1. General introduction

1.1. Potato production in Indonesia

Potatoes (*Solanum tuberosum* L.) are one of the essential food crops in the world and are grown in more than 100 countries under temperate, subtropical and tropical conditions. Its worldwide production in 2010 was close to 324 million tons and the plant was grown on approximately 19 million hectares (FAO, 2011).

Between 1991 and 2007, the potato production in the world increased by almost 21%, interestingly, a massive increase of harvested tubers was shown by developing countries with approximately 94% (FAO, 2008). Potatoes are served for either table consumption or as processed products. In addition to being a source of carbohydrates, potatoes also contain high content of protein, vitamin C, fiber, minerals and have a low fat content (Navarre et al., 2009). Due to the importance of potatoes for various reasons, including agriculture, economy and world food security, the FAO declared 2008 the "International Year of the Potato", where the main objective was to promote the sustainable development of potato-based systems and the potato industry and to enhance the well-being of producers as well as consumers (FAO, 2008).

Indonesia is the largest potato producer in South East Asia and exports tubers for table purposes (FAO, 2012a). On the other hand, the import of frozen potatoes to Indonesia has increased in recent years. In 2009, 15.42 thousand tons of frozen potatoes for processing purposes were imported, about 47% higher than numbers in 2000 (FAO, 2012b). Although Indonesia's traditional dietary pattern is rice based, in recent years, the country requires a large quantity of frozen potatoes to meet demands resulting from the popularity of fast food restaurants, a rise in consumer income and urbanization (Fuglie et al., 2003). The high demand for processing tubers cannot be fulfilled by local producers because approximately 90% of total cultivated area in Indonesia produces tubers for table purposes only (Fuglie et al., 2006).

To reduce dependency on imports, the Indonesian Ministry of Agriculture, in collaboration with International Potato Centre, is investigating means to provide new cultivars that are appropriate for processing purposes. In order to examine the suitability of new cultivars for the environment, field experiments for several years at different locations and during different seasons have been conducted (Basuki et al., 2005). However, potato research in Indonesia, in

recent years, primarily concerns on agronomy and breeding and thus places less focus on postharvest aspects. As such, further researches about postharvest and processing aspects are still needed to ensure improvement. Studies about potato tuber quality and chips characteristic of new cultivars are required to enhance existing knowledge and to further benefit for both producers and consumers.

1.2. The influence of potassium fertilization on tubers quality

One of the main considerations during tubers selection as raw processing materials is the potato cultivar. Additionally, environmental conditions, cultivation methods, handling during harvesting and/or storage also play an important role in determining the quality of processed products (Olsson et al., 2004; Trehan et al., 2009).

One of the important factors during the growing period that influences tubers yield and quality is the adequate and balanced supply of fertilizers. Furthermore, the availability of nutrients at a proper time must also be considered. A wide range of investigations concerning the effect of fertilizers on tubers quality have been conducted; however, the results vary depending on location, cultivar, application time, as well as the rate and type of fertilizer. Nutrients that are needed during cultivation include nitrogen, potassium, phosphorus, magnesium, calcium, sulfur, iron, zinc, manganese, copper and boron (Stark et al., 2004; Westermann, 2005).

Potato plants require nutrients supply through fertilization due to their shallow root system and high demand of nutrients for tubers development. Among the major nutrients, potassium is absorbed in large amounts due to its important role on osmoregulation (Westermann, 2005). Potassium, an essential nutrient, plays an important role in tubers yield and quality due to its contribution to many aspects of plant physiology through its high mobility in plant tissues (Marschner, 1995). An adequate supply of potassium in the fertilizer is required, as either a shortage or an excessive amount leads to unfavorable conditions for tubers bulking and quality.

With regard to tubers for processing purposes, potassium contributes to an increase in processed-grade tubers, dry matter and chips quality (Al-Moshileh and Errebi, 2004; Kumar et al., 2007) and decrease blackspot susceptibility (McNabnay et al., 1999). Furthermore, Kumar et al. (2007) report that potassium sulphate is more appropriate than potassium chloride due to its effect on improving chips yield as well as lowering the oil content of produced chips.

