Characteristics of Instant Black Tea Powder due to the extraction results of variations in black tea (*Camellia sinensis* L.) quality and solvent ratio

Asep Dedy Sutrisno and Willy Pranata Widjaja
[1,2]Food Technology Department, Pasundan University, Bandung
[1]E-mail: sister.asepdedysutrisno@unpas.ac.id, [2]E-mail address: willypranata@unpas.ac.id

ABSTRACT

The purpose of this research is to determine the quality of black tea and the ratio of the best solvent to the characteristics of the black tea extract produced. While the goal is to create tea products that are more practical and efficient in use.

The experimental design for this study was a Randomized Block Design (RBD), with a 3 x 3 factorial pattern, each treatment repeated 3 times. The treatment design that will be carried out in this study consists of two factors, namely the type of quality factor of black tea and solvent ratio. The analysis includes physical responses (solubility), chemical response (content of water, caffeine, theaflavin, and thearubigine), and organoleptic reapons that use hedonic methods with attributes of color, aroma and taste.

The results showed that the quality of black tea had a significant effect on solubility, contents of water, caffeine, theaflavin, and thearubigine and organoleptic tests. The solvent ratio has significant effect on contents of water, caffeine, theaflavin, and thearubigine and organoleptic tests, but does not significantly affect solubility. The interaction of black tea quality and solvent ratio significantly affected theaflavin and thearubigin contents and organoleptic tests, but did not significantly affect solubility, water and caffeine contents.

Keywords: tea, solubility, theaflavin, thearubigin, and caffeine.

INTRODUCTION

The tea plant (*Camelia sinensis* L.) is a very useful beverage ingredient, derived from the shoots of the tea plant, through a certain process. The benefits of drinking tea can actually cause a feeling of freshness and can restore body health and have been proven to have no negative impact. Tea is one of the export commodities in Indonesia and has a role in the world market, it appears that the condition of our country's territory is mostly mountainous areas which are suitable for growing tea plants so that this has an impact on the amount of tea exported abroad. Traditionally, processed tea is divided into three types, namely: green tea, oolong tea, and black tea (Hartoyo, 2003). Black tea is a tea made through a fermentation process, so that the catechins in black tea are degraded to thearubigin and theaflavins which will affect the steeping color and aroma of the tea itself. This fermentation itself does not use microorganisms, but uses the phenolase enzyme found in tea (Rohdiana, 2006).

Black tea products are divided into 3 types, namely tea derived from leaves (Leaf grades), powdered tea (Broken grades), and refined tea (Small grades). The types of tea that are included in the leaf grades are orange pecko which consists of smooth leaves and pecko which consists of rough leaves. The types of tea that are included in the broken grades are Broken Orange Pekoe (BOP), Broken Pekoe (BP), Broken Orange

Pekoe Fanning (BOPF), and Broken Tea (BT), while the types that are included in the small grades are Fanning, Pecko Fanning and Dust.

According to the Central Bureau of Statistics in 2014, tea production was mostly in Asian countries such as India, Indonesia, Sri Lanka and Bangladesh. Tea consumption in Asian countries is the highest compared to Europe, America, Africa, Oceania, and the United Kingdom.

Currently, there are many tea shops that serve various kinds of tea, ranging from tea mixed with fruit, tea mixed with milk, tea mixed with chocolate and many more. With the black tea extract powder is expected to facilitate the use and storage of black tea.

According to the Indonesian Pharmacopoeia Edition III, what is meant by an extract is a thick preparation obtained by extracting the active compound from vegetable or animal simplicia using an appropriate solvent, then all or almost all of the solvent is evaporated and the remaining mass or powder is treated in such a way that it meets the predetermined standard.

Water is a universal solvent because water has the ability to dissolve many chemical substances, such as salts, acids, several types of substances and many organic molecules. In black tea, many flavonoid compounds are polar, so water is the right solvent to extract the compounds present in black tea.

Making flavor powder to replace the use of leaves in fresh form is expected to be very useful because it will be more practical and easy to use and store. This flavor in powder form can be added directly to food/beverages before or after processing. The powder form will also facilitate packaging and transportation so as to expand the range of use to areas where there are no or difficult to obtain fresh leaves, as well as use on an industrial scale (Wijaya C. Hanny, 1994).

