Effect of Maltodextrin and Egg White Powder on Physical Characteristics of Sorghum Powdered Drink

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Abstract. Sorghum, a cereal plant variety, is cultivated in Indonesia as a promising food alternative with notable nutritional and bioactive properties. It presents opportunities for innovative food products like powdered beverages. To make sorghum powdered beverages, adding filler (maltodextrin) and foaming agent (egg white powder) is an essential factor that may impact the physical characteristics of the final products. This study aimed to explore how varying concentrations of maltodextrin and egg white powder affect the physical attributes of sorghum powder beverages. Maltodextrin (10%, 20%, 30%) and egg white powder (4%, 4.5%, 5%) were the independent variables examined. The analysis encompassed solubility, bulk density, foam stability, foam density, and drying rate. Findings indicated that incorporating maltodextrin and egg white flour increased foam density (0.69 g/mL) and stability (94%). Higher maltodextrin concentration enhanced beverage solubility, while bulk density remained relatively unaffected (0.79 to 0.87 g/mL). Notably, the blend with 30% maltodextrin and 4.5% egg white powder exhibited the swiftest drying rate (0.0456 g water/g dry solid min). These outcomes provide a foundation for advancing sorghum-based powdered beverages.

1 Introduction

Drying stands as one of the oldest food preservation methods [1]. Various techniques of drying have unique characteristics and are employed for the reduction of water content in food products, thus preserving the foods. Among these techniques, foam mat drying specifically targets the dehydration of liquid food products, offering an economical approach. This method notably reduces drying duration, thereby minimizing potential heat damage to sensitive components in food products [2]. Compared to freeze and spray drying, the rehydration ability of powder resulting from foam mat drying is high and is considered a worthwhile method. Notably, foam mat drying boasts a high drying rate and operates at lower temperatures, making it a cost-efficient alternative to traditional drying methods like air drying [3].

The underlying concept of foam mat drying involves the generation of foam by the utilization of whipping, foaming chemicals, and a drying technique. Whipping is employed...
to facilitate the incorporation of air, thereby augmenting the surface area for enhanced drying efficiency. Additionally, the foaming agent stabilizes the foam, enabling it to persist during drying. The water vapor can exit the foam material by utilizing the pathways formed by the air cells, resulting in an increased drying rate. The drying technique facilitates the provision of optimal thermal conditions necessary for generating vapors from the foam [4]. Egg white serves as a foaming agent, stabilizing the porous structure and enhancing the surface area available for drying. Previous research showed a two-fold drying rate increase when egg white is incorporated into the samples, compared to the drying process conducted without egg white [5]. Adding a stabilizing agent such as maltodextrin stabilizes the foam obtained from the whipping process. Maltodextrin is not only functions as a foam stabilizer but also beneficial for the prevention of powder agglomeration and stickiness [6].

Sorghum (*Sorghum bicolor* L.) is globally recognized as a staple food in regions such as Africa, East Asia, and Southeast Asia [7]. Its consumption is attributed to its rich nutritional profile and bioactive compounds, which contribute to human well-being [8, 9]. In Africa, sorghum has long been utilized as a fundamental component in the production of beverages, including both alcoholic and non-alcoholic varieties [10]. Conversely, in Indonesia, there is a noticeable surge in interest and renewed vigor in integrating alternative, climate-resilient, and traditional grains like sorghum into mainstream food items. The Indonesian government actively advocates for the adoption of these lesser-utilized crops as primary food sources or substitutes for other cereal crops like rice and wheat.

Currently, information is scarce regarding the progress made in the development of sorghum-based beverages in Indonesia. In addition, research on applying foam-mat drying to develop sorghum powder drinks and its characteristics still needs to be completed. Hence, this study aimed to assess how different concentrations of maltodextrin and egg white powder impact the physical attributes of sorghum powder beverages.

2 Material and methods

2.1 Materials

Sorghum (red variety) was purchased from Greenara (Jakarta, Indonesia). Maltodextrin (Lihua, China) and egg white powder (SKM, India) were obtained from the online marketplace. The main equipment used in this research were oven (Memmert UN62, Germany), mixer (Miyako, Indonesia), and blender (Phillips, China).

