1. INTRODUCTION

1.1. Background

Curcuma (*Curcuma xanthorrhiza* Roxb.) is known as Javanese turmeric and categorized as herbs in Indonesia. Traditionally, this rhyzome is used as medical plant to treat some diseases, such as constipation, bloodly diarrhea, liver disorders, etc (Hwang *et al.*, 2000 *cit* Nurcholis *et al*., 2012). Moreover, the yellow pigment that gives yellow color in curcuma is known as bioactive compound namely curcuminoid. Curcumin, one of curcuminoid compound, has antioxidant activity that can be used as radical scavenging, anti-inflamation, anti-tumor, anti-allergy, and anti-dementia(Hwang *et al.*, 2000 *cit* Nurcholis *et al.*, 2012). Based on those benefits, curcuma was developed in the industrial department, such as industry of foods and beverages, medicine; and also for export. However, curcuma is easily spoiled because of the high water content and incorrect handling that will make the nutrients and bioactive compound in curcuma become degraded. Therefore, drying is one of the solution to extend the shelf life of curcuma.

Dried curcuma is obtained through the drying process. Drying process is an essensial unit operation which is aimed to decrease water activity in product, so the microorganism growth can be inhibited. The Solar Tunnel Dryer (STD) is one of drying instrument that uses energy from UV rays. The benefits of drying process by using this instrument are economical, simple, and efficient. By using this instrument, the losing probability of nutrition content and the contamination of microorganism can be reduced if compared to drying process by using direct UV rays (Kamataka *et al*., 2012).

Drying process can prolong the shelf life of the product, but the process can lead to the loss of some nutritions and bioactive compounds contained in the product, such as antioxidant activity and curcumin compound in curcuma that can be easily degraded by light exposure (Wang *et al*., 1997). However, there are some pretreatments applied to reduce the losing probability, such as hot water blanching, steam blanching, and soaking in the citric acid solution. Citric acid is known to act as preservative and antioxidant (Sari, 2014). On the other side, steam blanching can inactivate enzymes in food which

prevent browning effect. Based on the previous research, steam blanching and soaking in the citric acid solution as pretreatments were efficient to reduce the losing probability of curcumin content and antioxidant acivity (Arsanti,2016; Dewi, 2016). This reseach is necessary to be conducted to know the effect of soaking in the citric acid solution and steam blanching as pretreatment on the curcumin content and antioxidant activity of dried curcuma which is dried by using Solar Tunnel Dryer (STD). The curcumin content are analyzed using High Performance Liquid Chromatography (HPLC) and spectrophotometric method.

1.2. Literature Review

1.2.1. Curcumin in *Curcuma xanthorixa* Roxb.

Curcuma (*Curcuma zanthorrhiza* Roxb.) is a rhizome from *Zingiberaceace* family. Curcuma is medical plant that can be used as medicine (Prana, 2008 *cit* Rosidi *et al*., 2016). Traditionally, its rhizomes is used to treat stomach diseases, liver disorders, constipation, bloody diarrhea, dysentery, children's fever, hemorrhoids, and skin eruptions. Pharmacologically, it has been reported that curcuma has antimicrobial, anti-metastatic, anti-cancer, antioxidant, and hypolipidemic activities (Yasni *et al*., 1993 *cit* Nurcholis *et al*., 2012).

Figure 1. *Curcuma xanthorhiza* Roxb.
(Riana, 2017)

The rhizomes of curcuma contains curcuminoids. Curcuminoids are the main yellow bioactive compound in curcuma. Curcuminoid is responsible for the yellow colour and comprises curcumin, demethoxycurcumin and bisdemethoxy curcumin (Hastati *et al.*, 2015). Curcuminoid has eficacy as antioxidant, anti-inflamation, anti-tumor, anti-

allergy, and anti-dementia (Hwang *et al.*, 2000 *cit* Nurcholis *et al.*, 2012). Curcumin [1,7bis(4-hydroxy-3-methoxyfenil)-1,6-heptadiene3,5-dione] can be used as yellow-orange natural dye (Zaibunnisa *et al.*, 2009 *cit* Rezki *et al.*, 2015). Curcumin is freely soluble in methanol, chloroform, ethanol and acetone, but practically insoluble in water. Curcumin has the ability to suppress both acute and chronic inflammation. Also it helps to prevent the damage of the skin from UV rays of the sun (Bangchi, 2012 *cit* Hazra *et al.*, 2015).

