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The Influence of Foaming Agent and Cake Thickness on the Drying Process Tomatoes Using a Tray Dryer

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Abstract

Moisture content of tomato (Licopersicon esculentum Mill.) is very high, so easily damaged due to physical impact, enzyme and microbes activity. Further processing is necessary in order to improve shelf life, one way is drying method. This work studied the effect of foaming agent and cake thickness in tomato drying using tray dryer at various temperatures. Foaming agent is used to convert the material into foam, so that the drying temperature can be set relatively low to preserves color, aroma and nutrient composition of the material. The tray dryer is used, because it is simple and the operation cost is relatively cheap. In this work, tomatoes were sliced, crushed for 10 minutes using blender, separated from the seeds and residues with a 60 mesh sieve, and then mixed with dextrin and foaming agent Tween 80 each by 5% weight respectively. Each mixture was blended for 10 minutes. The tray dryer was filled with hot air at 2.0 m/sec with temperature variation of 40, 50, 60 and 70ºC and cake thickness variation of 2 and 4 mm. The results obtained, drying at 50°C is faster than 40ºC, while 50 to 70ºC is relatively the same. The thicker the cake, the slower the drying time. Performance of foaming agent Tween 80 compared to chemical foaming agent is a natural egg white powder. Drying with a foaming agent Tween 80 faster than egg white powder.

Keywords: *cake thickness; foaming agent; tomato; tray dryer*

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INTRODUCTION

Tomatoes (*Licopersicon esculentum Mill.*) are horticultural products that are easily obtained in Indonesia. Tomato production continuously increases and as a result the tomato prices declines when the hervest time arrived. Tomatoes have a high water content, so they are easily damaged due to mechanical influences, enzyme and microbial activity.

The demand for tomatoes increases over time along with the increasing of population and interest in tomatoes. However, tometoes are food that easily damaged in fresh condition. This condition brings on wasting an abundant of damaged tomatoes during harvest season. Efforts to avoid losing and wasting tomatoes are a major interest, especially when there is an imbalance between supply and demand at the time of the non-harvest season. This growing market opportunity requires tomatoes to be obtained in a more practical form and spur the development of technology to maintain and sell tomatoes products in dried form.

Tomatoes contain many nutrients and bio-active chemicals that are complete and important for humans

health. Tomatoes are rich in vitamin C and some antioxidants, including vitamin E and lycopene. In addition, tomatoes contain natural dietary fiber which is very good for human digestion and also the presence of protein in tomatoes making it a very nutrient-laden fruit. In 180 grams of ripe tomatoes, it containes about 34.38 mg of vitamin C which fulfills 57.3% of daily needs, the fiber content reaches 1.98 grams and protein reaches 1.53 grams. Lycopene content contained in fresh tomatoes ranges from 3.1 to 7.7 mg every 100 grams.

Further processing is needed in order to increase shelf life, an alternative way is by drying the tomatoes products. This study studied the effect of foaming agent and cake thickness on drying the tomatoes using tray dryer at various temperatures.

Djaeni *et al.* (2015) reported that the increase of foam content enhances the drying rate (water surface evaporation). This because, the foaming agent forms the porous structure (foam) and breaks or opens the gel structure. Foaming agent serves to convert material into foam, hence the drying temperature can be maintained in lower level to prevent the degradation of natural color, aroma and nutritional composition of tomatoes. Tray dryer type is utilized because the process is simple and operating costs are relatively cheap.

Figiel *et al.* (2017) reported that the dehydration of agricultural products seems to be an extremely important matter, as currently the form and quality of food and pharmaceutical products decides their commercial success. Final quality in terms of physical and, more importantly, chemical properties of those products results of preparation steps and methods applied for their preparation.

The dehydration process is an alternative to provide the tomatoes commercially. The most popular tomato drying method is using hot air because it can be operated easily and relatively inexpensive in technology. The process is performed by streaming hot air (usually operated at the temperature range between 50 to 80ºC) to food. The heat given to the food material releases the water content in the food.

According to Berk *et al.* (2009), the drying curve is usually modeled so as to show three regions or phases: Region I – Phase of *rising rate*: the rate of drying increases as water is removed. Physically, this behaviour is attributed to the 'conditioning' of the sample, e.g.warming-up, opening the pores etc. This phase is usually short and not always observed in drying experiments. It is often omitted in the calculation of drying time. Region II – Phase of *constant rate*: drying rate remains nearly constant as water is removed. Region III – Phase of *falling rate*: below a certain moisture content, called the 'critical moisture content, X_C', drying rate drops sharply as water is removed.

