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ORANGE JUICE PASTEURIZATION USING OZONE

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Kalijudan 37 Surabaya 60114, +62 31 3891264 ext 108, felyciae@yahoo.com The objective of this research is to study the effects of ozonation on the quality of Pacitan sweet orange and to study the effects of the storage condition on the quality of the ozonated Pacitan sweet orange juice. The quality of the raw orange juice and ozonated orange juice was analyzed, such as total microorganism content, ascorbic acid (vitamin C) content, total acidity, total soluble solid, pH, and color. The result of these experiments showed that ozonation (0.20 g/L) has been useful to reduce the number of microorganism from 1.7 x 104 CFU/ml to 84 CFU/ml, which is fulfill the Indonesian standard requirement. Ozone pasteurization affected the orange juice quality such as vitamin C content, total acidity, pH and color, but not total soluble solid. Keywords: ozone, orange juice, pasteurization 1. Introduction Orange is rich in vitamins, fiber, and minerals that are important to humans. Vitamin C content in orange are useful as antioxidants in the body, which can help prevent cell damage caused by activity of free radical molecule. In general, to produce orange juice in industrial scale needed special treatment to extend its shelf-life [1-3]. General treatment is pasteurization, that can inactivated microorganisms that can damage the juice quality and inactivated the enzyme polyphenol oxidase (PPO) which can catalyzed browning reaction on orange juice [4]. Ozone in low concentration is very effective as disinfectant and does not leave toxic residues in the products [5, 6] since ozone is reacted with pollutant, bacteria, virus, spore, fungus, lice, and moss and destroy it. Ozone even can eliminate pesticide, formalin, growth hormone, preservatives, and coloring that used in vegetables, fruit, livestock, and seafood. After the reaction done, the ozone forming back to oxygen (O2) [6, 7]. Therefore in this research, ozone is used to minimize damaged in orange juice quality due to heating and to decrease the use of hazardous chemicals in foods. The objectives of this research is firstly to investigate the relation of ozonation time and concentration and its effect on the ozonated orange juice quality (total microbe content, vitamin C, total acidity, pH, color and total soluble solid). 2. Methodology Pacitan orange was washed, peeled and put it into juice extractor (Panasonic MJ-68M) to make orange juice. The orange juice then filtered to reduce pulp. Orange juice (100 ml) then pasteurized using ozone (DHX-IX, Tian Jing Yisheng, Bioengineering) in various time (1-30 minute). There was only time setting on the ozonator used in this experiment, therefore the relation of ozonation time and concentration were determined by Iodometric titration. The qualities of ozonated orange juice were measured such as total microbe content (Standard Plate Count method) [8], ascorbic acid content (iodimetric method) [6], total acidity (titrimetric method) [2, 9, 10], pH using pH meter (Mettler Toledo), total soluble solid using refractometer (Atago) and color (spectrophotometry at 420 nm). 3. Result and Discussion Ozone is very effective disinfectant [8,9], therefore it is important to determine the optimum concentration for efficient pasteurization. Since there was only time setting on the used ozonator, ozone concentration were determined using iodometric titration. Figure 1 showed that ozonation time was linear to ozone concentration. 1.6 1.4 Ozone

3**concentration (g/L) 1.2 1.0 0.8 0.6 0.4 0.2 0.0**

0 5 10 15 20 25 30 Time (min) Figure 1. Relation of ozonation time and ozone concentration The effectiveness of ozone as disinfectant is showed in Figure 2 that 1 minute (0.2 g/L) ozonation time was able to reduce the amount of microbe from 1.7x104 CFU/ml to 84 CFU/ml. The longer ozonation time resulted on lower total microbe content; however the microbe content reduction was not as significant as 1 minute ozonation time. 1800 Total Microbe Content (colonies/ml) 1750 1700 1650 1600 180 150 120 90 60 30 0 0 5 10 15 20 25 30 Ozonation Time (minutes) Figure 2. Total microbe content in ozonated orange juice Ozone is able to break the envelope of microbe cell that cause leakage of cell content. Another mechanism of microbe deactivation by ozone is enzyme inactivation. Ozone initiate enzyme inactivation in microbe that result on cell membrane disrupted [11, 12]. Ozonation time which related to ozone concentration affected the orange juice quality, such as ascorbic acid content (Figure 3). The degradation of vitamin C in orange juice was measured based on ascorbic content in this trials. Ascorbic acid content in ozonated orange juice decreased linearly with the ozonation time, which means higher ozone concentration caused higher vitamin C degradation. Ascorbic acid is unstable and oxidized when it is exposed to air. The result of ascorbic acid oxidation is dehydroascorbic acid and at the end it become furfural [9, 13-16]. The longer ozonation time, the higher oxygen content since one of the reaction result of ozone and microbe is oxygen. This condition accelerates the oxidation of ascorbic acid therefore for 1 minute ozonation time, the ascorbic acid reduced 1.7% and for 30 minutes ozonation time, the ascorbic acid reduced 46.72%. 0.80 Ascorbic Acid Content (mg/ml) 0.75 0.70 0.65 0.60 0.55 0.50 0 5 10 15 20 25 30 Ozonation Time (minutes) Figure 3. Ascorbic acid reduction after ozonation The trend of total acid reduction is similar to ascorbic acid reduction (Figure 4). Total acidity is amount of the total organic acids that titratable with NaOH solution. Total acidity expressed as