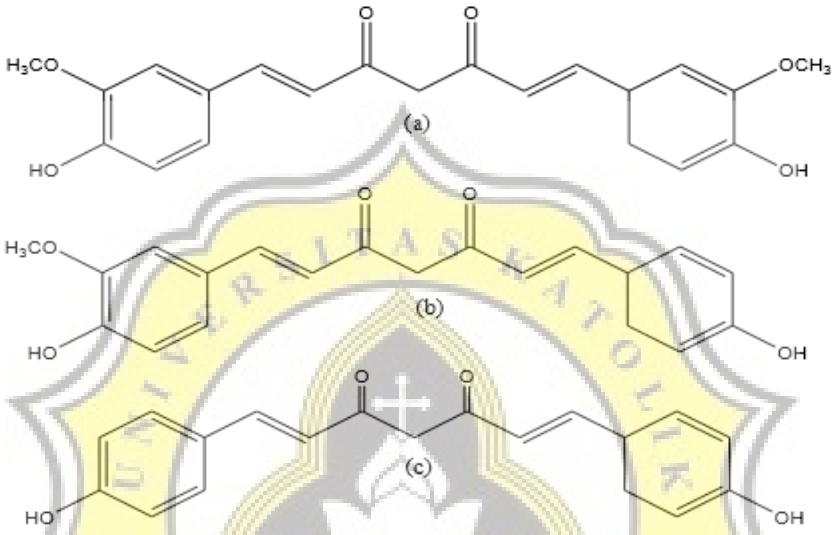

Figure 2. The chemical structure of (a) curcumin, (b) demethoxycurcumin, (c) bisdemethoxycurcumin
(Hwang, 2006)

The characteristic of curcumin is easily degraded by light, heat, and pH. In aqueous systems like water, it is understood in at alkaline pH, the acidic phenol group in curcumin donates its hydrogen, forming the phenolate ion that enables curcumin into dissolution in water. It is not stable at neutral and alkaline pH for longer period of time and gets easily degraded into compounds like vanillin, ferulic acid, etc. It is stable below pH 7.0 but as the pH decreases, the dissociation equilibrium shifts towards the neutral form with very low aqueous solubility (Wang *et al*., 1997).

1.2.2. Antioxidant Activity in *Curcuma zanthorrhiza* Roxb.

Previous studies have shown that curcuma rhizome exhibits antioxidant activity (Jitoe *et al.*, 1992 *cit* Rosidi *et al.*, 2016). Curcuma extract can be categorized as a relatively active and favorable source of natural antioxidant. Antioxidant is a compound that has

the ability to inhibit oxidation by reacting with reactive free radicals. Antioxidant compounds play important roles in the body's defenses against the adverse effects of free radicals (Rosidi *et al.*, 2016). The antioxidant activity of curcuma extract is greater than the activity of three types of curcuminoid that can be individually derived from curcuma (Jitoe *et al*., 1992 *cit* Rosidi *et al*., 2016).

Antioxidant activity of curcuma can be determined by measuring the curcuma extract to scavenge free radicals using the DDPH assay. In DPPH assay, DPPH is a stable free radical with purple color. The scavenge DPPH radical by donating hydrogen atoms leading to non radical with yellow color. The free radical scavenging activity of antioxidants in food has been substantially investigated and reported (Miller *et al.*, 2000). The odd electron in the DPPH free radical gives a strong absorption maximum at 517 nm and the purple in color which turns to yellow, as shown below.

$$\underset{\text{(purple)}}{\text{DPPH}} + \text{RH} \rightarrow \underset{\text{(yellow)}}{\text{DPPH-H}} + \text{R}$$