Research on flavor often encounters problems with its isolation and identification techniques. To obtain quality flavor isolates, it often requires equipment that is truly capable of trapping all flavor components, both volatile and non-volatile and requires high knowledge and skills, as well as identification often requires equipment that has high sensitivity. Although flavor isolation methods are growing, conventional flavor isolation methods (distillation and extraction methods) are still widely used. The conventional flavor isolation method is preferred because of cost considerations and the results obtained are not too disappointing (Gani, 2008).

Based on this, in-depth and detailed research on the effect of type of black tea quality and solvent ratio on the characteristics of black tea powder extract needs to be done.

METHODOLOGY

Materials

The basic material used in the research on making instant black tea powder is black tea obtained from one of the plantations in Bandung Regency, using quality I (BOPF), quality II (PF II) and quality III (BM). As a solvent used water, other additives such as dextrin, tween 60 and tween 80.

Method

Preliminary Research

Preliminary research was conducted to determine the appropriate foaming agent to be used and determined in the main study based on the panelists' preference level using foaming agents tween 60 and tween 80.

Main Research

This main research is a continuation of the preliminary research, where the foaming agent chosen in the preliminary study will be used in the main study to determine the type of black tea quality and the appropriate solvent ratio for the manufacture of powdered black tea extract. Furthermore, treatment design, experimental design, analysis design, and response design were carried out.Pembuatan Ekstrak Teh Hitam Powder.

The stages of making instant black tea powder include weighing, extraction using hot water, filtration, evaporation, mixing with foaming agent and dextrin, drying, size reduction using a blender, and sifting using 60 mesh.

The treatment design used in the main study consisted of two factors, namely the type of black tea quality which consisted

of 3 levels, namely Quality I and Quality II and Quality III. And the solvent ratio which consists of 3 levels, namely 1:10, 1:20 and 1:30.

The experimental design used in this study was a Randomized Block Design (RAK) with a factorial pattern of 3 x 3, each treatment was repeated three times to obtain 27 experimental units.

The analysis design used Analysis of Variance (ANOVA) to obtain conclusions about the effect of treatment. If the hypothesis is accepted regarding the characteristics of instant black tea powder, then Duncan's further test is carried out.

Response designs that have been carried out in the main research include chemical responses, physical responses and organoleptic responses. Chemical responses carried out in the main study included determination of water content, caffeine, theaflavin and thearubigin. The physical response carried out in the main research is the analysis of solubility and the organoleptic response is the hedonic test.

Results And Discussion

Preliminary Research

Preliminary research was conducted to determine the preferred foaming agent by the panelists on the characteristics of powdered black tea extract. The selected foaming agent will be used in the main study. In this preliminary study, a sample of quality III black tea was used with a solvent ratio of 1:10. The response is a hedonic test.

Table 1. Preliminary Research Results of Organoleptic Test of Color Attributes

Treatment	Average Value
Use of Tween 80	4.87
Use of Tween 60	5.03

Based on the table of organoleptic test results, the color attribute hedonic method shows that the sample using the foaming agent tween 60 is preferred by the panelists compared to tween 80. This is because tween 60 has a lighter color than tween 80 which has a darker color, so it is suspected that it will affect the color of the sample. presented to the panelists.

Table 2. Preliminary Research Results Preliminary Organoleptic Tests Preliminary Aroma Attributes

Treatment	Average Value
Use of Tween 80	4.37
Use of Tween 60	4.70

Based on the table of organoleptic test results, the hedonic method shows that black tea extract using foaming agent tween 60 is preferred by panelists. This is because tween 60 has a weak and characteristic odor. (Burdock, 2001).

Table 3. Preliminary Research Results Preliminary Organoleptic Tests Preliminary Taste Attributes

Treatment	Average Value
Use of Tween 80	3.50
Use of Tween 60	4.97

Based on the table, the organoleptic test results of the hedonic method showed that the black tea extract using the foaming agent tween 60 was preferred by the panelists. This is because tween 60 has a less bitter taste (Burdock, 2001).

Based on the results of preliminary research, the main research used is the foaming agent tween 60.

