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Antioxidant Activity from Various Tomato Processing

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Abstract

Tomato is one of the high antioxidant potential vegetables. Nowadays, there are many techniques of tomato processings instead of fresh consumption, i.e. boiled, steamed, juiced and sauteed. Every treatment of cooking will influence the chemical compound inside the fruits and the body's nutrition intake. It is important to conduct the research on antioxidant compound especially lycopene, β-carotene, vitamin C, α-tocopherol, and its activity after processing. This research has been done using the experimental method. Tomatoes were cooked into six difference ways, and then it was extracted using the same procedure continued with antioxidant measurement. The research results showed that steaming had promoted the higher antioxidant numbers (lycopene. α-tocopherol, β-carotene and vitamin C) and higher TCA and antioxidant activities in the tomatoes than other processings. It was indicated that steaming was the best way to enhance amount, capacity and activities of antioxidants of the tomatoes.

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INTRODUCTION

Atherosclerosis is strongly related with *Low-Density Lipoprotein* (LDL)-cholesterol. Unsaturated lipid acid components in the LDL-cholesterol are easy to bind with free radical and transform into oxidative LDL (Nasution, 2013). It triggering sponge cells and releasing reactive oxygen species (ROS) and inducing oxidative stress. ROS are able to form atherosclerosis plague, lipid oxidation, and endothelial disorder. Simultaneously oxidative stress will decrease immune respond to keep body health. It can be avoided through high antioxidant foods consuming. The antioxidant which is easily obtained from various foods that contain vitamin E, vitamin C, polyphenol and carotenoid especially lycopene and β-carotene (Khansari, et al., 2009). Tomato is one of the abundant and cheapest fruit or vegetables.

Tomato (*Lycopersicum esculentum* Mill) is a species from Solanaceae family; it contains a lot of natural antioxidants, such as vitamin E, vitamin C, and carotenoid (Barus, 2009; Namitha & Negi, 2010.; Foolad & Panthee, 2012). Based on the chemical composition, carotenoid is divided into two chemical compound group, carotene, and xanthophyll. The most abundant carotene in tomato is lycopene and β-carotene (Jackson, et al., 2008). Carotene is an antioxidant which has an ability to reduce malignant cell of cancer (Seifter. et al, 2012). Lycopene is a special carotenoid which is potential to prevent prostate cancer and cardiovascular degenerative disease (Mordente. et al, 2011) and anti-*aging* (Pan. et al, 2012).

Various techniques of tomato processings are prepared by the community. Some people eat the fresh tomato directly without any treatment. Meanwhile, most Indonesian people always cook tomatoes in the various processings, such as steaming, boiling and frying. The cooking process techniques are predicted to have an impact in antioxidant amount inside tomatoes. In order to understand and to determine the appropriate technique for a proper processing of tomatoes, a research on the effect of variation of the cooking methods to the level of the antioxidant in tomato is needed.

METHODS

This research was using 12 kg tomatoes (*Lycopersicum esculentum* Mill) which obtained from Bandungan market, Semarang, Centra Java, Indonesia and collected through purposive random sampling. The criteria that used to choose the tomatoes were ellipse form, red color, and approximately weighted 1,5-2 ons fresh and shiny peel. Tomatoes which processed in 6 different ways were then extracted by the same technique.

This study was an experimental study that was conducted at the Laboratory of Biochemistry, Department of Biology Universitas Negeri Semarang. The research design used in this study was a complete random design with posttest Only Randomized Controlled Group Design (Sheley, 2014; Campbell & Stanley, 2015).

Various tomato processing

A total of 12 kg tomatoes were processed using 6 different ways, each process required 2 kg tomatoes, i.e.(1) K1: fresh tomatoes without processing (sliced into small pieces); (2) K2: tomatoes were juiced with the addition water (water-tomatoes ratio 1: 1); (3) K3: tomatoes were cleaned and were cut into small pieces, and then it was put on the aluminum container for further steaming within 30 minutes; (4) K4: Tomatoes were washed and cut into small pieces and then boiled with water (water-tomatoes ratio 1: 1) for 30 minutes; (5) K5: fried tomatoes, the tomatoes were washed and were cut into small pieces, and then were fried in palm oil for 30 minutes; (6) K6: tomatoes were washed and were cut into small pieces, then were sauteed without oil for 30 minutes.

