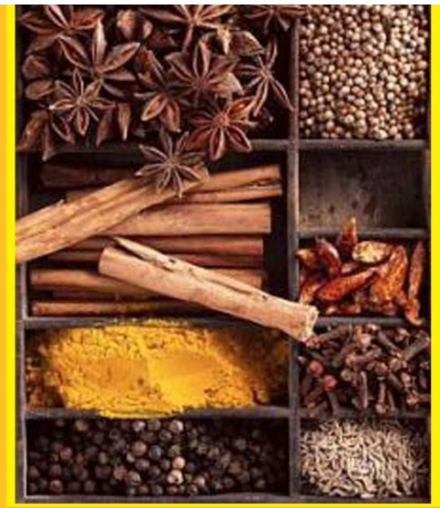
PROCEEDING



THE POWER OF LOCAL KNOWLEDGE

IN INCREASING FOOD BUSINESS COMPETITIVENES

TUESDAY, 4th DECEMBER 2012

THE 1ST INTERNATIONAL
12TH NATIONAL
STUDENT CONFERENCE

FOODTECH UNIKA
the breeding ground of excellence

Unika SOEGIJAPRANATA

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PREFACE

National Student Conference on food science technology has become the identity of Department of Food Technology, Soegijapranata Catholic University. Since 2000, this annual event had discussed various topics related to food science and businesses with recognized experts in their fields are cordially invited as keynote speakers. And thanks be to God, in this year, we can make these conferences as the 1st International Student Conference and 12th National Student Conference.

The theme of this year conference is "The Power of Local Knowledge in Increasing Food Business Competitiveness". This year theme was selected as a support towards local knowledge in creating a food business. Therefore with this conference, participants are expected to contribute in developing their own local knowledge to create food products that have more selling points. In addition, the conference is expected to be the place for student of food technology and other related sciences, food industry practitioners, and food scientists to share knowledge and innovative ideas for the development of the food in the future.

Lastly, I would like to give my sincere gratitude to all the honorable keynote speakers, sponsors, presenters, and participants for the valuable contribution and support for this conference. Also, I would like to give my gratitude to the committee members that has been work hard in order to make this conference happen. As this was our first time to hold the international conference, on behalf of the committee, I would like to apologize for our shortcoming. We always welcome any critics and suggestion for betterment of the next International and National Student Conference. I hoping all of you can enjoy the conference.

Have a nice conference!

Chairperson,

Nawang Sari Adhiyanti Muljo Kusumo

FOOD BUSINESS AND MANAGEMENT

FOOD PROCESSING AND ENGINEERING

FOOD MICROBIOLOGY AND BIOTECHNOLOGY

FOOD QUALITY AND SAFETY

HERBAL FOOD AND BEVERAGE

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12[TH] NATIONAL
STUDENT CONFERENCE

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Certificate of Appreciation

for the participation of

NURUL ASIAH

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PRESENTER

In the 1st International Student Conference & 12th National Student Conference
"The Power of Local Knowledge in Increasing Food Business Competitiveness"
Semarang, Indonesia, 4th December, 2012

Dean

...ita Sulistyawati, STP, MSc

Chairperson

Nawangsari Adhiyanti Muljo Kusumo

THE DRYING KINETIC OF FOAM MAT DRYING COMBINED WITH AIR DEHUMIDIFIED FOR CARRAGEENAN DRYING

Mohamad Djaeni, Aji Prasetyaningrum, and Nurul Asiah

Chemical Engineering Department ; Engineering Faculty ; Diponegoro University
m.djaeni@undip.ac.id; ajiprasetyaningrum@yahoo.com

ABSTRACT

This research concerns to study the kinetic of foam mat drying combined with air dehumidified for carrageenan drying in different operational temperature, thickness, and composition of foam agent and foam stabilizer. The result of the experiment showed that drying of foamed materials gave better textural properties of the final product than non-foamed ones. Dehumidified air combined with extensive porous structure and lower densities of foams which operated at 80 °C, 4 mm foam thickness, with using egg white (20%) as foaming agent and methyl cellulose (10%) as stabilizing agent has reduced drying time 70 min than non-foamed ones. Based on the experiment, the drying of carrageenan recomended to operate at 80 °C, 2 mm foam thickness, with using egg white (20%) as foaming agent and methyl cellulose (10%) as stabilizing agent. It has indicated shorter drying time and higher drying rates.

