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Application of Foam Mat Drying for the Production of Tempoyak Powder

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ABSTRACT

The production of tempoyak powder is a significant attempt to preserve tempoyak. Therefore, this study aimed to determine the proper amount of albumin and maltodextrin to produce tempoyak powder using foam mat drying. This study was divided into two stages, namely producing tempoyak powder by foam mat drying method and determining the characteristics. In the production, egg albumin was used as foaming agent in three concentrations, namely 10%, 15%, and 20%, as well as maltodextrin as a filler in 0% and 5%. Chemical and physical characteristics, such as proximate test, pH, total titrated acid, bulk and tap density, Carr Index (CI), and Hausner Ratio (HR) were investigated. The result showed that moisture content of tempoyak powder ranged from 10.22 to 13.34%. Tempoyak powder with 20% albumin but no maltodextrin had the lowest moisture content. Furthermore, the addition of albumin without maltodextrin increased foam overrun, accelerating drying process and powdered tempoyak with lower moisture concentration. The addition of maltodextrin decreased foam tempoyak overrun, causing drying process to be slower. Tempoyak powder had protein content ranging from 8.71 to 13.12%, and with 20% albumin and no maltodextrin, the highest protein level of 13.12% was obtained. Fat content ranged from 6.99 to 8.15%, with the highest observed in tempoyak powder with 20% albumin and no maltodextrin. The addition of albumin as foaming agent increased protein and fat content. Furthermore, the total titrated acid in powdered tempoyak products was not significantly different from fresh tempoyak. The result suggested that the acid content does not considerably reduce while drying. Tempoyak powders had CI and HR values that ranged from good to excellent, showing good flowability and cohesiveness.

Keywords: Fermented durian; foam mat drying; tempoyak

INTRODUCTION

Tempoyak is a matured durian flesh paste fermented with the addition of salt (Rajagukguk dan Arnold, 2021). Accordingly, it is a traditional dish among Malay community and popular in Malaysia and Indonesia, particularly in Sumatra and Kalimantan. Tempoyak generally has a white to yellowish color depending on the durian fruit used as raw material and a cooking ingredient in traditional dishes, such as fish tempoyak curry (Muzaifa et al., 2018a), shrimp, *brengkes* (Indonesian dish) (Haruminori et al., 2017), and others.

The fermentation of tempoyak is carried out spontaneously by heterofermentative lactic acid bacteria (LAB), which produces lactic acid compounds, ethanol, and CO_2. The fermentation process results in the accumulation of alcohol and CO_2 by-products (Reli et al., 2017). A higher accumulation of alcohol and CO_2 can affect flavor and decrease quality, thereby reducing shelf life (Junita dan Novitasari, 2019). Furthermore, the decrease in tempoyak quality can be observed physically through color changes, the emergence of a pungent alcohol aroma, and the presence of insects, such as maggots (Reli et al., 2017).

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Shelf life of tempoyak at room temperature storage cannot be prolonged for long periods. This condition requires product modifications that will increase shelf life at room temperature for an extended period. Studies on the preservation and storage of tempoyak are still limited, with only a few reported. Pasteurized tempoyak stored in Polyethylene Terephthalate (PET) with Modified Atmosphere Packaging (MAP) method can last for 84 days (less than 3 months) (Reli et al., 2017). According to (Junita dan Novitasari, 2019), vacuum packaging modification on tempoyak sambal can extend shelf life by 21 days. Conversion into powdered tempoyak has also been conducted to extend shelf life by adding maltodextrin to tempoyak and then drying for 48 hours at 55°C (Nizori et al., 2021).

The production of powdered tempoyak is a form of preservation that offers many advantages, such as smaller volume, lighter weight, easier packaging, and longer shelf life. However, drying process for 48 hours at 55°C (Nizori et al., 2021) and 65°C (Ariffin et al., 2015) can cause loss of flavor due to evaporation. Prolonged drying processes are also ineffective for Small and Medium Enterprises (SMEs) producing temporal due to the significant energy and production costs. Therefore, a study is needed on the production of tempoyak powder using faster drying methods applicable in SMEs. Foam mat drying is one of the method widely used in instant powder production.

Foam mat drying transforms liquid or semi-solid materials into stable foam, which is then spread out into thin layers and dried to a certain moisture content (Mounir, 2017). Drying process begin by forming foam through the agitation of materials mixed with foaming agent using a blender or specialized equipment. Foam is spread into thin layers and dried in hot air until a porous layer is formed, and then ground into powder (Sangamithra et al., 2014).