Antioxidant analysis

Tomatoes that have been processed were then dried in the oven at 40 °C until dry. Then, it was mashed using blender and was filtered with a 100 mess sieve to obtain tomato powders. The obtained powders were further analyzed for its antioxidant component. Tomato powders were weighed at 50 grams, and then were filled in pockets of filter paper and tied with a rope. The tomato extracts were put in the bottom part of Soxhlet flask which had been added with 300 ml petroleum ether. The resulting pulp was aerated to dry and remain odorless. Subsequently, it was resolved with 350 ml of methanol using Soxhletation set methods at 65 °C. Soxhletation process was stopped after a clear solution was obtained. The extract that obtained were concentrated by vacuum evaporator at 60 °C until it concentrated, hereinafter referred methanolic extract. Methanolic extract obtained was suspended with 100 ml water and was partitioned with 100 ml ether three times using separating funnel. The ether layer was separated and was concentrated. Further, the fractions obtained were then diluted with methanol. Water fraction was concentrated using evaporator, then it was diluted with methanol

(Gherraf, et al., 2011). Lycopene, β-carotene, vitamin C and α- tocopherol were analyzed and were measured in this study. The obtained number of β-carotene levels was measured using ELISA kit, while the amount of lycopene was measured using chromatography. The total antioxidant capacity was measured using TAC calorimetric assay kit. The vitamin C was measured using ascorbic acid colorimetric assay kit and the number of α-tocopherol analysis was performed using ELISA kit for α-tocopherol, The antioxidant activities were measured by using 1-1-diphenyl-2-picrylhydrazyl (DPPH) and stoichiometry method (Molyneux, 2004).

The obtained data (vitamin C, α-tocopherol, antioxidant activity, total antioxidant capacity, β-carotene, and lycopene) were continued with cleaning, coding and tabulation. Furthermore, the data were analyzed descriptively. Data were tested for its normality and homogeneity using Kolmogorov-Smirnov test and Lavene. The hypothesis was tested using One-way ANOVA; the results that significantly different was followed by the test of Least Significant Difference (LSD). The program assisted with statistical analysis SPSS for Windows version 20. Value of significance in this study had a $p < 0.05$.

RESULTS AND DISCUSSION

Results of the data analysis shown that all data were normally distributed and homogenous. The data were then tested by ANOVA and were continued by LSD, the results of the overall analysis of the variables are presented in Table 1 and Table 2.

Lycopene levels

Lycopene content was normally distributed, and one way ANOVA test results between groups was significantly difference. LSD test results shown that the boiled tomatoes were having lowest lycopene amount than other groups. But it could be assumed that processing technics werre able to change the lycopene compound. It was found that the highest level of lycopene could be obtained by steamed tomatoes (46.92 mg/100g).

β-carotene levels

LSD test result shown that the highest levels of β-carotene could be extracted from steamed tomatoes or K3 group (there is 5862,441 mg/100 g) and the lowest β-carotene concentration was found in fried tomatoes or K5 (2327,700 mg/100g). β-carotene content in sliced tomatoes was higher than K5. However, it was not higher than boiled tomatoes or K4 group (4274,178 mg/100g), followed by sautéed tomatoes without palm oil or K6, and K2 with amount of each treatment were 5618,310 mg/100g and 4976,526 mg/100g, respectively.

Total capacity antioxidant

The total antioxidant capacity (TAC) data shown that the data were normally distriburted and significantly difference by ANOVA test. LSD test results for total antioxidant capacity, was indicated that the boiled tomatoes (K4) had lowest TAC there was 4.85 mmol/g followed by sliced tomato (K1) at 5.59 mmol/g and the lower than juiced tomatoes (K-2) there was 6.51 mmol/g. While steamed tomato had the highest TAC there was 7.64 mmol/g. The statistic analysis was showing that fried tomato in the oil had not been affected TCA of tomatoes content.