2.2 Sample preparation

Sorghum milk was initially prepared following the previously outlined method with adjustments [11]. Initially, the materials underwent washing to eliminate impurities. Subsequently, they were combined with water at a ratio of 1:3 (100 ml water and 300 ml sorghum) and cooked until thoroughly done. The cooked sorghum was then blended with water at a ratio of 1:4 (100 g cooked sorghum in 400 ml water) for 2 minutes. The resulting slurry was filtered using cheesecloth to extract the liquid. After cooling, the liquid was infused with varying concentrations of egg white powder (4%, 4.5%, 5%), maltodextrin (10%, 20%, and 30%), colorant, and flavor. The sorghum liquid was then pasteurized at 72 °C for 15 minutes. Following pasteurization, the liquid was agitated with a mixer for 45 minutes to generate foam. The foam, with a thickness of 1 cm, was spread onto a tray and dried at 70 °C for 8 hours. Subsequently, the dried liquid was pulverized using a
blender and strained. The result was a sorghum powder drink. The detailed formula of sorghum powder drink is shown in Table 1.

Table 1. Formulation of maltodextrin-egg white powder in sorghum powder drink

<table>
<thead>
<tr>
<th>Formula</th>
<th>Maltodextrin (%)</th>
<th>Egg white powder (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>B</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>C</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>D</td>
<td>20</td>
<td>4.5</td>
</tr>
<tr>
<td>E</td>
<td>20</td>
<td>4.5</td>
</tr>
<tr>
<td>F</td>
<td>20</td>
<td>4.5</td>
</tr>
<tr>
<td>G</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>H</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>I</td>
<td>30</td>
<td>5</td>
</tr>
</tbody>
</table>

2.3 Foam density measurement

Foam density was calculated by dividing the weight of the sorghum foam by the volume of the foamed sorghum [12]. To measure the density of the foam, the mixture was put into a beaker and weighed using an analytical balance. Foam density is expressed in g/cm³ using the following formula:

$$\text{Foam Density (g/cm}^3\text{)} = \frac{\text{Weight of foam (g)}}{\text{Volume of foam (cm}^3\text{)}}$$  \hspace{1cm} (1)

2.4 Foam stability measurement

The stability of sorghum foam was assessed by placing 80 ml of sorghum foam in a beaker and allowing it to stand at room temperature for 3 hours [13]. Foam volume reduction served as an indicator of foam stability. Foam stability was quantified using the equation:

$$\text{Foam Stability (\%)} = \left(\frac{V_o}{V_i}\right) \times 100\%$$  \hspace{1cm} (2)

$V_o$ is the volume of the foam after 3 hours and $V_i$ is the volume of the foam at the beginning.

2.5 Bulk density measurement

The bulk density of sorghum powder was calculated following the previous method with modification [14]. First, an empty 10 ml volumetric flask was weighed and then compacting the sorghum powder into the 10 ml measuring flask to the mark line and then weighing the filled measuring flask again. The provided equation for calculating bulk density is as follow:

$$\text{Bulk density (g/cm}^3\text{)} = \frac{\text{Weight of powder (g)}}{10 \text{ ml}}$$  \hspace{1cm} (3)
2.6 Dispersibility of sorghum powder drink

The reconstitution time of sorghum powder drink is determined by calculating the time required for the powder to completely dissolve in water [15]. The sample was weighed at 2 grams, then added with 20 ml of water at room temperature (25 °C) in a beaker and stirred using a magnetic stirrer at a speed of 1500 rpm. Time was recorded in seconds (s) using a stopwatch.

2.7 Moisture content analysis

The analysis of moisture content was conducted using the oven method [12]. About 1 g of sorghum powder was weighed and put into a porcelain cup. Before use, the cup was first heated in an oven at 105 °C for 1 hour, then cooled in a desiccator for 30 minutes, then the empty weight was weighed. The cup filled with powdered sorghum was then heated in an oven at 105 °C for 3 hours and then cooled in a desiccator for 30 minutes until the weight was constant. The moisture content was calculated using the following equation:

\[
\text{Moisture content (\% wet bases)} = \frac{W_i - W_o}{W_i} \times 100\% \quad (4)
\]

Where \(W_i\) is the initial weight of the samples and \(W_o\) is the weight of the sample after drying.

