4. DISCUSSION

4.1. Pretreatments for The Curcuma

Curcuma contains bioactive compound which is easily degraded by light, oxidant, and pH. Therefore, the lossing probability during the drying process can be kept with adding pretreatments to increase the drying rate. The pretreatments were soaking in citric acid solution and steam blanching. Citric acid acts as preservative that prevent the enzymatic browning (Winarno *et al*., 1984). Besides, citric acid also acts as drying agent, chelathing agent, antidarkening and antimicrobial (Kendall, 2003), while steam blanching can inactive enzymes which also prevent browning effect (Surianti, 2008). Therefore, those pretreatments could reduce the lossing probability during the drying process.

Based on Table 1., pretreatments could accelerate drying process. The drying process of non-pretreatment curcuma required 180 minutes, while pretreated curcuma required 15-45 minutes less. Pretreated curcuma which soaked into 1% citric acid solution for 30 minutes and steam blanched for 10 minutes showed an efficient drying time reduction. The result that according to the theory of Kurhekar *et al*. (2015) told that pretreatment, such as steam blanching, could accelerate the drying process. Suresh *et al*. (2009) explained that steam blanching changes the component within rhizomes which fasten the drying process. The starch in curcuma would be gelatinized and cell structure become bigger, so it could accelerate the drying process (Darmadi & Ananingsih, 2008). In the other side, soaking into citric acid solution could accelerate the drying process because citric acid can hydrate the structure molecul of water in the product that will be dried (Pangavhane *et al*, 1999).

4.2. The Drying Process Using Solar Tunnel Dryer

The drying process in this research used UV rays energy Solar Tunnel Dryer (STD). So, the drying process become very economics and simple. The difference using direct UV rays is efficientcy and effectiveness of the drying process (Rohman, 2008). The drying mechanism starts when hot air blew onto the wet product, the heat within will transfer onto the surface while the air pressure differences will push evaporate water from the space between cells (Fellow, 2000). Thus, it will decrease the water content.

The drying process divided in three parts, that are warm-up period, first drying period (constant-rate period of drying), and second drying period (falling-rate period). In warm-up period, raw material starts to be heated from initial temperature to the wet bulb temperature and moisture starts to evaporate from the surface. So, concentration of water decrease. At constant-rate period of drying, the temperature of the material is equal to the wet thermometer temperature and stays constant. In the falling-rate period, the surface of the material dries up and the first particles are connected with the air, so the drying rate starts to decrease. Temperature of the material is rising and causes decreasing of the mass and heat transfer driving forces (Holecek & Kohout, 2011). In Figure 6 to Figure 8., the result showed almost all of the samples reached constant rate period until first hour and falling-rate period after an hour.

In this research, curcumas were dried until the water content reached <7% to keep the quality of the dried curcuma (Table 1). Standard export water content for dried simplicia of curcuma is <12%. However, the 7% achievement for this research is not only to prolong the shelf life of the simplicia, but also to prevent the microbial growth. How long the drying process will be done, it depends on the temperature of drying process, humidity, and drying rate. The higher temperature of drying process, the faster the drying process. There are some factors that influence the drying process, such as raw material, pretreatment, temperature, and product size (Swanson, 1991).

4.3. Antioxidant Activities of Curcuma (% Inhibition)

Curcuma rhizome exhibits antioxidant activity that classified as natural antioxidant. The antioxidant could be found within curcumin and phenol compound. Curcumin is a molecul with the low polyphenol level, but curcumin has high biology activity among other compounds that have potential as antioxidant (Jayaprakasha *et al*., 2005). The phenol compound in curcuma has the function of antioxidant activator which prevent free radical and peroxide radical that as effective as lipid oxidation scavenger (Kinsella *et al*., 1993).