The powder form has the advantage of being more durable, lighter and smaller in volume so that it can simplify packaging and transportation. The making of fruit extract powder usually is carried out by drying with the method of freeze drying, spray drying, and foam-mat drying. Freeze drying and spray drying are difficult to be performed in lab-scale due to the expensive equipment and also the human resources needed requires high expertise.

The equipment used in foam-mat drying is tray dryer. The reason for the use of tray dryers is that the construction of foam dryers is simple, the operating costs are relatively cheap, and the skilled labor needed is low. The material should be converted into foam form so that the drying temperature can be meintained at low level to maintain the natural color, aroma and nutritional composition of the fresh tomatoes.

Fitrotin *et al.* (2007) reported the use of Tween 80 as an emulsifier in the manufacture of tomato juice powder using a spray dryer. The treatment was using dextrin with the concentration of 3, 4, 5% and tween 80 (0%, 0.3%, 0.4% and 0.5%). The results showed that the best tomato extract powder was obtained from a combination of 5% dextrin and 0.5% tween 80 with water content of product was 2.53%. Kamsiati (2006) reported the use of Tween 80 combined with egg white as an emulsifier in making tomato juice powder using a cabinet dryer at 3 mm cake thickness, temperature 55ºC and 7 hours drying time. The tomatoes with 95.70% moisture content was used as feed until obtained dried extract of tomato juice with the average water content of tomato juice powder ranged from 1.75-2.61%. Abdulmalik *et al.* (2014) reported the production of tomato powder using tray dryer at temperatures of 50-60ºC and drying time for two days in fresh tomatoes with a moisture content of 93.1% resulting in tomato powder with a moisture content of 6.2%. Sramek *et al.* (2015) reported the making of powder from tomato paste with foam-mat drying method using an oven dryer. The composition of the sample mixture is 200 grams of tomato paste mixed with 50 grams of a maltodextrin solution and 1.25 grams of egg white. The mixture was dried using an oven dryer. The Cake thickness duting drying process was 15 mm, the temperature varied from 50 to 70ºC and the air flow rate was maintained at 0.5 m/sec. Drying time was performed for 4.3-8.5 hours. Moisture content of produced tomato powders were 3-6% wet weight. Wilson *et al.* (2012) recommended that foam mat drying of mango pulp can be carried out using 3% egg white as foaming agent and 65oC air drying temperature with the retention of nutritional quality.

The central theme of the problem in this study was to study and compare the use of synthetic foaming agent Tween 80 with the natural foaming agent egg white in drying using a tray dryer. The best operating condition of drying process including drying temperature and cake thickness were determined in this study.

MATERIALS AND METHOD

Materials

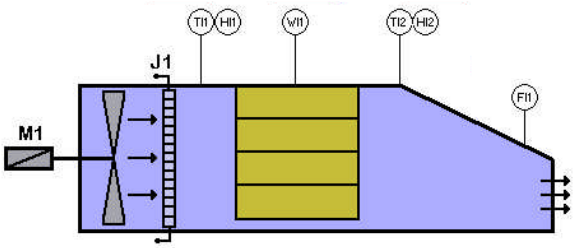
The main raw material is the tomato hybrid Amala 474 variety which was planted at an altitude of 1,200-1,270 above sea level. The tomatoes used as raw materials are ripe tomatoes, fresh red, relatively the

same diameter, not physiologically and mechanically damaged, plucked directly from the garden in Bandung. Additional ingredients consist of 2 types, namely emulsifying agent (Tween 80 and egg white powder) and carrier agent (maltodextrin) which functions as a foam stabilizer.

A food grade Tween 80 was used in this study in liquid form. Was purhased at one of the chemical stores in Bandung. Tween 80 is a polyoxyethylene sorbitan fatty acid ester or polyoxyethylene 20 sorbitan monooleate. The chemical formula of Tween 80 is $C_{64}H_{124}O_{26}$. Food grade egg white powder with 100% purity was purchased online from Tangerang. In the food industry, egg whites are more commonly used as foam stabilizers, while egg yolks are more commonly used as stabilizers of emulsions. Dextrin is a polysaccharide used as food additives. This compound is made from starch by partial hydrolysis, and is usually found in the form of white powder which is dried by spray-drying and it is considered as hygroscopic. The food grade dextrin used in this study was purchased online from the chemical store in Jogjakarta.

Equipments

The main equipment is Tray Dryer from Veneta (2015), as a drying equipment. The Tray Dryer equipment scheme was shown in Figure 1. The tray dryer is equipped with a thermometer to measure the temperature of the air inlet and outlet. The humiditimeter was installed to measure the humidity of the air inlet and outlet. Anemometer to measure the dried air flowrate, and the balance to measure the weight sample. Supporting equipment such as blender and sieve measuring 60 mesh.