Foaming agents, surfactant substances, are required in foam-making process to reduce surface tension between two liquids or with a solid, facilitating foam formation. Commonly used foaming agents include proteins, such as egg white, gelatin, casein, whey, and soy. Egg white is the most frequently used foaming agent due to the shorter agitation time compared to others (Mounir, 2017; Sangamithra et al., 2014). The use of egg white (albumin) also offered several advantages, including easy accessibility and affordability, facilitating the application in SMEs settings. In the powder-making process, filler materials are added to increase yield volume, maintain flavor, prevent heat damage to the ingredients, and expedite drying. According to a previous study, maltodextrin is a common filler material used in powder production (Ariska dan Utomo, 2020).

Instant powder production using foam mat drying method offers several advantages, such as faster drying, suitability for heat-intolerant food materials with high carbohydrate content, preservation of nutrients, good powder reconstitution, and cost-effectiveness (Sangamithra et al., 2014). Additionally, this method results in products with better aroma, flavor, and color quality compared to drying methods using higher temperatures (Djaeni et al., 2013).

A previous study showed that the development of instant tempoyak products is a form of innovation expected by the younger generation (Permana et al., 2021). These products are expected to be a consumer choice because they are easy to carry and store and have a long shelf life, allowing consumption without the need to wait for durian season. It was also expected to provide a solution for overripe durian fruit or those not sold fresh during the peak harvest season. Therefore, this study aimed to obtain the right formula for the concentration of egg albumin and maltodextrin in the production of powdered tempoyak using foam mat drying method.

METHODS

Materials

The materials used include durian (local Sumatera Barat), albumin/egg white (local Sumatera Barat), maltodextrin DE10 (Lihua Starch), H_2SO_4 (Merck, 99%), Conway indicator (Merck), H_3BO_3 (Merck), selenium reagent (Merck), NaOH (Merck), HCl (Merck), petroleum benzene (Merck), PP indicator (Merck). The equipments used are analytical balance (Kern), cabinet dryer, kitchen mixer (Phillips), Soxhlet flask (Buchi, Switzerland), Kjeldahl flask (Buchi, Switzerland), oven (Labtech), desiccator, and a set of glassware.

Production of Tempoyak and Analysis of the Raw Material Characteristics

The flesh of durian fruit, peeled and separated from the seeds, was mixed with 3% salt (Yuliana dan Dizon, 2011) and fermented for 3 days (Muzaifa et al., 2018b) in plastic jars. Tempoyak samples were analyzed for chemical characteristics, including proximate analysis, total titratable acidity, and pH.

Foam Tempoyak Production

Foam tempoyak was produced using the method developed by Ng and Sulaiman (2017) with slight

Table 1. Types of treatments for albumin and maltodextrin addition

Type of treatment	Composition of albumin and maltodextrin
1	10% albumin, 0% maltodextrin
2	15% albumin, 0% maltodextrin
3	20% albumin, 0% maltodextrin
4	10% albumin, 5% maltodextrin
5	15% albumin, 5% maltodextrin
6	20% albumin, 5% maltodextrin

modifications. Tempoyak was mixed with water in a ratio of 1:1 and blended using a kitchen blender until a slurry was formed. The slurry samples were added with egg albumin foaming agent with 10%, 15%, and 20% concentrations, as well as maltodextrin with 0% and 5%, as shown in Table 1. The mixture was beaten using a kitchen mixer for 10 minutes until foam tempoyak was formed.

Characteristics of Foam Tempoyak

The characterization of foam tempoyak followed the method by Suet Li et al. (2021) which observed density and overrun. Foam density was determined by comparing mass and volume. Furthermore, a transparent 20 mL beaker was weighed using an analytical balance and recorded as the weight of the empty beaker. Foam sample was then poured into the beaker to reach the 20 mL volume mark and weighed using the analytical balance. The weight of foam was obtained by subtracting the empty beaker from the weight of beaker with foam. The calculation of foam density used Equation 1, as follows:

$$Foam\ density = \frac{m}{V_1} \qquad (1)$$

where: m = weight of foam (g) and V_1 = final volume of foam (cm^3).

Foam expansion shows the amount of air trapped during the shaking process. A 1 g sample of tempoyak was placed into a transparent measuring glass, and the volume (V0) was observed. The same procedure is carried out for the volume (V1) of foam tempoyak. Foam expansion was calculated using Equation 2, as follows:

$$Foam\ expansion\ (\%) = \frac{V_1 - V_0}{V_0}\ x\ 100 \qquad (2)$$

where: V_0 = initial volume of puree (cm^3) and V_1 = final volume of foam (cm^3).