The method of antioxidant activity in this research is using DPPH assay that is based on the ability of DPPH, a stable free radical, to decolorize in the presence of antioxidants. The decreased color intensity occurs via a single electron transfer mechanism that cause the color to change from purple to yellow. The reactive group in DPPH is a nitrogen group, which pairs with a hydrogen atom in antioxidant to form a stable DPPH radical. The more electrons that are donated, the more purple color will fade and the more yellow-brownish color will appear that reflecting a high concentration of antioxidant (Rosiyani, 2010). The DPPH radical contains an odd electron, which is responsible for the absorbance at 517 nm and also visible deep purple color (Nurcholis *et al.*, 2012; Rosiyani, 2010). Lower the absorbance between the test and the control (DPPH in methanol) was calculated and expressed as (%) inhibition of DPPH radical (Nahak & Sahu, 2011), also the amount of antioxidant activity was expressed as percent antioxidant activity per gram extract (Green & Mitchell, 2014).

Based on Table 2., we can see that the (%) inhibition for the dried curcumas in wet basis were almost higher than the fresh curcuma (before drying process). Before the drying process, almost all of curcuma steam blanched had higher (%) inhibition than controled one and citric acid soaked curcuma. It showed that steam blanching process increased the antioxidant activity level. This was happened because there were changing component in the curcuma during blanching, which increasing the extraction efficiency (Pujimulyani *et al.*, 2010). The extraction efficiency happened because the curcumin spread out. Curcumin as antioxidant activity in curcuma contains two phenolic groups (each curcumin molecul can scavenge two free radical molecul) in the structure that consists of a beta diketone group and phenolic hydroxyl group. The first phase of antioxidant process, the phenolic hydroxyl group serves as free radical scavenge, The next phase, beta diketone group will serve as free radical scavenge (Kumavat *et al.*, 2013).

The result also showed that soaking curcuma with citric acid solution could maintain, even increase the antioxidant activity level. It compares to the theory of Ketaren (1986) that said some antioxidant compound could give synergy effect if those are mixed. The synergy means compound that has low antioxidant, generate big effect for the primary antioxidant. Citric acid give synergy effect to the other antioxidant and used as antioxidant in food.

After the drying process, antioxidant activity showed there was no significant difference in antioxidant activity level between curcuma soaked in 0.5% and 1% citric acid solution, but there was significant difference between curcuma steam blanched and citric acid soaking. There was also no antioxidant activity level diffrence between soaking curcuma with 0.5% citric acid for 10, 20, and 30 minutes. As for the steam blanching, it should be noted that the shorter time of steam blanching will maximize the antioxidant activity level (Pujimulyani *et al*., 2010). In this research, we can see that the best antioxidant activity level could be found in curcuma steam blanched for 3 minutes.

In dry basis (Appendix 1), the antioxidant activity level of curcuma after drying process was lower than the fresh curcuma. The decrease of antioxidant activity could be explained with the theory from Zapsalis (1985) which said antioxidant is a chemistry compound that will be gradually oxidated by some effects, such as light, heat, peroxide iron, and direct reaction with oxigen and heat. Curcuma during drying process got too much contact with oxygen and heat.

4.4. Curcumin Contents Using HPLC and Spectrophotometric

The bioactive compound in curcuma is curcuminoid and xanthorrhiza. Curcuminoid is responsible for the yellow colour and comprises curcumin, demetoxycurcumin and bisdemethoxy curcumin (Hastati *et al.*, 2015). In this research, only curcumin compound in curcuma that was analyzed. Curcumin compound in curcuma is the main active of all three curcuminoids.

The curcumin compound was extracted using methanol because curcumin is insoluble in water, but practically soluble in organic solvent, depends on the theory of Jansirani *et al*. (2014) that said the best organic solvent to extract the prigments (curcuminoids) are acetone and methanol. The theory from Mudge *et al*. (2016) also said that extraction using 100% methanol would give the higher concentration of curcuminoids and choosen as the optimized extraction solvent. After the extraction process, the curcumin compound would be analyzed using High Performance Liquid Chromathography (HPLC) at 425 nm (Hastati *et al*., 2015; Rosidi *et al*., 2016; Mudge *et al.*, 2016) and spectrophotometer at 421 nm (Sharma *et al*., 2012; Hazra *et al*., 2015).

In this research, Shimadzu LC-10AT VP HPLC-System was used. The column was GraceSmart RP 18 5u. The Chromatography type was reversed-phase chromatography. So, the mobile phases were acetonitrile; acetic acid; aquabides (50;1;49). The eluents that is used in this research are corresponding with the theory of Bulemela *et al*. (2006) that said if methanol or water and acetonitrile or water mixtures are commonly used in chromatographic mobile phases.