Caption:
M1 : Blower motor
J1 : Heater element
TI1 : Thermometer (T inlet air)
HI1 : Hygrometer (%Rh inlet air)
WI1 : Balance (sample weight)
TI2 : Thermometer (T outlet air)
HI1 : Hygrometer (%Rh outlet air)
FI1 : Anemometer (air flowrate)

Figure 1. The scheme of tray dryer equipment

Methods

Fitrotin *et al.* (2007) reported that the vitamin C content decreased after tomato juice was converted into powder. The decrease was due to vitamin C degradation as an effect of oxidation process. Dextrin is composed of glucose units that can bind water hance the dissolved oxygen can be reduced. As a result the oxidation process can be prevented. Higher concentration of vitamin C will be obtained along with the increase of dextrin concentration. Thus only a few vitamin components are lost during drying. The addition of dextrin as a carrier agent is expected to reduce vitamin C degradation.

Kamsiati (2006) reported that foam-mat drying of tomato juice with a level of Vitamin C 35.17 mg/100 g of fresh tomatoes produced an average vitamin C level of dried tomato powder ranging from 66.79-135.89 mg/100 g. Vitamin C levels increase with increasing concentration of egg white foam. This phenomenon happens because the increased concentration of egg white foam can strengthen the film layer which protects the components in the froth system including vitamin C. the thicker film has more capability in protecting the dissolved materials in the air bubbles. Vitamin C is an easily oxidized vitamin, therefore vitamin C levels increase with increasing concentration of egg white foam addition.

In this study, tomatoes were sliced and blended for 10 minutes. The seeds and pulp were separated from tomato juice by sieving the juice using 60 mesh sieve. Then the tomato juice was mixed with dextrin and Tween 80 foaming agent as much as 5% by weight for each additive. The mixture was then blended for 10 minutes. Tray dryer was heated by streaming the hot air at the flowrate of 2.0 m/sec with a temperature variation of 40, 50, 60 or 70ºC. A stainless steel pans containing 2 mm or 4 mm tomato paste were inserted into the tray dryer. Tomato paste weight was measured every 5 minutes. From the weight, the water content of sample can be determined. Data retrieval was stopped after there was no significant change in sample weight.

Dry basis and wet basis water content can be calculated using equation (1) and (2) as follow:

$$dry\ basis\ water\ content = \frac{a}{k}\ x\ 100\ \% \quad (1)$$

$$wet\ basis\ water\ content = \frac{a}{(k+a)}\ x\ 100\ \% \quad (2)$$

Details:
a = weight of water (in gram or in the same unit as used for dry material)
k = material weight/dried weight of material without water content (g or kg)

Water content measurements were carried out before and after drying process using oven method to determine the evaporated water content. The amount of water contained in food in total was usually expressed in weight percentage of the food itself and it was called as water content.

From the caculation results, it can be seen the effect of temperature on water content (dry basis) at various temperature condition of 40, 50, 60 and 70ºC which was presented in Figure 2, while the effect of cake thickness at each temperature was shown in Figure 3.

For comparison study, the egg white was used as a substitute for tween 80 at a temperature of 50ºC

and cake thickness was varied for 2 and 4 mm. the advantage of egg white foaming agent is a natural ingredient, so it is safer to be consumed than tween 80. The results of the study using the tween 80 foaming agent and egg white are presented in Figure 3.

RESULTS AND DISCUSSION

Raw Materials

The water content of tomato juice in this study is different from the research conducted by previous researchers, as shown in Table 1. This is due to the differences in varieties, cultivation place and method as well as influenced by several factors including: climate conditions, growing condition, maintenance, how to harvest, maturity at harvest time and storage conditions after harvest.

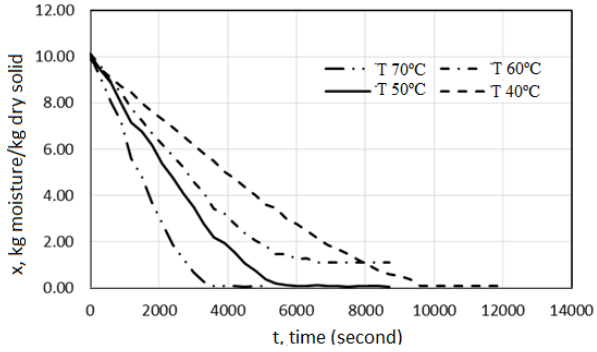
Table 1 water content of tomato juice

Tomato variety	Water content (%)	Source
Amala 474	96.23	Analysis data
Aple variety	95.70	Kamsiati (2006)
Ponta Grossa	94.50	Jorge *et al.* (2014)
Nigeria	93.10	Abdulmalik *et al.* (2014)