Keywords : *drying kinetic, foam mat drying, dehumidified air, carrageenan , drying time.*

INTRODUCTION

In food industry, carrageenan is widely used for stabilizing and texturing some food product: a chocolate, frozen desserts, ready-to-eat deserts, soy milk, and cottage cheese dressings (Bixler et al., 2001). Carrageenan is extracted from the seaweeds, species of Euchema *cottonii*. (Mc Candless et al., 1973).

The foam-mat drying is a process in which the transformation of products from liquid to stable foam follows air drying at relatively low temperatures to form a thin porous honey-comb sheet. The foam-mat drying produces better quality, porous and can be easily reconstituted product (Kadam., et al 2010). Recently foam-mat drying widely used in drying process of vegetable puree and fruit juice commodities. (Falade et al., 2003; Sankat and Castaigne., 2004; Ratti and Kudra., 2005). The stable foam is produced by foaming agents. Generally, foaming agent are soluble proteins. Proteins moves through the aqueous phase and are spontaneously adsorbed at the air–aqueous interface where the viscoelastic films are subsequently formed. The outcome of proteins adsorption is a reduction in surface tension, which improves the foam formation (Prins., 1988).

Foam structure increased interfacial area of foamed materials; as a consequence it can be accelerate transport of liquid water to the evaporation front. It gives the shorter drying time. Besides that foamed materials have lower density, so that the mass load of the foam-mat dryer is also lower (Rajkumar et al., 2005). Some research informed that foam structure plays a major role in moisture movement during drying process and influence of it to product quality (Cooke et al.,1976; Karim and Wai., 1999b; Sankat and Castaigne., 2004). Foam mat drying method was suitable used for heat sensitive, sticky, viscous and high sugar content food products (Chandak & Chivate., 1972; Labelle., 1984). Suitable with physical characteristic of extract carrageenan that heat sensitive, sticky, viscous and high sugar content food products, the foam mat drying method was recommended to produce carragenan powder.

The drying times reduce with increase of the driving force. It's is increased by: 1) reducing the humidity of air, 2) decreasing air pressure, or by combinations of these two (Djaeni et al., 2007). In other research, the influence of air dehumidification is improves the driving force for drying and allows drying at low and medium temperatures at atmospheric pressure (Ratti C., 2001). The capability of zeolite to absorb the humidity of the air is another option for air dehumidification in drying process. Djaeni et al was developed the drying process with dehumidified air by zeolite. To produce the dehumidified air the processes is operated by passing the ambient air through a bed of activated zeolite. The effect of dehumidified air is increasing the driving force and the air temperature due to the release of adsorption heat. The experience showed that dryers operating at 40-60°C reach an energy efficiency up to 90%, which is 30-40% above that of conventional dryers (Djaeni et al., 2009).

This research concerns to study the kinetics of foam mat drying combined with using air dehumidified in different operational temperature, thickness, and composition of foam agent and foam stabilizer using tray dryer to produce carrageenan powder.

MATERIALS AND METHODES

Extract Carrageenan Process

The first step to made extract carrageenan was identified and choosed the seaweeds. Make sure that it was *Euchema cottonii species*. Then, washed them by aquadest to remove salt, sand and stones before treating with various alkalis to swell the seaweed and extract the carrageenan. Clean seaweeds submerged in alkali solution (HCl

+ Aquadest) in pH 5-6 for 15 minutes. After that, seaweeds submerged in alkali solution (KOH + Aquadest) in PH 9-10 for 24 hours. The seaweeds were ready to be dried by the sun ray about 2 - 3 days. The extraction processes run in the stirrer column extraction. Mixed the dried seaweeds (15 gr) with aquadest (900ml), and then added alkali solution (NaOH + Aquadest) until the pH of the solution to be 9 with temperature of the extraction was (70-80) ^{o}C for 2 hours. After extraction process, the dilute carrageenan solutions were filtered. Then, precipitated the solutions with potassium chloride (KCl 2, 5%) to give a fibrous mass which is pressed to removed impurities and then dried.

