FOAM MAT DRYING of RED SPINACH (Amaranthus tricolor L.)

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Abstract

Red spinach is a plant that provides various essential vitamins and minerals beneficial to human health. Creating red spinach powder as a convenient product can enhance its shelf life and ease of use while preserving its nutritional value and health benefits. The production of red spinach powder can be achieved through the foam mat drying technique. This research aims to evaluate the impact of different temperatures and maltodextrin concentrations on the production of spinach powder utilizing the foam mat drying method. The process involves adding egg white at concentrations of 15, 20, 25, and 30%, with maltodextrin variations of 15, 20, 25, and 30%, and drying temperatures set at 60, 65, and 70ºC to spinach puree made from grinding 20 grams of red spinach leaves for each sample. The study's findings indicate that the foam mat drying method is an effective approach for drying red spinach puree, particularly when compared to traditional drying techniques. The rate of drying using the foam-mat method is higher than that of the conventional drying process. Moreover, the drying temperature significantly influences the reduction of water content in the product; higher temperatures lead to a more rapid decrease in moisture. During the drying process at temperatures ranging from 60 to 70ºC, the combination of 15% maltodextrin and 30% egg white yields red spinach powder with a lower moisture content compared to other sample combinations. The optimal drying process results in red spinach powder containing 0.08% water, achieved through the foam mat drying method at 65ºC.

Keywords: red spinach, foam mat drying, maltodextrin

INTRODUCTION

In today's market, food products are not only expected to satisfy consumer nutritional needs but also to possess a long shelf life and be ready for immediate consumption. As a result, there is significant research focused on developing ready-to-eat items as commercial offerings (Cui et al., 2024; Mathew & Sharma, 2023). Generally, these ready-to-eat products exhibit a crumbly texture, allowing them to dissolve easily in water. Instant powders are examples of products that exhibit this crumbly texture and solubility in water (Prasoona et al., 2020; Trimedona et al., 2022; Ueda et al., 2023). One food item that boasts high nutritional content and can be processed into a product with a long shelf life while being ready for consumption is red spinach.

Red spinach (Amaranthus tricolor L.) is a type of vegetable that is rich in various minerals, vitamins, fiber, carotenoids, chlorophyll, and phenolic compounds which function as antioxidants (Isherdini et al., 2023; Mullai et al., 2023; Putri et al., 2022). The mineral content in red spinach includes calcium, magnesium, potassium, phosphorus, and iron, whereas the vitamins present in red spinach plant comprise vitamin A, the B vitamin complex, vitamin C, and vitamin K (Mullai et al., 2023; Pratiwi et al., 2022; Rahman et al., 2023). Additionally, red spinach is known to have beta carotene and lutein, which are beneficial for safeguarding body cells against the harmful effects of free radicals (Perdana et al., 2024; Rahman et al., 2023). Given the array of minerals and vitamins found in red spinach, it makes sense to explore the production of ready-to-serve red spinach powder. This type of powder can be produced using advanced technology such as freeze-dryers and spray-dryers. Nevertheless, the drawback of utilizing such technology is the high cost of equipment, which leads to elevated production expenses (Munin & Edwards-lévy, 2011). Various processes are being researched and developed to offer alternatives to these costly technologies.

One potential alternative drying method that may be employed in the drying of red spinach puree is the foam mat drying technique. Foam mat drying involves a drying methodology for liquid and heat-sensitive products through a foaming process that includes a foaming agent. Drying is the process of reducing the moisture content in the material to the extent that bacteria responsible for spoilage can no longer survive, thereby preventing damage. This study aims to investigate how temperature and the concentration of filler (maltodextrin) affect the drying process of red spinach when utilizing the foam mat drying method in reducing the product's moisture content.

METHODOLOGY

Red spinach is the main raw material in this study. Other materials used consist of distilled water, maltodextrin, and egg white. The drying process is carried out using a tray dryer. The study was conducted by weighing 20 grams of wet red spinach that had been mashed and then added with maltodextrin with variations of 15%, 20%, 25%, and 30% and egg white with variations of 15%, 20%, 25%, and 30% with a drying temperature of 60, 65, and 70^{0}C. The composition variations are listed on Table 1.