Vitamin C

From LSD analysis, the data of vitamin C levels of tomatoes processing were significantly different. It proved that various cooking method was impacting the vitamin C levels of tomatoes, except vitamin C content of K1 and K4 (Table

Table 1. The average value of lycopene, β-carotene and total capacity antioxidant from tomatoes with various processing*

Group	Lycopene (mg/100g)	β-carotene (mg/100g)	Total Capacity Antioxidant (mmol/g)
K1 (sliced tomatoes no heating)	27.48[a]	3334.742[a]	5.59[a]
K2 (juiced tomatoes no heating)	32.11[b]	5618.310[b]	6.51[b]
K3 (steamed tomatoes)	46.92[c]	5862.441[c]	7.64[c]
K4 (boiled tomatoes in water)	19.44[d]	4274.178[d]	4.85[d]
K5 (fried tomatoes in oil)	20.93[e]	2327.700[e]	5.72[a]
K6 (fried tomatoes without oil)	35.28[f]	4976.526[f]	7.06[e]

* a-f letters indicate significant differences at level 5 %

Table 2. Average value of vitamin C, α- tocopherol and antioxidant activity from tomatoes with various processing*

Groups	Vitamin C (mg/100g)	α-tokoferol (mg/100g)	Antioxidant activity (%)
K1 (sliced tomatoes no heating)	17.33[a]	0.30[a]	35.86[a]
K2 (juiced tomatoes no heating)	18.78[b]	0..40[b]	36.19[a]
K3 (steamed tomatoes)	22.98[d]	0.41[b,]	38.35[b]
K4 (boiled tomatoes in water)	15.87[c]	0.22[c]	30.85[c]
K5 (fried tomatoes in oil)	17.11[a]	0.28[a]	33.57[d]
K6 (fried tomatoes without oil)	19.21[e]	0.37[b,]	37.02[e]

* a-f letters indicate significant differences at level 5 %

2). The lowest level of vitamin C was found in K4 is 15.87 mg/100g and the highest level of vitamin C was obtained from K3 there is 22.98 mg/100g. In this research the vitamin C levels had different amount per each treatment of processing. The K1 or no processing group (control), were higher than K5 and K1 but no more than K6.

α-tocopherol

Based on the LSD analysis, it showed that α-tocopherol had significantly different in particular data and some of different processing were no fluently impacting the α-tocopherol levels. The highest level of α-tocopherol was found in K3 (0.42 mg/100g) based on LSD test it did not significantly different with K2 (0.40 mg/100g) and K6 (0.37mg/100 g). Sliced tomatoes had the same impact with steamed and sautéed tomatoes in tocopherol level.. Meanwhile, the lowest level of α-tocopherol was shown in K4 (0.28 mg/100 g). Moreover, K1 and K5 were no significantly different; it was assumed that either temperature treatment did not show any impact in increasing the α-tocopherol levels.

Antioxidants activity

It was possible that amount of all antioxidants had a correlation with the antioxidant activity. The level of each antioxidants were showed that steamed tomatoes had an impact in antioxidants level, most of them showed a significant different proved by LSD analysis. In this research, it showed that steamed tomatoes (K3) had the highest level of antioxidant activity and as like as measurement other in parameters. No heating method (K1 and K2 groups) in this research had a direct impact on the antioxidant activity and it was significantly different with the antioxidant activity of tomatoes with heating processing (K3-K6 groups).

Heating the tomato is basically has a positive effect on the activity of lycopene and β-carotene, but long duration of heating promotes a loss in the number of carotenoids because of covalent bond diffraction among atom C (Svelander, et al., 2010). β-carotene is a compound that easily damaged comparing with lycopene during the heating process. β-carotene is a carotenoid pigment that causes the presence of yellow to orange color in tomato because it can be concentrated together with another carotenoid pigment. β-carotene is potentially damaged by the drying process (Capanoglu, et al., 2010) as well as high heat. This is due to β-carotene is readily oxidized by air, light, peroxides, metal and high temperature. In contrast, lycopene is the fat-soluble component.

