Drying Spirulina with Foam Mat Drying at Medium Temperature

Aji Prasetyaningrum[1] and Mohamad Djaeni[2]
Department of Chemical Engineering Faculty of Engineering
Diponegoro University
Jl Prof H. Soedharto, SH, Tembalang, Semarang

[1]e-mail: ajiprast@undip.ac.id
[2]e-mail: m.djaeni@undip.ac.id

***Abstract*— Spirulina is a single cell blue green microalgae (Cyanobacteria) containing many Phytonutrients (Beta-carotene, Chlorophyl, Xanthophyl, Phyocianin) using as anti-carcinogen in food. Producing dry spirulina by quick drying process at medium temperature is very important to retain the Phytonutrient quality. Currently, the work is still challenging due to the gel formation that block the water diffusion from inside to the surface.**

This research studies the performance of foam-mat drying on production of dry spirulina. In this method the spirulina was mixed with foaming agent (glair/egg albumen, popular as white egg) at 2.5% by weight at air velocity 2.2 m/sec. Here, the effect of spirulina thickness and operational temperature on drying time and quality (Beta-carotene and color) were observed. The drying time was estimated based on the measurement of water content in spirulina versus time. Result showed that the thicker spirulina, the longer drying time. Conversely, the higher operational temperature, faster drying time. At thickness ranging 1-3 mm and operational temperature below 70^{o}C, the quality of spirulina can fit the market requirement.

***Keywords*— Cyanobacteria, Phytonutrient, foam-mat drying, spirulina**

I. Introduction

The study of spirulina for food resources has developed involving breeding, cultivation, harvesting, and processing for food.The processing is an important step to retain the nutrition and active compound. Spirulina is a single cell blue green microalgae (Cyanobacteria) containing many Phytonutrients (Beta-carotene, Chlorophyl, Xanthophyl, Phyocianin) using as anti-carcinogen in food. The drying is one of important process that determines the quality of spirulina. However, proper dryer method resulting high quality dry spirulina with high energy efficiency is not well performed.

Foam-mat drying in which the product is mixed with foaming agent such as egg is an option method for spirulina [1]. Here, the spirulina is mixed with foaming agent to increase the surface area during the drying. Hence, the process can be well done in low or medium temperature in which minimize the nutrition degradation. Previous research pointed that foam-mat drying is able to increase surface area and speed up evaporation rate [2]. The formation of foam depends on several aspects such as liquid composition, foaming method, temperature, and foaming time. In case, foam stabilizer can be added to stabilize the foam consistency during the drying process. The composition of foam stabilizer and foaming agent influences the stability of foam in which affects the drying effectiveness.

In general, drying product with foaming materials is faster than that of non-foamed ones. The application has been proven for from soymilk [3], star fruit [4], tomato paste [5], bananas [6], and mango [7]. This research aims to compare foam-mat and conventional drying for spirulina. The air flow, foam to spirulina composition, and thickness of spirulina are observed. This step is meaningful for further development in drying spirulina.

II. Material and Method

The material, spirulina with 95% moisture content, was obtained from PT. Trans Pangan Spirulindo, Jepara, Indonesia. The material was mixed for 5 minutes with foaming agent (glair/albumin) with different composition (2.5% and 5% with foam stabilizer namely methyl cellulose 0.25%). The mixture was then dried in tray dryer (Fig. 1) under constant air velocity (2.2 m.s^{-1}). As variables, the thickness of spirulina mixture and operating temperature were varied. Firstly, air as drying medium was transported and heated up to 60^{o}C. The hot air was then contacted with wet spirulina in the dryer. As a response the water content was observed every 5 minutes until moisture content close to 5%. The data was used for estimating drying rate. The process was repeated for different spirulina thickness and operating temperature.

At the second, the spirulina quality (colour, texture, and Beta-carotene) were analyzed using the product sample from the best drying process. The result was the compared to the dry spirulina produced by PT Trans Pangan Spirulindo.

