>a</sup> | 2.25<sup>c</sup> | 1.97<sup>a</sup> | 1.83<sup>e</sup> | 110.00<sup>a</sup> | 1.50<sup>e</sup> | 2.09<sup>c</sup> | 2.75<sup>a</sup> |

Description: The same letter in the same column behind mean value showed no significant difference (P> 0.05)

On the gumminess value, the values obtained were in the range 110–436.97 for raw patties burger and 1.50–4.75 for cooked patties burger. The results of the analysis of variance showed that the treatment
had a significantly effect. The 100% tofu had the lowest value, while the addition of tempeh to patties burger, resulting a significant increase in gumminess of cooked products.

Likewise, with the chewiness value, the use of 50% tempeh in patties burger increases chewiness in tempeh and tofu mix burgers. Chewiness represents the energy required to chew a solid food into a form that is ready to be swallowed. The value of chewiness is influenced by the hardness, springiness and gumminess of the product. The texture of tempeh is influenced by the expansion of the seeds during the immersion process, as well as the cooking process as well as the degradation of the intercellular matrix by the Rhizopus oligosporus [2]. The growth of fungus mycelium produces a dense and compact texture of tempeh [11].

3.4. Moisture retention
Moisture retention of patties burger ranged from 10.34 to 34.84. The 100% tofu patties burger have the lowest moisture retention. The results of variance analysis showed that the treatment had a significant effect on moisture retention of patties burger that produced. The moisture content of tofu ranges from 75–77% with a protein content of 12.39–13.26% [4]. Meanwhile, tempeh has a moisture content of 63–65%, with a protein content ranging from 49–51% [3]. Tempeh has denser texture compared to tofu. The texture is more compact so that the tempeh-based burger patties are more able to hold water than tofu.

| Treatment          | Moisture retention | Cooking yield |
|--------------------|--------------------|---------------|
| Tempeh (100)       | 31.91b             | 78.05b        |
| Tempeh: Tofu (50:50)| 34.84b             | 66.63b        |
| Tofu (100)         | 10.34a             | 44.20a        |

Description: The same letter in the same column behind mean value showed no significant difference (P> 0.05)

3.5. Cooking yield
The cooking yields of patties burger range from 10.34–3 4.84. Tofu patties burger had the lowest cooking yield. The analysis of variance showed that the treatment had a significant effect on cooking yield of patties burger. Tofu has a moisture content of about 75–82% which is higher than tempeh [3,4,14]. When burger patties were fried, water will be evaporated then causing weight loss of the product. Tofu which has higher moisture content and less compact texture will have more water loss when cooked than the others. This was in line with the value of moisture retention where tofu patties burger has the lowest value.

4. Conclusion
According to the current study, the base material had significantly affect to the characteristic of vegetarian patties burger. The 100% tofu burger has highest moisture content at raw, then it had lowest moisture content when it’s cooked. The lightness of patties burger decreased as its had cooked, meanwhile the redness and yellowness were increase. The 100% tempeh burger has highest hardness, gumminess and chewiness. Moreover, the mix of tempeh and tofu (50:50) patties burger has more moisture retention and cooking yield.

References
[1] Taylor J, Ahmed I A M, Al-Juhaime F Y and Bekhit A E D A 2020 Foods 9 63
[2] Astawan M, Wresdiyatib T, Widowati S, Bintarid S H and Ichsania N 2013 Pangan 22 241–252
[3] Astawan, M, Adiningisih N R and Palupi N S 2014 Pangan 23 244–255
[4] Yulifianti R and Ginting E 2012 Prosiding Seminar Hasil Penelitian Tanaman Aneka Kacang dan Umbi (Indonesia: BALITKABI)
[5] Aoki H, Uda I, Tagami K, Furuya Y, Endo Y, and Fujimoto K 2003 *Bioscience, Biotechnology, and Biochemistry* 67 1018–23

[6] Carvalho G R, Milani T M G, Trinca N R R, Nagai L Y and Barretto A C S 2017 *Food Sci. Technol* 37 10–16

[7] Mora E, and Andrés C 2015 *UNED Research Journal* 7 33–8

[8] Utami N, Jumirah, and Siagian A 2013 *Gizi, Kesehatan Reproduksi dan Epidemiologi* 2 1–8

[9] Fadly D, and Purwayantie S 2020 *Ghidza: Jurnal Gizi dan Kesehatan* 3 19–24

[10] Elhak A B D, Nasra A, Ali S E and Zaki N L 2014 *Egypt. J. Agric. Res.* 92 995–1008

[11] Sparringa R A, Kendall M, Westby A and Owens J D 2002 *Journal of Applied Microbiology* 92 329–337

[12] Andarwulan N, Nuraida L, Adawiyah D R, Triana R N, Agustin D, and Gitapratiwi D 2018 *Jurnal Mutu Pangan* 5 66–72

[13] Haliza W, Kailaku S I and Yuliani S 2012 *J. Pascapanen* 9 96–106

[14] Meyza M I, Nawansih O and Nurainy F 2013 *Jurnal Teknologi Industri dan Hasil Pertanian* 18 62–77