Foam Preparation

Foaming is a process to make liquid or semi solid to be form foams. Many foods which contain soluble proteins, e.g., egg white, beef extract and milk can be converted into stable foams when being whipped. In general, when the content of soluble solids in the sample is low, more amounts of foaming agent and stabilizers are required to be added (H art et al., 1963). This experiment used egg white as foam agent and methyl cellulose as foam stabilizer with various composition. The combination of those materials were : 20% egg white with 10 % methyl cellulose, 10% egg white with 20 % methyl cellulose, and 15% egg white with 15 % methyl cellulose. Both of those agents mixed by blender with rotational speed 720 rpm for 15 min to made stable foam. Based on the research, higher stirring time increases foam stability and higher stirring speed increases foam expansion significantly.

Experimental procedure for carrageenan drying

The drying experiments were performed in a tray dryer which equipped with seri unit for air dehumidification by zeolite and 3000 W electritical heated element capacity. The drying air carried out from the blower to the drying chamber with 28 x 43 cm cross-section area. A removable tray was placed to support the petri dishes which located above. Ambient air with relative humidity (RH) between 70-80% and temperature between 29-33°C was carrying out from the blower. Kept the superficial air velocity which passed the absorber column (suppose A) which contains the activated natural zeolite constantly. After the drying air trough out from the zeolite column, about 70-80% of water in air removed, the humidity of the air was increased and the air temperature increased about 5-10°C.

At the first experiment the dehumidified air was heated by heater component which was set 80 ^{o}C by thermocouple. The hot air with low humidity and high driving force was entering the dryer chamber from the center of bottom side. Moisture content of the material evaporated from the wet extract carrageenan sheets which placed 4 mm thickness in the petri dishes. About 150 minutes after the drying process, the capability of zeolite was decrease. It must be regenerated at 200°C for 2 hours. The process still continued by removed air flow rate to the other zeolite column (side B).

To generate the data which needed for drying kinetics, the decreasing of weigh of carrageenan was measured by electronic balance (accuracy ± 0.01 g) every 10 minutes. Information of drying process condition were collected. Humidity of drying air measured by humidity meter and velocity of the drying air measured by anemometer. The drying process stopped after about 120 minutes. In other operational variables, the procedure of drying process was repeated.

This research work in various operational variables: temperature 60 °C 80 °C and 100°C, carrageenan thickness 2 ,3 and 4 mm, and various foam agent and foam stability, 20% egg white with 10 % methyl cellulose, 10% egg white with 20 % methyl cellulose, and 15% egg white with 15 % methyl cellulose.

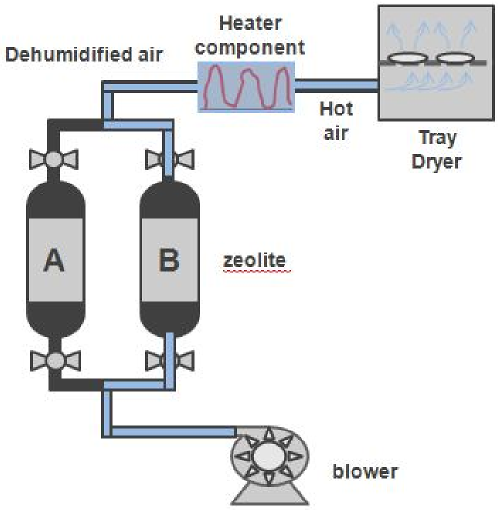


Figure 1. Schematic overview of the experimental equipment

Data processing

The data measurement showed the decreasing of carrageenan weigh. It used for calculated the theoritical of moisture content by :

$$X\ (dry\ basis) = \frac{M\ (wet\ solid) - M\ (dry\ solid)}{M\ (dry\ solid)} \quad (1)$$

The drying curve of carrageenan as a funtion of drying time vs moisture content. Drying rate curve known as N versus X. From the experiment, the drying rate determined by this equation:

$$N = -\frac{Ms}{A}\frac{dX}{dt}$$
(2)