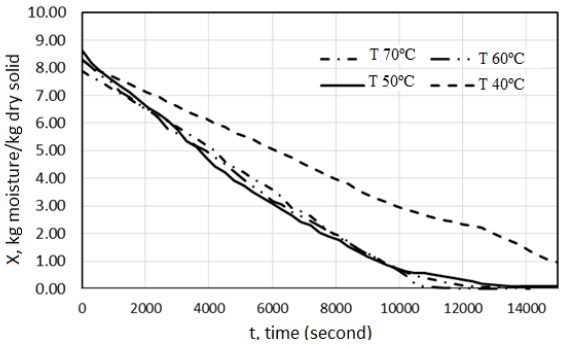
The Effect of Temperature

Based on the results of research on tomato slurry with 2 mm and 4 mm cake thickness, the temperatures were varied of 40, 50, 60 and 70ºC, the result was graphed as shown in Figure 2. As can be seen in Figure 2 that drying temperature at 40ºC showed slower drying rate than drying process at higher temperature. As shown in Figure 2a, it is a little bit different, where the drying rate of the sample with cake thickness of 2 mm and at an operating temperature of 60ºC is slower than evaporation rate at temperature of 50ºC, however at temperature of 70ºC is faster. In Figure 2, it can be seen that the temperaure variation at 50, 60 and 70ºC does not show a significant change in water content. Generally, higher evaporation rate of water is solid occurs when the drying temperature is increased.

According to this study, the change in drying temperature from 50 to 60 and 70ºC did not have a significant effect on the rate of evaporation of water in solids. It can be concluded that the optimum operating temperature of tomato drying process to convert it into powder is at 50ºC.



a. 2 mm cake thickness

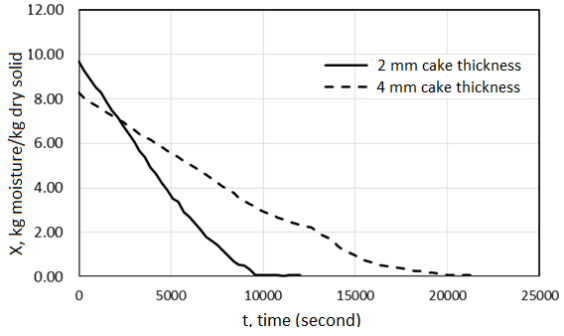


b. 4 mm cake thickness

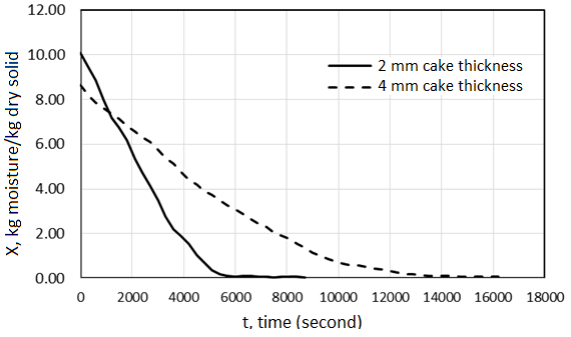
Figure 2 Effect of temperature on the water content of sample

The Effect of Cake Thickness

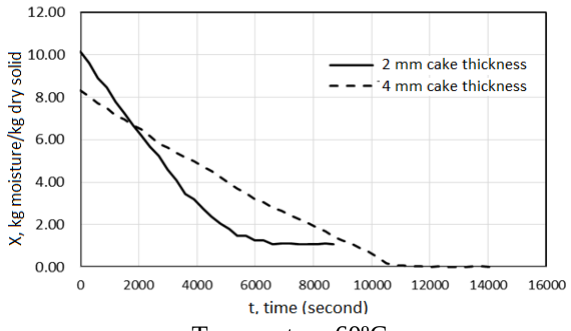
According to Figure 3, it can be seen that the cake thickness is very influential on the rate of water evaporation. For various drying temperature variations, there are similar results where the drying rate of sample decreases along with the cake thickness of the smple. This could be happen due to the thicker cake of sample will takes longer time the heat to penetrate into the body of solid as well as greater energy demand in evaporating the water content in solid.