citric acid because it is the largest organic acid in orange juice, beside malic acid, tartaric acid, benzoic acid, ascorbic acid and succinic acid [17]. Citric acid is participating in the reaction of brown pigment formation and it is catalyzed oxidation of ascorbic acid, which is part of total acidity. 1.4 1.2 Total acidity (mg/ml) 1.0 0.8 0.6 0.4 0.2 0 5 10 15 20 25 30 Ozonation Time (minutes) Figure 4. Total acidity of ozonated orange juice Degradation of ascorbic acid and other organic acid caused ozonated orange juice pH increase from 6.0 for fresh orange juice to 6.8for 30 minutes ozonated orange juice. Ozone pasteurization was affecting orange juice color. The color of orange juice was measured based on the absorbance of spectrophotometer at wavelength of 420 nm. The initial absorbance of orange juice color was 0.250 and it increased after 1 minute ozonation became 0.268. Figure 5 showed that the absorbance of ozonated orange juice increase linearly which mean the color of ozonated was darker as increasing ozone concentration by longer ozonation time. This is because of browning reaction. Browning reaction that occurred in the ozone pasteurization were enzymatic and non- enzymatic browning [9, 16]. The enzymatic browning reaction is occurred because there was polyphenol enzyme that catalyzed phenolic compound oxidation and the non-enzymatic browning was caused by ascorbic acid oxidation. 0.60 0.55 0.50 Color (A420) 0.45 0.40 0.35 0.30 0.25 0.20 0 5 10 15 20 25 30 Ozonation Time (minutes) Figure 5. Ozonated orange juice color measured by spectrophotometer Total soluble solid in orange juice during ozone pasteurization was stable on 8.5%Brix. The largest content of total soluble solid is carbohydrate [2, 18], which was not affected by ozone in room temperature. 4. Conclusion The result of these experiments showed that ozonation (0.20 g/L) has been useful to reduce the number of microorganism from 1.7 x 104 CFU/ml to 84 CFU/ml, which is fulfill the Indonesian standard requirement. Ozone pasteurization affected the orange juice quality such as vitamin C content, total acidity, pH and color, but not total soluble solid. 5. Acknowledgement The authors would like to acknowledge the financial support of I- MHERE Widya Mandala Catholic University Surabaya (IBRD Loan No 4789- IND & IDA Loan No 4077-IND) 6. Reference 1. Ashurst, P.R., The Chemistry and Technology of Soft Drinks and Fruit Juice. 1998, Kingstone: Sheffield Academic Press. 77, 88. 2. Canumir, J.A. and J.E. Celis, Pasteurisation of Apple Juice by Using Microwaves. 2002. 35: p. 389- 392. 3. Farnworth, E.R., M. Lagace, and R. Couture, Thermal processing, storage condition, and the composition and physical properties of orange juice. Food Research International, 2001. 34: p. 25-30. 4. Lewis, M. and N. Heppel, Continuous Thermal Processing of Food. 2000, Maryland: Aspen Publisher, Inc. 219-222. 5. Seydim, Z.B.G., A.K. Greene, and A.C. Seydim, Use of ozone in the food industry. Lebensm.-Wiss. u.-Technology, 2004. 37: p. 453-460. 6. Seydim, Z.G., P.I. Bever, and A.K. Greene, Efficacy of ozone to reduce bacterial populations in the presence of food components. Food Microbiology, 2004. 2: p. 475-479. 7. Akbas, M.Y. and M. Ozdemir, Application of gaseous ozone to control populations of Escherichia coli, Bacillus cereus and Bacillus cereus spores in dried figs. Food Microbiology, 2007. 8. Hadioetomo, R.S., Mikrobiologi Dasar Dalam Praktek : Teknik dan Prosedur Dasar Laboratorium. 1993, Jakarta: PT Gramedia. 9. Esteve, M.J., A. Frigola, and C. Rodrigo, Effect of storage period under variable conditions on the chemical and physical composition and colour of Spanish refrigerated orange juice. Food and Chemical Toxicology, 2005. 43: p. 1413-1422. 10.Horwitz, W., Official Methods of Analysis of AOAC International. 17 ed. Vol. 2. 2000, Maryland: AOAC International. 11.EPA Guidance Manual : Alternative Disinfectants and Oxidants, in Ozone. 1999, U.S. Environmental Protection Agency: Washington, DC. 12.Pascual, A., I. Llorca, and A. Canut, Use of ozone in food industries for reducing the environmental impact of cleansing and disinfection activities. Trends in Food Science and Technology, 2007. 18: p. S29-S35. 13.Geveke, D.J., C. Brunkhorst, and X. Fan, Radio frequency electric fields processing of orange juice. Innovative Food Science & Emerging Technologies, 2007. Article In Press. 14.Kuellmer and Volker, Ascorbic Acid. 2001: Kirk- Othmer Encyclopedia of Chemical Technology. 15.Manso, M.C., et al., Modelling ascorbic acid thermal degradation and browning in orange juice under aerobic conditions. International JOurnal of Food Science and Technology, 2001. 36: p. 303-312. 16.Vernin, G., S. Chakib, and S.M. Rogacheva, Thermal decomposition of ascorbic acid. Carbohydrate

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