More over, The total drying time to reduce the solid moisture content from initial moisture content *(X1)* to moisture content that expected *(X2)* can be estimated. Its can be simply calculated by:

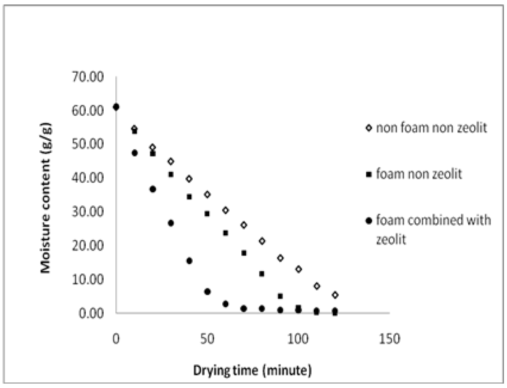
$$tc = \frac{Ms}{A} \frac{(X2 - X1)}{Nc} \quad (3)$$

$$tf = \frac{Ms}{A} \frac{(X2 - X1)}{(N1 - N2)} \ln \frac{N1}{N2} \quad (4)$$

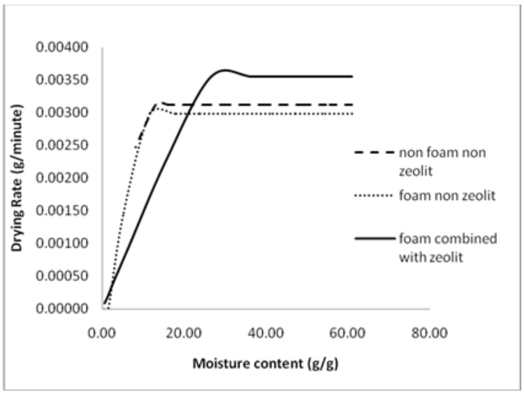
RESULTS AND DISCUSSION

Drying Kinetics

The effect of Foam Mat Drying Combined with Air Dehumidified



Graph 1. Drying curves of at the normal drying process (non foam and non zeolite), application of foam mat drying, and combination foam mat drying with air dehumidified to dry extract carrageenan



Graph 2. Drying rate curves of the normal drying process (non foam and non zeolite), application of foam mat drying, and combination foam mat drying with air dehumidified to dry extract carrageenan

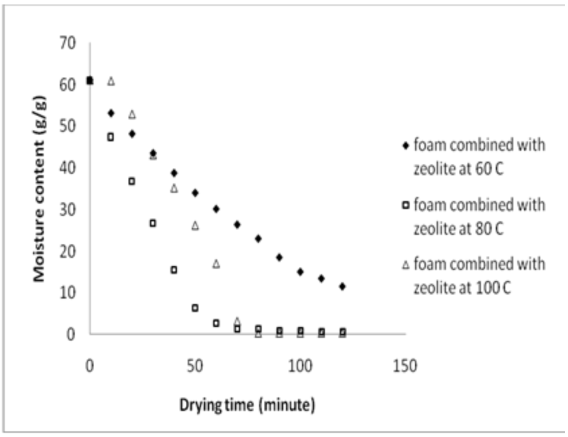
The first step of this research was compare the drying kinetic at the normal drying process (non foam and non zeolite), application of foam mat drying, and combination foam mat drying with dehumidified air by zeolite to dry extract carrageenan at the same condition of operation. The drying process operated in 80°C, drying air velociry 3,5 m/s, 4 mm thickenes, and foam produced by 20% egg white ang 10 % methyl cellulose. The result of this experiment was shown by drying curves (see Graph 1). Foam mat drying process gave shorter drying time to decrease of moisture content carrageenan from 61 g/g to 0,1 g/g dry basis than normal drying process. The mixed of carragenan, egg albumin as foam agent and methyl cellulose as foam stabilizer produced stable bubble structure of the foam. It's mean that the surface area for evaporation of the material which foamed was increased. The higher evaporation area gave impact to reduce the drying time. The shortest drying time performed by combination foam mat drying with dehumidified air by zeolite. When the humidity of the air was lower, the gradien humidity betwen solid material and drying air was higher to. As a concequency, mass transfer of moisture content from the material to the drying air can be accelerated.