Similar to the results obtained from the measurement of β-carotene. Sequentially, the highest lycopene concentration was found in steamed tomatoes, tomato fried without oil, juiced tomatoes, and tomatoes that only small sliced, fried in palm oil. The lowest lycopene content was found in the boiled tomatoes. Lycopene has a double chain active site in reducing free radicals such as singlet oxygen and peroxide (Holzapfel. et al., 2013; Shi. et al., 2015). Treatment with high temperature and pressure are able to destruct the cell wall and release the lycopene outside the cells (Takeoka, et al., 2001; Demiray. et al., 2013).

The content of total antioxidant capacity has successively shown the results of the highest value on steamed in the order from the highest to the low, fried without oil tomatoes, tomato juiced, tomatoes fried in palm oil, tomato sliced into small pieces and the lowest on boiled tomatoes, respectively. It correlates with a number of antioxidants that were activated and able extracted well. The tomatoes which were processed with the steamed technique was showing the high number of vitamin C and α-tocopherol. The steamed tomatoes containing lycopene, β-carotene, α-tocopherol and vitamin C were higher thus increasing the total antioxidant capacity than toma-

toes that processed with other techniques.

Processing of tomatoes by boiling showed the lowest antioxidant that influences the antioxidant activity and total antioxidant capacity. This was caused by the water that used to boil is potentially dissolving the water-soluble antioxidant compounds such us α-tocopherol, vitamin C and β-carotene. Due to slicing process, the broken cell wall could release the water-soluble antioxidant to the water and solute out from the tomato's cells. Draining process will leave the antioxidant dissolved in the water (Klopotek, et al., 2005). Meanwhile, the unprocessed tomatoes, such as slicing and juicing without using temperature treatment showed a higher antioxidant level than boiled tomatoes. It is the possible due to the mechanical processing of tomatoes' antioxidants extraction.

The mechanical processing had destroyed the cell wall and release antioxidant outside, but no heating process did any change in chemical compounds causing the antioxidant activity and total capacity antioxidant still low than heating process groups. At the K1 had low levels than K2 it possible by all antioxidants cannot be extracted properly due to numbers of destructed cell. Appropriate treatment can help destroy the cell walls and allow the compounds contained in the cell out when extracted.

Processing using steaming technique is creating a pressure generated by the pan covered and high temperature. It could damage the cell walls structure and release out antioxidants in tomatoes (Colle, et al., 2010a: 2010b). Based on the results of the research on total antioxidant capacity and antioxidant activity, the TCA value of tomatoes in steamed tomato was higher than all processing groups. The steaming process was able to break the tomato's cells and was able to reduce the number of dissolved antioxidants by antioxidant solubilizing agents (water and oil).

Oil used-processing was able to extract more antioxidants especially β-carotene, but when the tomatoes put out from the oil, it will leave the antioxidant compound and reduce the number of the total capacity of antioxidant and antioxidant activity. The unique thing in this research was the number of α-tocopherol. In this research, it showed that tomatoes which fried in the oil had low levels of α-tocopherol than others and there were 3 processing that had the same impact. It could be that oil may impact the number of α-tocopherol.

The use of antioxidant compounds has been growing rapidly along with the increasing knowledge of free radical activity against several degenerative diseases (Yoon, et al., 2014). The high exogenous antioxidants in the body may help protect the body against free radicals and dampen the negative impacts.

CONCLUSION

The highest amount of antioxidant was obtained in the K3 group (steamed tomatoes) that showed the level of lycopene at 46.92, β-carotene at 5862.441, α-tocopherol at 0.41 mg/100g, vitamin C at 22.98 mg/100g and total capacity antioxidant was 7.64 and antioxidant activity was 38.35%. In order to obtain the high level of antioxidant from tomatoes, it is suggested that the proper cooking method is steaming. Furthermore, it is still needed a research on fried tomatoes processing using steamed given on hypercholesterolemia condition in term of understanding its effect.

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