The calculation of curcumin content used linear regression. The linear regression got from some concentrations of curcumin standard. The optimized method confirmed if all of the curve had correlation coefficients approach 1. The result showed linear regression equation for HPLC method was y=344395x-48625 with correlation coefficient 0.9944 and linear regression equation for spectrophotometric was y=0.2188x-0.006 with correlation coefficient 0.9979. Both HPLC and spectrophotometric analysis had correlation coefficient approach 1 (Appendix 33 and 34). That means the performance characteristics of the methods were optimized.

Based on Table 3., the highest curcumin content from HPLC for the dried curcuma could be found in curcuma which soaked in 1% citric acid solution for 30 minutes. Overall, pretreatment, such as steam blanching gave the most significant difference to curcuma which soaked in citric acid solution. For the spectrophotometric, the highest curcumin content can also be found in curcuma which soaked in 1% citric acid solution for 30 minutes. As we can see, the result showed that control and soaking curcuma into citric acid solution gave high concentration of curcumin after the drying process. Those suitable with the theory of Cahyono *et al*. (2011) that said the total of curcuminoids level extracted from the dried simplicia had higher quantity than fresh curcuma. The reason is the curcumin pigment (as non-volatile compound) in fresh rhizome can be found in atsiri oil inside the oleoresin (volatile compound) and curcuminoid is accumulated in the centre of cell. So, during the drying process, the oleoresin cell would break thus the curcumin compound would spread out.

The fresh curcuma (before drying) which soaked in 1% citric acid solution for 30 minutes had higher amount than curcumin content after the curcuma steam blanched. It because curcumin is more stable below pH 7 (Kumavat *et al*., 2013). So when the pH belows 7, the degradation of curcumin could be minimized. That's why the curcumin compound for fresh curcuma which soaked in 1% citric acid solution had high curcumin content.

The result showed that curcumin content in curcuma steam blanched decreased after the drying process. Both HPLC and spectrophotometric showed curcuma steam blanched had the lowest curcumin content. This could be explained with the theory of Cahyono *et al*. (2011) about the changing of component in curcuma during the drying process. The pretreatments, such as steam blanching, gave heat to the product. This caused the damage oleoresin and continued within the drying process that increase the lossing probability of curcumin in the sample. Another reason could be that the heating process occured twice (steam blanching and drying process). Curcumin degraded to Trans-6-(40-hydroxy30-methoxyphenyl)-2,4-dioxo-5-hexanal, ferulic acid, feruloylmethane and vanillin. The initial degradation will form ferulic acid and feruloylmethane. Feruloylmethane rapidly forms yellow to brownishyellow colour. Hydrolysis of feruloylmethane will form degradation product (vanillin and acetone). The amount of degradation products increase with incubation time (Kumavat *et al*., 2013).

Based on the result (Table 3), there was insignificant difference in ranking of curcumin content in curcuma between HPLC and UV spectrophotometric. However, the HPLC is highly automated and extremely sensitive (Clark, 2016), where as UV spectrophotometric method is more simple because it does not require the elaborate treatment and procedures, which is less time consumption and more economical. However, HPLC method is more accurate and precise than UV spectrophotometric method (Dhole *et al*., 2012).

4.5. Water Activity (a_w)

Curcuma is easily spoiled because the high water content thus drying process can be the solution the maintain the quality of curcuma. Drying process can prolong the selflife of the product, so the microorganism growth can be inhibited (Kamataka *et al*., 2012). Water activity is the amount of free available water within food that supports microbial growth, chemical, and enzymatic reactions, and also spoilage processes. It functioned as food stabilitator, wheter chemical and microbial. So, water activity is more important than total water content. At less than 0.75 bacterial growth is inhibited, but some yeast and moulds might grow. At less than 0.6 all growth is inhibited (Safefood 360, 2014). Based on Table 4., water activity of fresh curcumas were higher than dried curcumas. The reduction of water activity is related with the water content. The higher water content, the higher water activity. The water activity of dried curcuma is lower than 0.6, which inhibite any microbial growth (Safefood 360, 2014).