Table 1. Drying time to reducing moisture content from 61 g/g until 0,1 g/g.

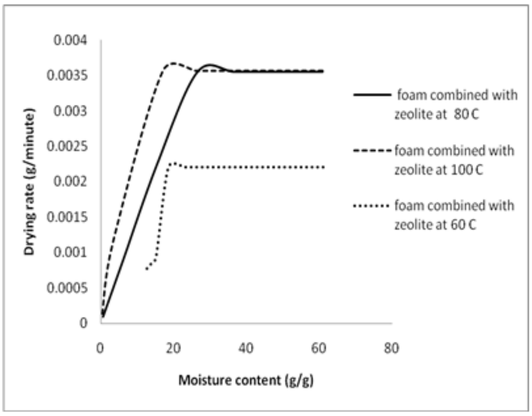
	Normal drying process	application of foam mat drying	combination foam mat drying with air dehumidified
Drying time (minute)	223	166	153

As seen in Graph 2, drying rate curve for foam combined with zeolit need shortest time for constant period rate phase and continued by falling period. Drying rate was the function of mass transfer coefficient and driving force between humidity of solid and humidity of air. Lower air humidity affected higher driving force; automatically it was increased the drying rate.

The effect of operational temperature



Graph 3. Drying curves of combination foam mat drying with air dehumidified to dry extract carrageenan at different temperature



Graph 4. Drying rate curves of combination foam mat drying with air dehumidified to dry extract carrageenan at different temperature.

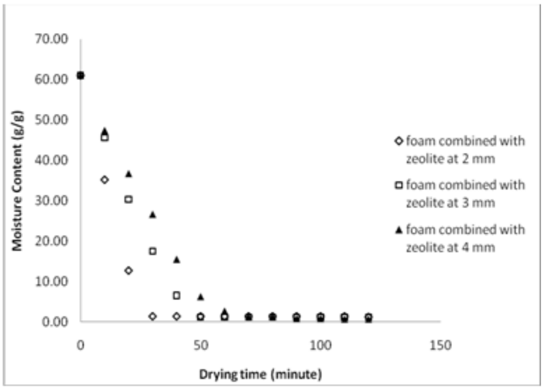
In the second type of the experiments studied the effect of operational temperature in combination foam mat drying with dehumidified air by zeolite. The drying process operated in drying air velocity 3,5 m/s, 4 mm thickenes, and foam produced by 20% egg white ang 10 % methyl cellulose with different drying temperature; 60 °C 80 °C and 100°C. From the drying curve showed that the shortest drying time obtained by operational temperature at 100°C. The higher temperature affect the higher moisture diffusifity of the solid material. It's mean that the drying time to evaporate the moisture content from the solid material can be speed up. At 80 °C drying operational temperature, the drying time of the carragenan almost similar with 100°C, operational temperature at 100°C gave about 10 minute faster than 80 °C. But in the other way, when the operational temperature operated at 60 °C, the drying process need so long drying time, about two time longger than it operated at 80 °C. The higher temperatur affected higher diffusivity. In spite of higher temperature give higher diffusivity, all of the drying process cannot operate in the high temperature. There are some consideration, including the critical temperature of the material, heat sensitive characteristic of the material and drying cost efficiency. The relationship between temperature and diffusivity used to optimise the drying proses variable, especially in temperature variable.

Table 2. Drying time to reducing moisture content from 61 g/g until 0,1 g/g in some different temperature.

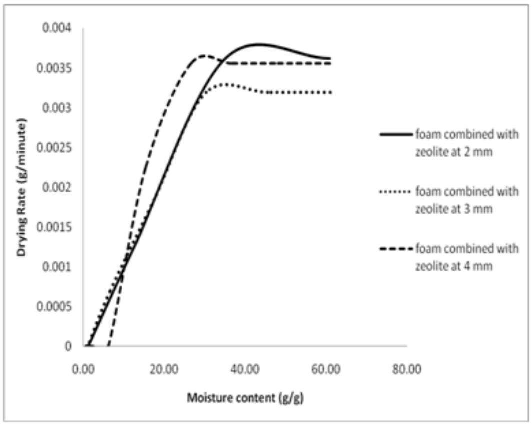
	Drying temperature		
	60°C	**80°C**	**100 °C**
Drying time (minute)	329	158	149

Besed on the calculation of the drying time at some different temperature, the drying process of carrageenan recommended operating at 80°C. It gave more efficient cost of energy and retains the quality of the carrageenan product.