2.8 Moisture ratio and drying rate

Moisture ratio and drying rate were measured following the equation described in previous research [1]. The moisture ratio is calculated using the equation below:

\[
\text{Moisture Ratio (MR)} = \frac{M - M_e}{M_i - M_e} \quad (5)
\]

Where \(M\) is the moisture content at time \(t\), \(M_i\) is the initial water content, and \(M_e\) is the equilibrium moisture content.

\(W_i\) is the initial weight of the samples and \(W_o\) is the weight of the sample after drying.

Drying rate of samples was calculated following the equation:

\[
\text{Drying Rate (DR) (1/min)} = \frac{MR_{t1} - MR_{t2}}{t_1 - t_2} \quad (6)
\]

Where \(MR_{t1}\) and \(MR_{t2}\) are the moisture ratio at certain time \(t_1\) dan \(t_2\).

2.9 Statistical analysis

The samples were subjected to triplicate analysis, with each analysis being performed in three distinct and independent studies. The data were computed as the average ± standard deviation and then examined using IBM SPSS 22.0 statistical software. The study utilized a one-way analysis of variance (ANOVA) and the Duncan New Multiple Range Test to ascertain whether there was a statistically significant disparity across the samples. The analysis was conducted using a 95% confidence interval (\(p < 0.05\)).
3 Result and discussion

3.1 Foam density and foam stability of sorghum powder drink

There were nine samples of powdered sorghum drink with different concentrations of maltodextrin and egg white powder. When it was foamed, its density and stability were observed. The result of the foam density and stability measurement of the sorghum drink is shown in Table 2.

<table>
<thead>
<tr>
<th>Formula</th>
<th>Foam Density (g/cm3)</th>
<th>Foam Stability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.51 ± 0.02 b,A</td>
<td>0.38 ± 0.08 b,B</td>
</tr>
<tr>
<td>B</td>
<td>0.36 ± 0.04 b,B</td>
<td>0.40 ± 0.08 b,B</td>
</tr>
<tr>
<td>C</td>
<td>0.31 ± 0.01 b,B</td>
<td>0.78 ± 0.02 b,A</td>
</tr>
<tr>
<td>D</td>
<td>0.43 ± 0.02 b,A</td>
<td>0.84 ± 0.02 a,B</td>
</tr>
<tr>
<td>E</td>
<td>0.37 ± 0.02 b,B</td>
<td>0.87 ± 0.05 a,B</td>
</tr>
<tr>
<td>F</td>
<td>0.34 ± 0.01 b,B</td>
<td>0.92 ± 0.03 a,A</td>
</tr>
<tr>
<td>G</td>
<td>0.69 ± 0.03 a,A</td>
<td>0.83 ± 0.03 a,B</td>
</tr>
<tr>
<td>H</td>
<td>0.43 ± 0.05 a,B</td>
<td>0.85 ± 0.02 a,B</td>
</tr>
<tr>
<td>I</td>
<td>0.41 ± 0.04 a,B</td>
<td>0.94 ± 0.03 a,A</td>
</tr>
</tbody>
</table>

The results showed that adding more than 20% of maltodextrin could decrease the foam density significantly (p ≤0.05). The results are following previous research stating that adding maltodextrin could increase viscosity and prevent air trapping into the foam structure during liquid stirring, thus disturbing the foam expansion [16]. To prevent this, foaming agents such as egg white powder were added. The addition of egg white powder by more than 4.5% significantly decreased the foam density of the powdered sorghum drink (p ≤0.05). Comparable findings were also noted in earlier investigations, where an increase in egg albumin concentration led to a reduction in foam density [1]. This decline in foam density can be attributed to the increased protein interface absorption, consequently reducing the surface area. Prior research has illustrated that decreasing foam density (FD) can improve heat conductivity, thereby facilitating more efficient and economical drying of the foam material [17].