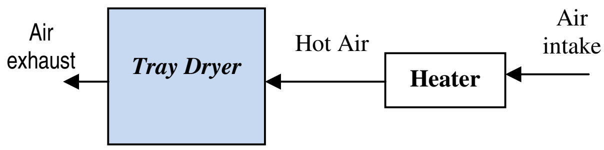

Fig 1. Schematic of tray dryer for drying spirulina

III. Result and Discussion

Effect of Foaming agent

Results presented in Fig. 2 and 3, indicated that the foaming agent affects the drying time and rate, significantly. With foaming agent 2.5% or more, the drying time can be accelareted up to 80 minutes shorter (Fig. 2) and drying rate can be two times higher (Fig. 3). However, increasing foaming agent composition from 2.5 to 5.0 % does not affect the drying time significantly. The responses of water content during the time as well as constant drying rate are comparable.

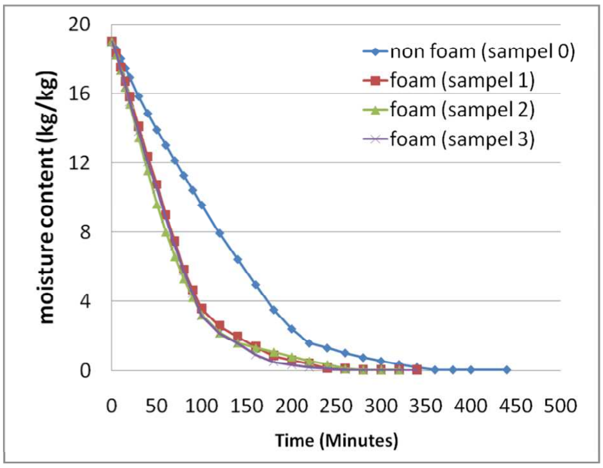

Fig 2.Typical drying (X) and temperature (T) curves for foamed and non-foamed spirulina dried as 1 mm layer by air at 60°C and air velocity 2.2 m.s^{-1} (sample 1,2,3 foaming agent 2.5%, 3.5%, and 5%, respectively)

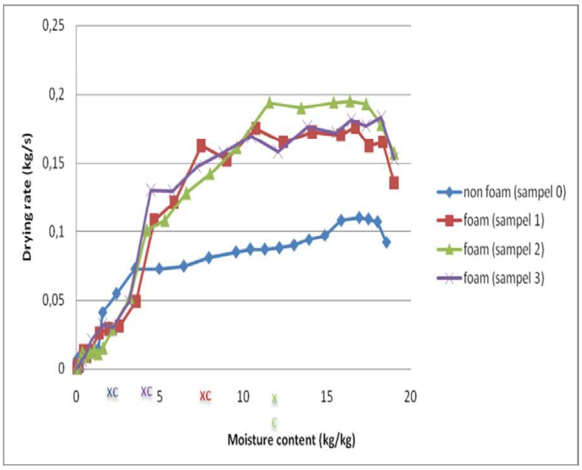

Fig 3. Drying rate curves for foamed and non-foamed spirulina dried at 1-mm layer by air at 60°C(sample 1,2,3 foaming agent 2.5%, 3.5%, and 5%, respectively)

Effect of Spirulina Thickness

The step was conducted at operational temperature 60^{o}C, air velocity 2.2 m.s^{-1} with water content in spirulina 95% the composition consisting of foaming agent 2.5% and methyl cellulose 0.5%. The spirulina layer in tray dryer was varied at 1, 3, and 5 mm (See Fig. 4 & 5). The thickness affects the drying performance significantly. The thinner, the faster drying time. Here, 1 mm of spirulina thickness can speed up drying time 4 and 6 times shorter than that of 3 mm and 5 mm, respectively (Fig. 4). The thickness of layer inhibits the diffussion of moisture from the inside to the surface of spirulina. Then water is more difficult to be evaporated resulting in slower drying rate (Fig. 5).