1.3. Potato chips production

Nowadays, the utilization of potatoes is shifting away from table consumption to processed products. In developed countries, approximately 60% of potatoes are consumed in a processed form; it is caused by the changing of consumers' lifestyle that prefer for greater convenience (Kirkman, 2007; Storey, 2007). French fries and chips are the preferred products in the world, where tubers with a high content of dry matter and low concentration of reducing sugars are preferable raw materials in order to produce the desired texture and light yellow color (Mestdagh et al., 2008). In many countries, chips are referred to as the "king of snack foods" due to their popularity (FAO, 2008). During the last decade, an increasing trend in chips production were reported in the USA (USDA, 2011) and Great Britain (Potato Council, 2011), while in Germany the amount and value of produced chips and sticks also rose during the last seven years (BMELV, 2011).

To ensure the availability of tubers for processing purposes throughout the year, low temperature storage is conducted. Consequently, there is an accumulation of reducing sugars in the tubers. An excessive amount of reducing sugars leads to an undesired chips quality, dark color and high acrylamide concentration, resulting from the involvement of reducing sugars in the Maillard reaction (Mestdagh et al., 2008; Zhu et al., 2010).

Reconditioning cold-stored tubers at 15°C for three weeks has a positive effect on lowering reducing sugars concentration (de Wilde et al., 2005). Furthermore, several attempts have been made to decrease the concentration of reducing sugars prior to frying such as blanching, immersion in acid solutions and soaking in sodium chloride solutions (Pedreschi et al., 2004; Mestdagh et al., 2008; Pedreschi et al., 2010). Reconditioning followed by a blanching process is the most common practice for preparing tubers for either French fries or chips. This pretreatment requires additional storage room, considerable time and large amounts of energy. Thus, studies concerning pretreatments for chips production that can decrease reducing sugars concentration in cold-stored tubers without reconditioning are important in order to shorten the raw materials' preparation times.

Ultrasonication, an advanced food technology, is considered an alternative pretreatment for chips production due to its capability to improve the extraction processes of particular substances from plant products (Knorr et al., 2004). Ultrasonication is the application of sound

waves through the solvent that induce cavitation effect. Cavitation is a cyclical process, whereby tiny bubbles are formed and implode as a result of compression and rarefaction caused by the transmission of sound waves through the solvent (de Castro and Capote, 2007). Currently, ultrasonication is used for food processing, including cleaning food surfaces, ultrasonically assisted extraction, crystallization, emulsification and meat tenderization (Knorr et al., 2004).

However, publications about the use of ultrasonication for chips processing are scarce. Since previous studies have demonstrated that ultrasonication has significant effect on the extraction of particular compounds from plant materials in laboratory-scale experiments (Wu et al., 2001; Balachandran et al., 2006; Jacques et al., 2007; Nitayavardhana et al., 2008), studies about the application of the ultrasonication for chips pretreatment is required, particularly to ascertain how it influences chips color.

1.4. Objective of the studies

The characteristics of potato tubers for raw materials as well as appropriate treatments during chips processing contribute to the quality of produced chips and subsequently consumers' acceptance. This study aims to examine the suitability of new Indonesian potato cultivars for chips production and to investigate the effect of potassium fertilization and ultrasonication treatment on improving the quality of potato tubers and produced chips.

The present study is designed to respond to the following research questions:

- Are new potato cultivars in Indonesia appropriate for chips production and subsequently, will their chips product fulfill the requirements established by the Indonesian Standard?
- Does the application of different levels of potassium fertilizer influence the potassium concentration and the quality parameters of potato tubers?
- Does ultrasonication contribute to an improved chips color?

With regard to the research questions, this study tests the following hypotheses:

- New Indonesian potato cultivars are appropriate for processing purposes and their chips characteristics satisfy the Indonesian Standard.
- Potassium fertilization increases the potassium concentration in tubers and positively influences the processing properties of potato tubers.
- Ultrasonication treatments contribute to an improved chips color.

1.5. Outline of the dissertation

Analytical methods for the quality determination of potato tubers and those for chips are described in Chapter 2.

Chapter 3 presents a study of tubers and chips properties in new as well as established Indonesian cultivars. Furthermore, this chapter analyzes whether these cultivars meet the Indonesian Standard in order to access their potential for chips production.

Chapter 4 describes the effect of different levels of potassium fertilizers on the potassium concentration in tubers and the selected quality parameters of tubers.

Chapter 5 provides a better understanding of the influence of ultrasonication treatment on chips color. In addition to color parameters of chips, the effect of ultrasonication at different temperatures and durations are evaluated with regard to reducing sugars, sucrose and free asparagine concentrations of potato slices.

Conclusion and a summary of the research are presented in Chapter 6 and Chapter 7, respectively.

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