Main Research

Physical Response

Solubility

Based on the results of analysis of variance (ANOVA) showed that the type of tea quality significantly affected the solubility of black tea extract. The effect of the type of tea quality on solubility can be seen in the following table.

Table 4. Duncan's further test of black tea quality on the solubility of instant black tea powder.

Black Tea Quality	Average Value (%)
Q_{I}	90.00 ^{a}
Q_{II}	93.00 ^{b}
Q_{III}	94.11 ^{b}

Note: Each different letter represents a significant difference at the 5% level.

Based on Table 4, it can be seen that the results of the analysis show that the quality of black tea produces significant differences in the solubility of instant black tea powder.

This is presumably due to the fact that the first quality is the extract from the tea leaf shoots to the 2nd leaf, the second quality is

the 1st leaf to the 3rd leaf and the third quality is the 3rd leaf to the upper stalk where the tea shoots have the highest tannin content. about 26.5%, so the lower the quality of the tea, the higher the solubility.

This is in accordance with what Robinson said in 1991, the purer the condensed tannin, the less soluble in water and the more easily formed in the form of crystals. Tannins are soluble in polar solvents and insoluble in non-polar solvents.

Chemical Response

Water Content Respon

Based on the results of analysis of variance (ANOVA) showed that the type of black tea quality significantly affected the water content of black tea extract. The effect of the type of black tea quality on the water content can be seen in the following table.

Table 5. Duncan's further test of the quality of black tea on the moisture content of instant black tea powder.

Black Tea Quality	Average Value (%)
Q_{I}	3.70 [a]
Q_{II}	3.83 [b]
Q_{III}	4.00 [c]

Note: Each different letter represents a significant difference at the 5% level.

Based on table 5 the results of the analysis show that the treatment of black tea quality variations is significantly different. The lower the quality of black tea, the water content will increase. This is because the quality I black tea produced instant black tea powder contains a lot of polyphenols and the like which can bind water chemically. This is as explained by Winarno 1997, type 2 water, namely water molecules that form hydrogen bonds with other water molecules, is present in microcapillaries and has a slightly different nature from pure water. This type of water is more difficult to remove and the removal of type 2 water will result in a decrease in aw (water activity). If type 2 water is removed completely, the moisture content of the material will be in the range of 3-7%, and optimum stability of the food material will be achieved.

Table 6. Duncan's further test of the ratio of black tea with solvents to moisture content of instant black tea powder

Treatment of black tea to solvent ratio	Average Value (%)
1:10	2.93 [a]
1:20	3.76 [b]
1:30	3.88 [b]

Note: Each different letter represents a significant difference at the 5% level.

Based on table 6 the results of the analysis show that the treatment of the ratio of black tea with solvents shows a significant difference. Water content is an important component in foodstuffs because water can affect the texture, appearance and taste of food in general. Determination of the water content in foodstuffs is important to determine the water content as well as the dry matter content of the food (Winarno, 1997).

A material needs to be known for its water content to see how much water content is contained in the material and its resistance to storage. Free water in the material can accelerate the emergence of microorganisms, thereby accelerating the deterioration of the material. (Winarno, 1997)

Caffeine Content Response

Based on the results of analysis of variance (ANOVA) showed that the quality of black tea and the ratio of black tea to solvent, significantly affect the caffeine content of instant black tea powder. The effect of the interaction between the quality of black tea and the ratio of black tea with solvent to caffeine content can be seen in the following table.

Table 7. Duncan's further test treatment of the ratio of black tea with solvents to caffeine content of instant black tea powder

Treatment of black tea to solvent ratio	Average Value (%)
1:10	0.10 [c]
1:20	0.06 [b]
1:30	0.03 [a]

Note: Each different letter represents a significant difference at the 5% level.

The results of the analysis showed that the treatment of tea quality was significantly different. The lower the quality of the tea, the lower the caffeine content. This will affect the briskness taste produced from the tea.

Bioactive components	Quality Characteristics (steeping)
Polyphenols,Theaflavin	Astringent
Amino acid	Brothy
Caffeine	Bitter
Thearubigin	Ashy
Caffeine + Theaflavin	Briskness

Table 8. Bioactive components and flavor of brewed tea.