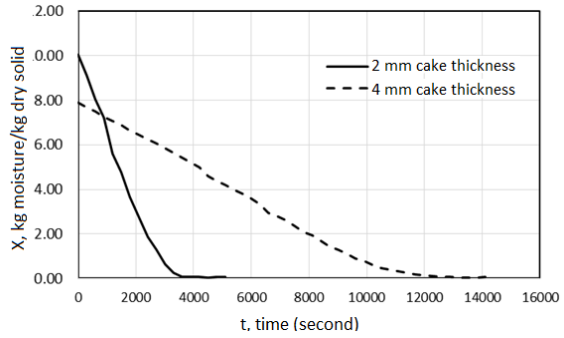
a. Temperature 40ºC



b. Temperature 50ºC



c. Temperature 60ºC



d. Temperature 70ºC

Figure 3 Effect of cake thickness on water content of sample

Based on Table 2, it can be seen that drying rate at a temperature of 50ºC is faster than drying rate at a temperature of 40ºC. However, if it is compared to the drying temperatures of 60 and 70ºC the drying time did not show a significant difference. The higher the drying temperature produces better dried tomato powder (lower water content).

Table 2 Drying time and water content of tomatoes juice powder at various temperature and cake thickness

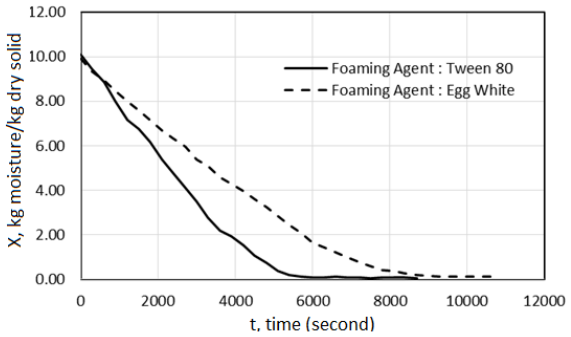
Cake thickness	Temp. (ºC)	Drying time (minute)	Water content (%)	
			Wet Basis	Dry Basis
2 mm	40	140	8.411	9.183
	50	100	6.723	7.208
	60	110	8.568	9.371
	70	60	7.241	7.807
4 mm	40	335	8.157	8.881
	50	230	8.028	8.729
	60	180	5.851	6.215
	70	205	5.034	5.301

Effect of Foaming Agent

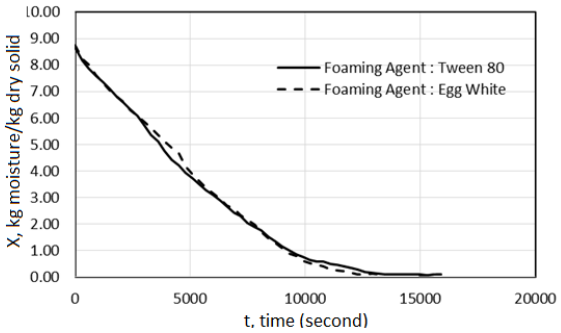
Figure 4a shows that the use of albumin (egg white) foaming agent at 2 mm cake thickness gives the effect of slower drying rate than tween 80, however when cake thickness is set at 4 mm, the results are almost similar.

According to Table 3, the 2 mm cake thickness with Tween 80 as the foaming agent requires shorter drying time with lower water content of product compared to the use of egg white powder as foaming agent. For 4 mm cake thickness, the use of Tween 80 foaming agent and egg white exhibit a similar result in term of drying rate and product quality.

The value for the moisture content varied from 7.208 to 12.199 g/100 g (dry matter), higher than the values found by de Sousa *et al.* (2008) (4.00 to 6.8%) for the tomato powder using spray dryer, and lower than the values found by Jorge *et al.* (2014) (15.32 to 22.40%) for the tomato powder with blanching treatment.



a. 2 mm cake thickness



b. 4 mm Cake thickness

Figure 4 Effect of Foaming Agent type on the sample water content

Tabel 3 Comparison of drying time and water content of tomatoes powder with Tween 80 dan Egg White Powder as foaming agent at 50ºC

Cake thickness	Foaming Agent	Drying time (minute)	Water content (%)	
			Wet Basis	Dry Basis
2 mm	Tween 80	100	6.723	7.208
	Egg White	160	10.873	12.199
4 mm	Tween 80	230	8.028	8.729
	Egg White	220	8.193	8.924

CONCLUSION

Based on the various data from the research results, it can be concluded that the drying operation is very effective at a temperature of 50ºC. Drying operation at a temperature of 40ºC, takes longer and produces tomato powder with lower quality (higher moisture content), while drying operations with temperatures at above 50ºC, are less effective at speeding up the drying rate, because it will require more energy as heater, which means increasing the production costs for producing similar drying rate and product quality.

For drying operations with 4 mm cake thickness, foaming agent Tween 80 can be replaced by egg white powder, as a natural foaming agent.

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