Drying

Drying was conducted using the method by Suet Li et al. (2021) with slight modifications. Foam tempoyak was spread onto an aluminum tray with foam thickness of 5 mm and dried in a cabinet dryer at 50±5 °C for 8 hours. The dried thin layer was ground using a Philips chopper blender to obtain and then sieved through a 60-mesh sieve. Subsequently, the powder was packaged in Polypropylene (PP) plastic for further analysis.

Analysis of Powdered Tempoyak Characteristics

Chemical Characteristics

The analysis of moisture, protein, fat, carbohydrate, and ash content follows AOAC (2005) method. pH was measured using pH meter and total titratable acidity analysis was carried out based on the acid-base titration principle outlined in AOAC (2000).

Physical Characteristics

Bulk and Tap Density

Bulk and tap density were analyzed using the method developed by Dehghannya et al. (2018a). The 2 g of the sample was placed into a 10 mL measuring glass, and the initial powder volume was recorded. The measuring glass filled with the sample was placed 10 times on a soft surface (a towel) from a height of 15 cm, and the volume was observed (final tapped powder volume). Bulk and tap density are calculated using Equations 3 and 4, as follows:

$$Bulk\ density = \frac{mass\ of\ powder (g)}{initial\ powder\ volume} \qquad (3)$$

$$Tap\ density = \frac{mass\ of\ powder\ (g)}{final\ volume\ of\ powder\ tap} \qquad (4)$$

Powder flowability

Carr Index (CI) and Hausner Ratio (HR) were measured using the method by Dehghannya et al. (2018a) to evaluate the flowability of powdered tempoyak. The values of CI and HR were calculated using Equations 5 and 6, as follows:

$$CI = \frac{tap\ density - bulk\ density}{tap\ density}\ x\ 100 \qquad (5)$$

$$HR = \frac{tap\ density}{bulk\ density} \qquad (6)$$

RESULTS AND DISCUSSION

Raw Material Characteristics

The characteristics of fresh tempoyak raw materials analyzed include moisture, protein, fat, and ash content, as well as total titratable acidity and pH. Tempoyak used in this study was fermented for 3 days and obtained moisture content, pH, and total titratable acidity of 68.32%, 4.31, and 2.15%, respectively (Muzaifa et al., 2018a). The result showed similar values to the characteristics of tempoyak used in this study.

Table 2. Characteristics of raw materials

Characteristic	Value
Moisture content (%)	66.25±0.83
Protein content (%)	2.22±0.04
Fat content (%)	ND
Ash content (%)	1.84±0.01
Carbohydrate content (%)	29.69±0.78
Total titratable acidity (%)	2.25
pH	4.56

Characteristics of Foam Tempoyak

Density and overrun are foam characteristics that affect the drying process and the resulting product. The density value was affected by the amount of air trapped during foaming process. According to a previous study, lower foam density can increase water removal process during drying due to a larger sample surface area (Suet Li et al., 2021). In this study, the density and overrun of each foam treatment are shown in Table 3. The lowest foam density and the highest overrun were observed in the treatment with 20% albumin and 0% maltodextrin, which were 0.62 g/cm^3 and 57.84%, respectively.

The addition of albumin as foaming agent influenced the density and overrun of foam. Specifically, the more albumin added, the lower the density and the higher the foam overrun produced. This result is consistent with the previous studies showing that increasing the albumin content can enhance foam overrun and decrease density in foaming of prem fruits (Sifat et al., 2021) and beetroots (Ng dan Sulaiman, 2017). Furthermore, increasing the concentration of foaming agents enhanced foam ability to trap air during shaking and form air bubbles, resulting in an increase in volume expansion and reducing foam density (Ng dan Sulaiman, 2017). On the other hand, the addition of maltodextrin as a filler material inhibits foam formation. Foam produced with maltodextrin had higher density and lower overrun than those without maltodextrin. This result is consistent with a previous study showing that a high maltodextrin content can decrease foam expansion and increase density in beetroots (Hajiaghaei dan Sharifi, 2022). The increase in maltodextrin concentration leads to an increase in sample viscosity, thereby inhibiting air entrapment into foam structure, reducing foam overrun, and the size of air bubbles formed (Kubbutat et al, 2021; Karim dan Wai, 1999).