Table 1. Variation of the composition of the red spinach foam mat drying

Sample Code	Mass of red spinach	Foam material
A	20 grams	-
B	20 grams	15% Maltodextrin
C	20 grams	15% Maltodextrin + 15% egg white
D	20 grams	15% Maltodextrin +

		20% egg white
E	20 grams	15% Maltodextrin + 25% egg white
F	20 grams	15% Maltodextrin + 30% egg white
G	20 grams	15% egg white
H	20 grams	20% Maltodextrin + 15% egg white
I	20 grams	25% Maltodextrin + 15% egg white
J	20 grams	30% Maltodextrin + 15 egg white

RESULT AND DISCUSSION

Effect of Maltodextrin Concentration

In the study examining the impact of adding varying concentrations of maltodextrin and egg whites, the drying process was conducted at temperatures of 60, 65, and 70°C, incorporating 15%, 20%, 25%, and 30% maltodextrin along with egg white variations of 15%, 20%, 25%, and 30%. Water content analysis of the product was performed at intervals of 15 minutes, repeated four times, 30 minutes, repeated four times, and 45 minutes, conducted two times. Figures 1-3 illustrate the differences in water content between red spinach powder produced from the conventional drying method and red spinach powder created through the foam mat drying technique using 15-30% maltodextrin and 15-30% egg white at drying temperatures of 60°C, 65°C, and 70°C. The findings indicated that the water content of red spinach powder obtained via the foam mat drying method at temperatures of 60°C, 65°C, and 70°C, across all drying times and varying maltodextrin and egg white additions (15-30%), was lower in comparison to that acquired from the conventional drying method (without foam formation). This indicates that the foam mat drying approach is an effective technique for drying red spinach puree. The effectiveness of foam mat drying techniques over the conventional one were also reported (Diógenes et al., 2022; Hartati & Kusumaningrum, 2019; Khatri et al., 2024).

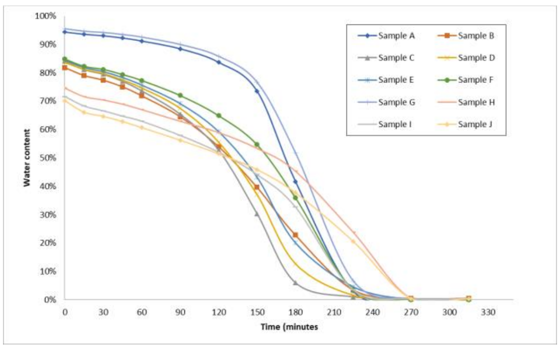

Figure 1. Water content of the product obtained from the drying process using the foam mat drying method at a temperature of 60ºC.

Figure 1-3 also shows that the rate of the red spinach puree drying process using the foam mat drying method is fast at 0-120 minutes. The acceleration of the decrease in water content in the dried material is stated as a result of the large surface area interacting with the drying air. The movement of water vapour is also stated as a result of the capillary diffusion process (Afifah et al., 2017). The results of the study also showed that at 30-60 minutes, the red spinach powder obtained from the conventional drying process had a water content value of approximately twice the water content value of the red spinach powder obtained from the drying process using the foam mat drying method (Figure 1-3). The foam mat drying method is stated to be able to dry materials at relatively low temperatures and shorter drying times when compared to the drying process of materials that are not formed into foam using the same type and drying condition (Hossain et al., 2024; M et al., 2018; Mounir, 2018). In short, the time required in the drying process using the foam mat drying method is due to the large surface area exposed to the drying air.

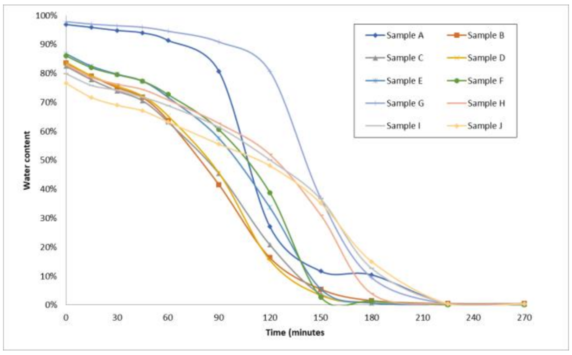

Figure 2. Water content of the product obtained from the drying process using the foam mat drying method at a temperature of 65ºC .

Figure 1-3 also shows that the addition of Maltodextrin with a concentration of 15% and also 30% egg white gets a lower product water content when compared to the product water content with other variations of maltodextrin and egg white additions. This shows that the added maltodextrin will be more effective if added in low concentrations, conversely the addition of egg white is more effective if added in higher concentrations. Maltodextrin is said to be able to form gels and retain water (Chronakis, 1998; Triyono et al., 2017). Therefore, with the addition of higher maltodextrin, the water retained by maltodextrin will increase.

This results in the use of maltodextrin with high concentrations having an impact on the high water content of the product (Figure 1-3). Furthermore, the results of the study showed that the product water content of 0.11% was obtained from the drying process of red spinach puree using the foam mat drying method at a temperature of 60°C, the addition of 15% maltodextrin and 30% egg white and a drying duration of 315 minutes (Figure 1).

The drying process of red spinach puree using the foam mat drying method at a temperature of 65°C, the addition of 15% maltodextrin and 30% egg white and a drying duration of 180 minutes produced red spinach powder with a water content of 1.3% (Figure 2). Meanwhile, the drying process of red spinach puree using the foam mat drying method at a temperature of 70ºC, the addition of 15% maltodextrin and 30% egg white and a drying duration of 180 minutes was able to produce red spinach powder products with a water content of 1.813% (Figure 3).