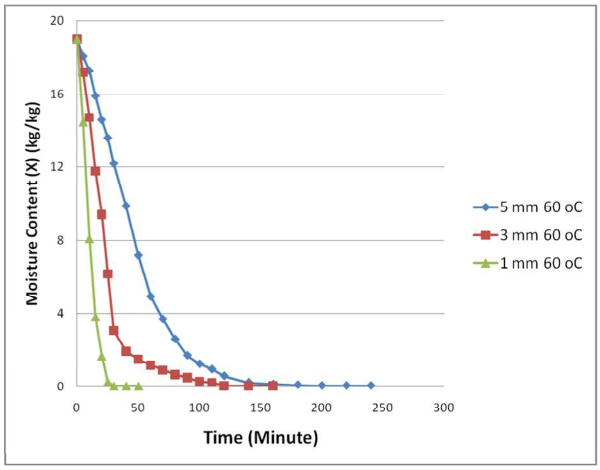

Fig 4.Moisture content (X) and temperature (T) curves for foamed and non-foamed spirulina (dried as varied layer thickness at 60°C and air velocity 2.2 m.s^{1}).

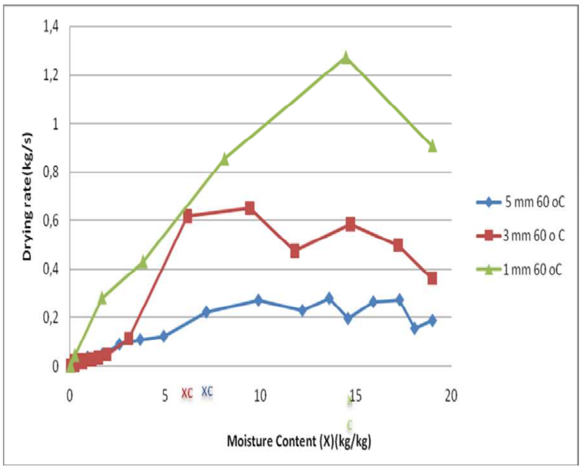

Fig 5. Drying rate curves for foamed and non-foamed spirulina (dried as varied layer thickness at 60°C and air velocity 2.2 m.s^{1}).

Effect of Drying Temperature

In this step, the operational temperature was varied at 50, 60, and 70^{o}C. As a product, 1 mm of spirulina containing 2,5% albumin and 0,5% methyl cellulose, was dried. The results were presented in Fig. 6 and 7. Based on the Fig. 6, the drying time can be shortened at higher drying temperature. This because, at higher temperature the movement of water in spirulina layer increases. In this case, more water diffuses from the inside to the surface of spirulina. In addition, with higher temperature, the capacity of air as drying medium to evaporate water increases. Hence, higher drying rate can be also obtained (Fig. 7).

However, upper 60^{o}C, with spirulina thickness 1 mm, the increase of drying rate is not significant (see Fig 6 & 7). As a result, drying time at 60 and 70^{o}C is not big different (about 30-40 minutes). Perhaps, the total water in spirulina is too small. So, the total heat required for evaporation is not comparable with the increase of sensible heat in hot air (by increasing temperature). Perhaps, the effect can be significantly observed at thicker spirulina or by adding more spirulina in tray dryer.

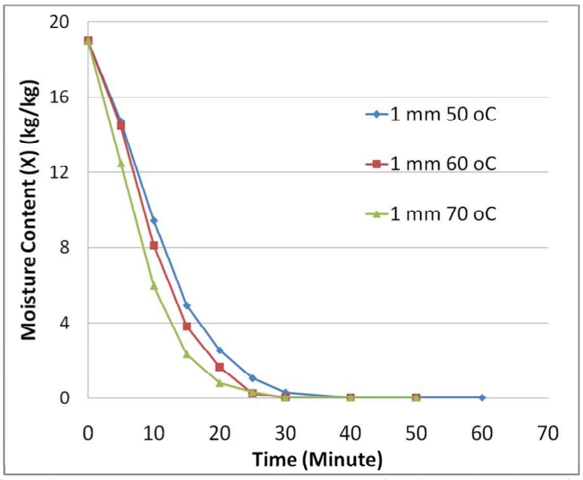

Fig 6. Moisture content (X) versus time curves for foamed and non-foamed spirulina dried at1 mm thickness and air velocity 2.2 m.s^{-1}