Product Characteristics

Chemical characteristics

The composition of powdered tempoyak produced through foam drying process had higher protein and fat content than dried tempoyak, which had protein and fat content of 6.37% and 2.69%, respectively (Aisyah et al., 2014). Table 4 shows that protein content of powdered tempoyak ranges between 8.71% and 13.12%, while fat is in the range of 6.99% and 8.15%. Fat content of powdered tempoyak was obtained from the raw material, durian fruit. According to Aziz dan Jalil, (2019), some durian varieties in Indonesia contain 1.59 - 2.92% fat. However, the test result showed no detected fat in fresh tempoyak, which contradicts

Table 3. K foam characteristics

Treatment	Density (g/cm^3)	Overrun (%)
10% albumin 0% maltodextrin	0.69±0.004^c	41.92±1.29^c
15% albumin 0% maltodextrin	0.67±0.009^d	46.93±2.74^b
20% albumin 0% maltodextrin	0.62±0.003^e	57.84±1.19^a
10% albumin 5% maltodextrin	0.89±0.005^a	9.65±0.49^e
15% albumin 5% maltodextrin	0.89±0.004^a	10.47±0.61^e
20% albumin 5% maltodextrin	0.82±0.008^b	19.39±0.88^d

Table 4. Chemical composition of powdered tempoyak products

Treatment	Moisture content (%)	Ash content (%)	Protein content (%)	Fat content (%)	Carbohydrate content (%)
10% albumin 0% maltodextrin	11.45±0.04[c]	6.16[e]	10.61±0.88[b]	6.99±0.67[a]	64.80±1.51[c]
15% albumin 0% maltodextrin	12.25±0.07[d]	7.18±0.01[f]	12.95±0.37[c]	7.12±0.08[a]	60.51±0.40[a]
20% albumin 0% maltodextrin	10.22±0.21[a]	5.79[d]	13.12±0.42[c]	8.15±0.54[b]	62.73±1.17[b]
10% albumin 5% maltodextrin	12.29±0.21[d]	4.56[b]	8.71±0.07[a]	7.39±0.04[ab]	67.05±0.24[d]
15% albumin 5% maltodextrin	13.34±0.18[e]	4.44±0.02[a]	9.42±0.06[ab]	7.29±0.04[ab]	65.52±0.17[cd]
20% albumin 5% maltodextrin	10.82±0.20[b]	4.63[c]	10,55±0,53[b]	7.47±0.04[ab]	66.53±0.29[cd]

previous studies showing fat contents in durian. The discrepancy may be due to errors in testing fresh tempoyaIOk raw materials. A previous study showed that egg albumin contributed fat to powdered tempoyak and contained about 0.02% (Sato et al., 1972). Protein content in powdered tempoyak products was influenced by the amount of added albumin. Powdered tempoyak products in all treatments met the standard moisture content for flour, which is a maximum of 14.5%, based on SNI (Indonesian National Standard) 3751:2009. However, ash content does not meet the standard, which is a maximum of 0.7% for flour ([SNI], 2009). Ash content of powdered tempoyak products was relatively high compared to other flour products. This is because the raw material had a relatively high ash content of 1.84%, and added albumin also had 2.44% in the form of albumin powder (Budiman, Wulandari, and Suryati, 2009). Carbohydrate content in powdered tempoyak was quite high, ranging between 60 and 67%. This high content originated from the raw material, fresh tempoyak, which had a high carbohydrate content of 29.69% in this study and 23.33% in others (Reli et al., 2017). Furthermore, the difference in carbohydrate content of tempoyak was influenced by the addition of maltodextrin, a carbohydrate filler. Maltodextrin results from the partial hydrolysis of starch using enzymes and acids, leading to a mixed product of glucose, maltose, oligosaccharides, and dextrin (Meriatna, 2013).

Total acidity and pH ranged between 1.90 - 2.47 and 5.19 - 5.35, respectively, as shown in Table 5. Total acidity of 2.25 was not significantly different from fresh tempoyak. According to Muzaifa et al. (2018a), the lactic acid content of tempoyak ranges between 2.05 and 2.55%, with an average of 2.3%. Total acidity and pH of tempoyak were influenced by the amount of lactic acid produced by LAB, with longer fermentation, resulting in higher acid levels (Reli et al., 2017). pH of powdered tempoyak also increased compared to fresh tempoyak, which has pH of 4.56. This pH value increased in powdered tempoyak due to the addition of egg white, with a significantly higher pH. Egg albumin has a high pH, averaging pH of 9 (Agustina et al., 2013) and the high pH of albumin leads to an increase in powdered tempoyak. The sour taste was a characteristic flavor of tempoyak curry, which should be maintained during processing. The production of powdered tempoyak using foam mat drying method was able to maintain the total acidity value of tempoyak. Therefore, drying using foam mat method was considered suitable for application in powdered tempoyak production.