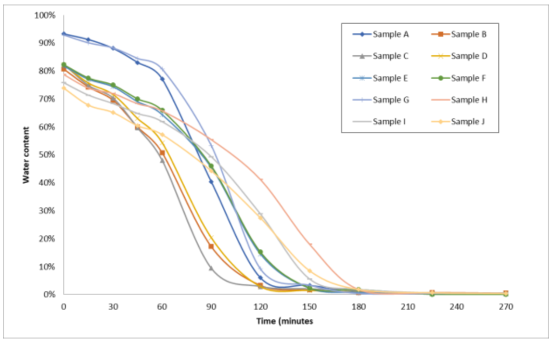

Figure 3. Water content of the product obtained from the drying process using the foam mat drying method at a temperature of 70ºC.

These results indicate that the drying process of red spinach puree using the foam mat drying method at a temperature of 65°C, with the addition of 15% maltodextrin and 30% egg white and a drying duration of 180 minutes can be considered as relatively good process conditions for the foam mat drying method of red spinach puree.

The water content data in the sample without foam decreased more slowly than the sample with the addition of maltodextrin and egg white. The final weight of the sample without foam obtained after constant water content was lighter than the sample with the addition of foam, namely 1.13 grams with an initial water content of 94.37% and a final water content of 0.49% at a drying temperature of 60°C, 0.63 grams with an initial water content of 96.86% and a final water content of 0.46% at a drying temperature of 65°C, and 1.36 grams with an initial water content of 93.23% and a final water content of 0.48% at a drying temperature of 70°C.

Effect of Temperature

The foam mat drying process of red spinach puree was studied at different process temperatures, namely 60-70°C. The results of the study showed that the higher the temperature used, the faster the drying process (Figure 4). This is in line with the statement that the ability of the material to release water from its surface will increase with the increasing temperature of the drying air used (Caparanga et al., 2017; Yusufe et al., 2017; Zhang et al., 2021). The higher the temperature and speed of the drying air flow, the faster the drying process will take place (Caparanga et al., 2017; Kosasih et al., 2020; Longdong et al., 2024).

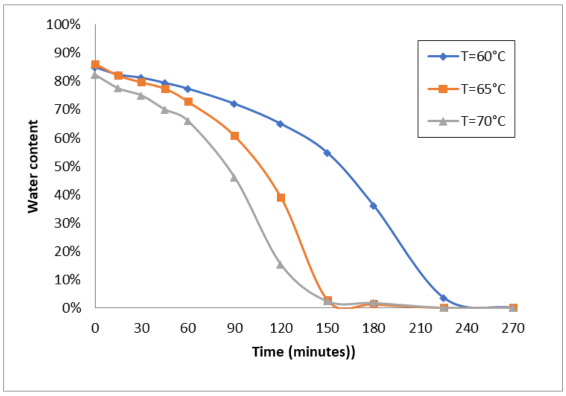

Figure 4. Graph of the relationship between water content and drying time

Effect of adding maltodextrin on total anthocyanin levels in products

From the research results, data on the total anthocyanin content was obtained in each product sample dried at a temperature of 65°C, which showed that the product results with the highest total anthocyanin content were obtained from samples without the addition of 0% maltodextrin and 15% egg white, namely 4.56 mg/l (Table 2).

Table 2. Results of total anthocyanin levels in products

Sample	Total Anthocyanin (mg/l)
A	2,47
B	3,89
C	1,83
D	1,01
E	1,82
F	1,90
G	4,56
H	1,75
I	2,43
J	2,52

This is because the increasing concentration of fillers results in lower anthocyanin concentrations, higher pH and lower total acid. This is because with the addition of maltodextrin concentrations, the total solids in the powdered red spinach also increase. That the higher the concentration of maltodextrin, the lower the water content of the product and the total anthocyanin will also decrease. The addition of maltodextrin will increase the amount of solids and do not contain anthocyanin pigments, thereby reducing the anthocyanin content in each weight of maltodextrin particles. The effect of the maltodextrin concentration on anthocyanin level was also reported (Lestario et al., 2023). It was indicated that an increased amount of maltodextrin led to a reduction in the total anthocyanin content, implying that the amount of maltodextrin had a negative correlation with anthocyanin levels (Lestario et al., 2023).

CONCLUSSION

Based on the research that has been done, it can be concluded that drying red spinach puree using the foam mat drying method is an effective method, especially when compared to conventional drying methods. The rate of drying process using the foam mat drying method is faster when compared to the conventional drying process. The drying temperature has a significant effect on the process of reducing water content in the product, the higher the drying temperature, the faster the reduction in water content in the product. In the drying process at a temperature of 60-70°C, the addition of 15% maltodextrin and 30% egg white can produce red spinach powder with a lower water content when compared to other sample variations. The best drying process producing red spinach powder with a water content of 0.08% was obtained from the drying process using the foam mat drying method at a temperature of 65°C.

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