The effect of carrageenan thickness



Graph 5. Drying curves of combination foam mat drying with air dehumidified to dry extract carrageenan at different thickness.



Graph 6. Drying rate curves of combination foam mat drying with air dehumidified to dry extract carrageenan at different thickness.

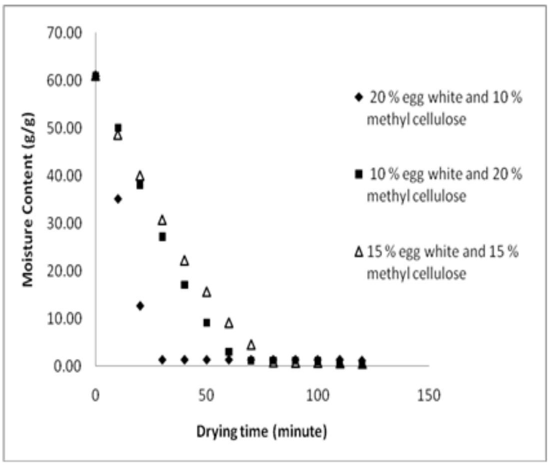
The recommended temperature of drying process from the past experiment was used to set drying temperature when studied the effect of carrageenan thickness. From the Graph 6, it wass seen that the moisture content reduced linearly with the drying time. The drying process with 2 mm thickness showed fastest drying time. The less of thickness affect the less distance of diffusivity, as a consequence the time of the moisture evaporation can be accelerated.

Table 3. Drying time to reducing moisture content from 61 g/g until 0,1 g/g in some different thickness.

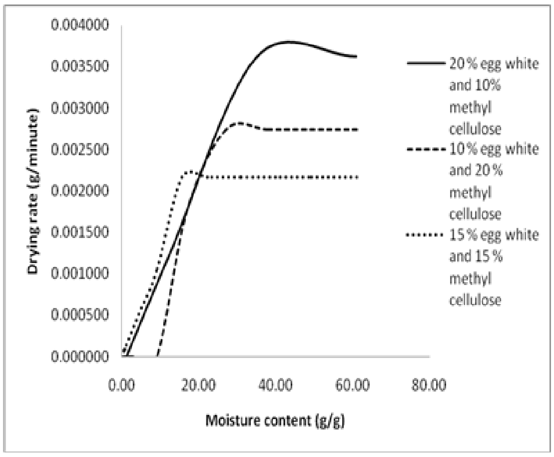
	Drying thickenes		
	2 mm	**3 mm**	**4 mm**
Drying time (minute)	136	150	158

From the calculation of the drying time at some different thickness it is seen that the different thickness had no significant effect to accelerate the drying rate, nevertheless the drying process recommend operating in 2 mm thickness for shorter drying time.

The effect of composition foam agent and foam stabilizer



Graph 7. Drying curves of combination foam mat drying with air dehumidified to dry extract carrageenan at different composition



Graph 8. Drying curves of combination foam mat drying with air dehumidified to dry extract carrageenan at different composition

In this section, the studying of effect of composition foam agent and foam stabilizer was evaluated. The drying curve shown that the shortest drying time performed by 20% egg white and 10 % methyl cellulose. The higher foam agent (egg white) and lower foam stabilizer (methyl cellulose) give better foam stability. The stability of the foam, affect the stability of expose area interface of the foamed material during drying process.

Table 4. Drying time to reducing moisture content from 61 g/g until 0,1 g/g in some different composition.

	Drying thickenes		
	20% egg white and 10 % methyl cellulose	**10% egg white and 20 % methyl cellulose**	**15 % egg white and 15 % methyl cellulose**
Drying time (minute)	136	168	147

From the calculation of the drying time at some different composition, it was seen that

20% egg white and 10 % methyl cellulose were recommended for drying process for shorter drying process.