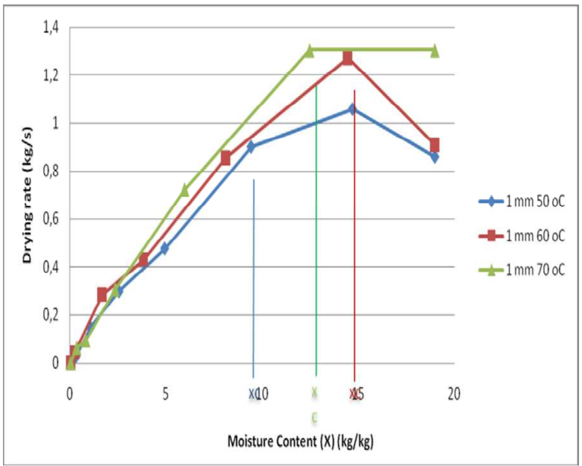

Fig 7. Drying rate curves for foamed and non-foamed spirulina dried at1 mm thickness and air velocity 2.2 m.s^{-1}

Quality Analysis

The quality was measured based on colour, texture, and B-carotene content (see Table 1). As a comparison, the dry spirulina produced by PT Trans Pangan Spirulindo, Jepara, Indonesia, was used. In organoleptic aspect, the color test was divided into 5 digit levels and preference for the texture of spirulina products with six levels of assessment. The higher and greater level is good quality product.

Result indicated that the quality of product with foam-mat drying still fits with the market requirement. Even, the product resulted from foam-mat drying is a bit better than that of available market product.

TABLE I
SPIRULINA QUALITY UNDER FOAM MAT DRYING

No	Parameters	Source	
		PT Trans Pangan Spirulindo	Dried with foam at 60^{o}C
1	Colour	4.20	4.52
2	Textur	2,68	5,24
3	Beta-carotene (mg/100 gr)	149.03	140.00

IV. Conclusions

The drying spirulina with foaming agent has been conducted in tray dryer at different composition, temperature, air flow, and thickness of spirulina. Results showed that the thinner layer, higher temperature give significant effect on drying rate as well as product quality. In addition, the existence of foaming agent can also improve the drying rate, but adding foaming agent higher than 2.50%, the improvement is not significant anymore.

The quality of spirulina has been also analyzed and compared with the spriluna produced from industry with conventional dryer. Based on colour, texture, and Beta-carotene content, the quality of spirulina dried by foam-mat drying is a bit higher than that of produced by industry.

Acknowledgment

We thank to PT. Trans Pangan Spirulindo Jepara Indonesia for the facility to provide product sample of spirulina.

REFERENCES

[1] Muthukumaran, A. *Foam Mat Freeze Drying of Egg White and Mathematical Modeling*. Department of Bioresource Engineering, Macdonald Campus of McGill University, 2007.

[2] Rajkumar, P., Kailappan, R., Viswanathan, R., Raghavan, G.S.V. and Ratti, C. Studies on Foam-mat Drying of Alphonso Mango Pulp. In *Proceedings 3rd Inter-American Drying Conference*, CD ROM, paper XIII-1. Montreal, QC: Department of Bioresource Engineering, McGill University, 2005.

[3] Akintoye, O.A. and Oguntunde, A.O. Preliminary investigation on the effect of foam stabilizers on the physical characteristics and reconstitution properties of foam-mat dried soymilk. *Drying Technology* 1991, 9(1): 245-262.

[4] Karim, A.A. and Wai, C.C. Foam-mat drying of starfruit (*Averrhoa carambola L.*) puree. Stability and air drying characteristics. *Food Chemistry* 1999, 64: 337-343.

[5] Lewicki, P.P. Mechanisms concerned in foam-mat drying of tomato paste. *Transactions of Agricultural Academy in Warsaw* 1975, 55: 1-67 (in Polish).

[6] Sankat, C.K. and Castaigne, F.F.. Foaming and drying behaviour of ripe bananas. *Lebensmittel Wissenshaft und Technolgie* 2004, 37: 517-525.

[7] Cooke, R.D., Breag, G.R., Ferber, C.E.M., Best, P.R. and Jones, J. Studies of mango processing. 1. The foam-mat drying of mango (Alphonso cultivar) puree. *Journal of Food Technology* 1976, 11: 463-473