Physical characteristics

Bulk and tap density were the physical tests commonly used to predict the characteristics of flour or powdered products. Bulk density is the ratio of weight to flour volume without any volume compression. Meanwhile, tap density is the ratio of weight to volume after compression in a cylinder. This ratio is related to rehydration, packaging, transportation, and product appearance, similar to the storage ability of flour in smaller packaging (Dehghannya et al., 2018). Table 6 shows the values of bulk and tap density in this study, ranging from 0.39 - 0.48 g/cm^3 and 0.42 - 0.54 g/cm^3,

Table 5. Total titratable acidity and pH of powdered tempoyak

Treatment	Total titratable acidity (%)	pH
10% albumin 0% maltodextrin	2.25	5.35
15% albumin 0% maltodextrin	2.30	5.31
20% albumin 0% maltodextrin	2.47	5.24
10% albumin 5% maltodextrin	1.90	5.14
15% albumin 5% maltodextrin	1.99	5.19
20% albumin 5% maltodextrin	2.04	5.21

Table 6. Physical characteristics of powdered tempoyak

Treatment	Bulk density (g/cm^3)	Tap density (g/cm^3)	Carr index (%)	Hausner ratio
10% albumin 0% maltodextrin	0.48	0.54	10.58	1.12
15% albumin 0% maltodextrin	0.46	0.51	9.09	1.10
20% albumin 0% maltodextrin	0.47	0.51	8.03	1.09
10% albumin 5% maltodextrin	0.42	0.46	8.17	1.09
15% albumin 5% maltodextrin	0.43	0.46	7.38	1.08
20% albumin 5% maltodextrin	0.39	0.42	8.33	1.09

Table 7. Specifications of CI and HR

No	Flowability	Carr index (%)	Hausner ratio
1	Excellent	0 – 10	1.00 – 1.11
2	Good	10 – 15	1.12 – 1.18
3	Fair	16 – 20	1.19 – 1.25
4	Possible	21 – 25	1.26 – 1.34
5	Poor	26 – 31	1.35 – 1.45
6	Very poor	32 – 37	1.46 – 1.59
7	Extremely poor	>38	>1.60

Source: (Lebrun et.al., 2012)

respectively. The addition of maltodextrin causes a decrease in both bulk and tap density values. This result is consistent with the report of (Bhusari et al., 2014) that an increase in the concentration of carrier material decreases in bulk density. According to Dehghannya et al. (2018), bulk density was influenced by the ability to trap air during foaming process. Foam that can trap air well will result in a higher bulk density value. In this study, treatments without maltodextrin had better air-trapping capabilities, resulting in higher bulk density values for the product. However, the addition of maltodextrin as a filler material hindered the air-trapping process, leading to lower bulk density values in powdered products.

Flowability and cohesiveness of flour were determined using CI and HR. Both characteristics are primary indicators of flour product quality (Suet Li et al., 2021). Flour products with excellent to fair flowability values showed good quality, while those with lower value are considered low quality (Dehghannya et al., 2018). The specifications of CI and HR values are shown in Table 7. In this study, CI values range from 8.33 to 10.58%, showing good and excellent values for all treatments.

The range of HR values for powdered tempoyak was 1.08 to 1.12. This result shows a good value for the treatment with 10% albumin and 0% maltodextrin, as well as excellent for the other treatments. HR value identified the cohesiveness of the flour, while a low value leads to better flowability (Suet Li et al., 2021).

CONCLUSION

In conclusion, foam mat drying method could be applied to the production of powdered tempoyak. The addition of albumin as foaming agent could increase overrun and decrease foam density while maltodextrin inhibited foam formation. Similarly, the addition of 20% albumin and without maltodextrin results in foam with the highest overrun and lowest density. Powdered tempoyak products with 20% albumin and without maltodextrin had the lowest moisture and the highest protein content compared to other treatments. The total titratable acidity of powdered tempoyak products was not significantly different from that of fresh tempoyak. Based on CI and HR values, flowability and cohesiveness of powdered tempoyak in all treatments had good to excellent values. Conclusively, the addition of 20% albumin and without maltodextrin was the best treatment for producing powdered tempoyak using foam mat drying method. Future studies are required to observe shelf life and stability of powdered tempoyak products during storage.

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CONFLICT OF INTEREST

All authors declare no conflicts of interest with any party in this article.

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