1.2.3. Citric Acid and Steam Blanching

Citric acid ($C_6H_8O_7$) is an organic acid that can be used as preservative, which prevent color, taste, and flavor damage. Moreover, citric acid also posseses an antioxidant properties (Sari, 2014). Citric acid included in secondary antioxidant that scavenge free radicals and prevent the happening of chain reaction, so it can prevent the damage. As secondary antioxidant, citric acid can give synergy effect to the primary antioxidant (compound that end the free radicals chain in oxidation process) (Ketaren, 1986). Citric acid maintain the natural color of the ingredient to prevent the reaction that decrease the product tissue pH which ignite enzymatic browning. It is manufactured in the crystal form, no scent and so easily to dissolve in the hot water (Surianti, 2008). In the drying process, citric acid acts as drying agent, chelathing agent, antidarkening and antimicrobial (Kendall, 2003).

Blanching is a preliminary heating process which is aimed to inactivate enzymes in food ingredients which prevent browning effect. Blanching treatment is usually performed

for frozen, canned, and dried ingredients. There are two types of blanching, hot water blanching and steam blanching. Hot water blanching has disadvantages such as water soluble nutritions will be leaching to the water because of this pretreatment. In the other side, the main purpose of steam blanching is to reduce the nutrient loss from the food ingredient, maintain the nutrients that can be dissolved in water. In addition, steam blanching is carried out at a temperature of 82-93^{o}C for 3-5 minutes to kill the microbes (Winarno *et al*., 1984).

1.2.4. Drying Process Using Solar Tunnel Dryer (STD)

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). Traditionally, the food products are dried by spreading in direct UV light in thin layer. In addition of that method, the UV rays can be exposed in Solar Tunnel Dryer. The Solar Tunnel Dryer (STD) is one of drying instrument that uses energy from UV rays. Though this method is economical and simple, it has some draw backs such as; no control over the rate of drying, non-uniform drying, chances of deterioration due to exposure of products against rain, dust, storm, birds, rodents, insects and pests which results in poor quality of dried products. Whereas, solar drying system leads to faster rate of drying and product exposure against rain, dust, storm, birds, rodents, insects and pests is avoided. This ensures a better quality of the dried products, which would fetch higher price for the dried products (Karnataka *et al*., 2012). The specifications of STD are ± 450 kg in weight, 18 meters in lenght, 2 meters wide, spacious 20m^2 drying area and drying area 16 m^2. STD has a capacity of ± 200 kg raw materials, where the drying time is about 1-2 days with a humidity of 15-18%. Drying appliance is suitable for fruits, vegetables, herbs, spices, fish, meat, and other foods (Zimpel, 1996).

1.2.5. High Performance Liquid Chromatography (HPLC) to Identify Curcumin Compound

Curcumin quantification in dosage forms using high performance liquid chromatography (HPLC) has been carried out (Pandey & Katiyar, 2010). The most suitable method to quantitation of curcuminoids is with HPLC with UV-Vis and/or

mass spectrometric detection (Jayaprakasha *et al*., 2005; Jiang *et al*., 2006; Wichitnithad *et al*., 2009). HPLC is a chromatographic technique used to separate a mixture of compounds in analytical chemistry and biochemistry with the purpose of identifying, quantifying, and purifying the individual components of the mixture. HPLC technique has several advantages, such as the speed, sensitivity, efficiency, and easy in operation (Wiley, 1992). There are two types of chromatography, that are normal phase chromatography and reversed phase chromatography. Normal phase chromatography uses non-polar stationary phase and polar mobile phase (such as hexane). It commonly used isocratic elution. Reversed phase chromatography uses hydrophobic packing-Octadecyl (C18) as stationary phase and the mobile phase is water and water-miscible organic solvent, such as H_2O and ACN or MeOH. Commonly, it used gradient elution. The maximum wavelength to determine curcuminoids using HPLC is 425 nm (Hastati *et al*., 2015).

1.3. Purpose of Research

The purpose of this research was to determine the effect of pretreatments (citric acid soaking and steam blanching) on the curcumin contents and antioxidant activities (%inhibition) of fresh and Solar Tunnel dried curcuma (*Curcuma xanthorriza* Roxb.).