Regarding foam stability, the results showed that adding maltodextrin and egg white powder could increase the foam stability of sorghum powder drinks. The addition of more than 10% maltodextrin and 4.5% maltodextrin significantly increased the stability of foam (p <0.05) due to increment of porosity and enhancement of structure stability [18]. The stability of foam could also be due to the contribution of egg white powder, which forms a complex hydrogen bond or hydrophobic interactions, providing highly stable foam [19].

3.2 Bulk density and foam solubility of sorghum powder drink

As shown in Table 3, the addition of maltodextrin at all concentrations did not give a significant difference in the bulk density of the sorghum powder drink. However, the addition
of egg white powder significantly influenced the bulk density of the samples (p < 0.05). The higher the egg white powder concentration, the more air entrapped in the particles. High bulk density was observed on Formula I (30% maltodextrin, 5% egg white powder).

Based on the experiment, the most dispersed sample was observed on Formula F with 20% maltodextrin and 5% egg white powder. Statistical results showed no significant differences between samples added with maltodextrin. However, adding egg white powder showed a significant difference in dispersibility (p < 0.05). Higher dispersibility could be attributed to the more porosity and uniformity of dried powder, thus increasing the solubility time [15].

Table 3. Bulk density and foam solubility of sorghum drink

<table>
<thead>
<tr>
<th>Formula</th>
<th>Bulk Density (g/cm³)</th>
<th>Dispersibility Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.79 ± 0.01 a,A</td>
<td>11.70 ± 0.37 a,A</td>
</tr>
<tr>
<td>B</td>
<td>0.83 ± 0.06 a,B</td>
<td>9.86 ± 0.42 a,B</td>
</tr>
<tr>
<td>C</td>
<td>0.86 ± 0.02 a,C</td>
<td>9.02 ± 0.4 a,C</td>
</tr>
<tr>
<td>D</td>
<td>0.80 ± 0.03 a,A</td>
<td>5.57 ± 0.67 a,C</td>
</tr>
<tr>
<td>E</td>
<td>0.84 ± 0.02 a,B</td>
<td>7.71 ± 0.71 a,B</td>
</tr>
<tr>
<td>F</td>
<td>0.86 ± 0.02 a,C</td>
<td>11.51 ± 1.10 a,A</td>
</tr>
<tr>
<td>G</td>
<td>0.82 ± 0.02 a,A</td>
<td>5.84 ± 0.70 a,C</td>
</tr>
<tr>
<td>H</td>
<td>0.85 ± 0.02 a,B</td>
<td>8.28 ± 2.97 a,B</td>
</tr>
<tr>
<td>I</td>
<td>0.87 ± 0.02 a,C</td>
<td>14.73 ± 2.51 a,A</td>
</tr>
</tbody>
</table>

3.3 Drying rate and moisture ratio of sorghum-based drink

Through the moisture ratio and drying rate graph in Figure 1, sample H with 30% maltodextrin and 4.5% albumin is the treatment with the fastest drying rate and the lowest is sample A with 10% maltodextrin and 4% albumin treatment with a drying rate 0.0376 g water/g solid. The high concentration of maltodextrin and albumin in samples F, G, H and I produced foam with a high drying rate, ranging from 0.042 – 0.046 g H₂O/min.

Both maltodextrin and egg white powder exert an influence on the rate of drying and the moisture ratio. One of the contributing variables to the acceleration of the material's drying rate is the foam's stability. To achieve favorable foam stability, the addition of maltodextrin serves to decrease surface tension, enhancing the substance's overall stability [20]. In addition, the employment of egg white powder as a foaming agent within this study will induce foam formation and enhance the surface area of sorghum foam, thus facilitating the process of water evaporation and the subsequent drying of sorghum powder-based beverage products [21]. The higher the concentration of egg white powder added, an increase in the rate of drying is obtained.
It can be concluded that the addition of maltodextrin and egg white powder influenced the foam density, foam stability, bulking density, and dispersibility of sorghum powder drink. Higher concentration of maltodextrin and egg white powder influenced the stability and surface area of the foam, thus increasing the drying rate of the product.

References

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