Product Quality

Textural properties

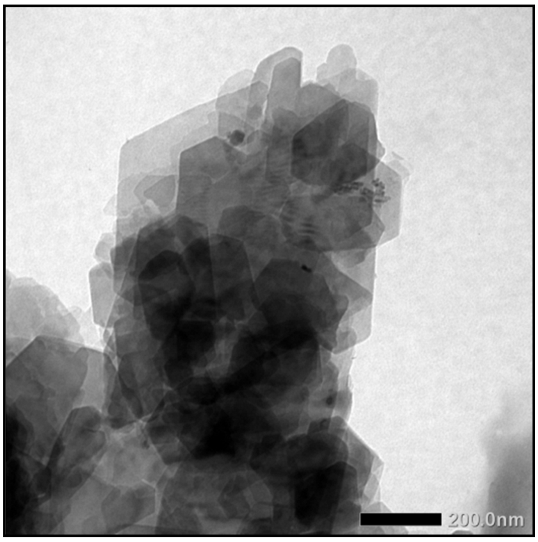


Figure 2. TEM image of carragenan powder after dried by non foam and non zeolite drying

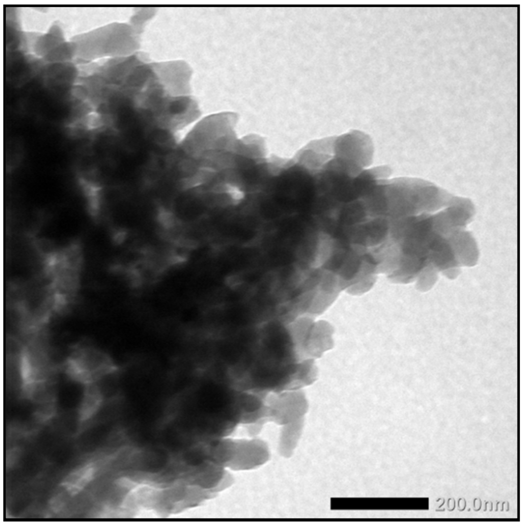


Figure 3. TEM image of carragenan powder after dried by combination foam mat drying with air dehumidified

High resolution transmission electron microscopy (TEM) image was used to determine the phase composition of the nanoparticles. The microstructures of the resulting nanoparticles were characterized by Transmission electron microscope JEM-1400 (JEOL, Japan) is optimized for high-contrast hogh-relosution. Accelerating voltage: 40-120 kV, cathodes – tungsten ar LaB6, magnification: x50-x800000, resolving power (points) – 0.38 nm. The microscope is equipped with high-tilt goniometer, high-resolution water-cooled bottom-mounted CCD-camera and a film camera. Microscope functionality is fully computer-controlled, with high degree of automation.

As seen at Fig. 10 and Fig. 11 the microstructures nanotape of carragenaan at dimension 200 nm in length can be identified. Both of those image showed similar shape, but different in size. At the same dimension, textural properties of the carragenan which dried by combination foam mat drying with air dehumidified was smaller than non foam.

CONCLUSIONS

The combination of foam mat drying with air dehumidified to dry carrageenan gave better performance than non foam and non zeolite ones. The drying time can be speeded up 70 minutes, with better quality of textural properties of carrageenan powder.

Based on the calculation of the drying time, the temperature drying process at 80°C performed more efficient cost of energy and able to retain the quality of carrageenan product.

From the experiment, the different thickness had no significant effect accelerated the drying rate, nevertheless the drying process recommended to operate in 2 mm t thickness for shorter drying time.

The combination of 20% egg white and 10 % methyl cellulose gave better foam stability and gave the sortest drying time.

ACKNOWLEDGEMENT

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NOMENCLATURE

A = evaporation area (m^2)

M = mass (kg)

N = drying rate ($kgm^{-2}h^{-1}$)

Nc = drying rate at constant rate period ($kgm^{-2}h^{-1}$)

t = drying time (h)

tc = drying time at constant rate period (h)

tf = drying time at falling rate period (h)

X = moisture content (kg/kg)

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