(Chaturvedula dan Prakash (2011) dalam Rohdiana 2015)

The main alkaloids in tea leaves are caffeine, theobromine and theophylline. Caffeine does not change during tea processing (black tea) but is seen as an ingredient that determines quality. Caffeine which will react with catechins will form a briskness compound from steeping tea. (Rohdiana, 2006)

Table 9. Duncan's Advanced Test of Solvent Ratio to Caffeine Levels of Black Tea Extract.

Treatment of black tea to solvent ratio	Average Value (%)
1:10	0.17 [a]
1:20	0.19 [a]
1:30	0.22 [b]

Note: Each different letter represents a significant difference at the 5% level.

The results of the analysis showed that the solvent ratio treatment was significantly different. The solvent ratio of 1:10 has lower caffeine content compared to the solvent ratio of 1:20 and 1:30. This is because the smaller the ratio of solvent to extract, the smaller the substance extracted. This is the same as what Khopkar 1990 said, if the solvent-raw material ratio is large it will also increase the number of dissolved compounds. As a result, the extraction rate will increase.

Theaflavin Content Respon

Based on the results of analysis of variance (ANOVA) showed that the type of black tea quality, solvent ratio, and its interaction significantly affected the theaflavin content of black tea extract. The effect of the interaction between the type of black tea quality and the ratio of solvents to theaflavin levels can be seen as follows:

Table10. Results of the Effect of Interaction Between Types of Black Tea Quality and Ratio of Solvents to Theaflavin Levels (%) Black Tea Extract

Black Tea Quality	Solvent Ratio		
	1:10	1:20	1:30
Q_{I}	0.46 C a	0.51 C b	0.57 C c
Q_{II}	0.27 B a	0.28 B b	0.33 B c
Q_{III}	0.16 A a	0.20 A b	0.24 A c

Note: The average value marked with the same letter notation in the row and column shows no significant difference at the 5% level. Lowercase letters are read horizontally, uppercase letters are read vertically.

The results of the analysis showed that the interaction between tea quality and solvent ratio resulted in significant differences in theaflavin levels. Quality I has the highest levels of theaflavins compared to quality II and quality III. The lower the quality, the lower the theaflavin content. This will affect the steeping characteristics of black tea quality. The higher the levels of theaflavins, the more astringent and briskness (fresh) will be produced, theaflavins will produce a reddish color in black tea.

Young tea leaves are preferred for the production of quality tea. This is because the young tea leaves are bright green in color when compared to the dark green old tea leaves. Differences in the age of tea leaves will have an impact on the composition of chemical compounds such as total polyphenols, catechins, caffeine and the activity of polyphenol oxidase enzymes. Tea leaf shoots have the highest total polyphenol composition, which is 26%. (Turkmen, 2009)

Theaflavin is the result of oxidation of catechin compounds. Catechins are the most important compounds in tea leaves. Changes in these compounds are always associated with the properties of the finished tea, namely taste, color and aroma.

Catechins are composed mostly of catechin compounds from epicatechin, epigalocatechin, epigalocatechin, and galocatechin. The content of catechins ranges from 20-30% of the total dry weight of tea leaves. (Rohdiana, 2006)

Thearubigin Content Respon

Based on the results of analysis of variance (ANOVA) showed that the type of black tea quality, solvent ratio, and their interactions had a significant effect on the thearubigin content of black tea extract. The effect of the interaction between the type of black tea quality and the ratio of solvent to thearubigin content can be seen as follows:

Table 11. Results of the Effect of Interaction between Types of Black Tea Quality and Ratio of Solvents to Thearubigin Levels (%) Black Tea Extract Ekstrak

Black Tea Quality	Solvent Ratio		
	1:10	1:20	1:30
Q_I	18.30 A a	18.75 A c	18.37 A b
Q_{II}	16.49 B c	17.01 A b	17.82 A a
Q_{III}	16.30 C c	16.85 B b	16.98 B a

Note: The average value marked with the same letter notation in the row and column shows no significant difference at the 5% level. Lowercase letters are read horizontally, uppercase letters are read vertically.

The results of the analysis showed that the interaction between tea quality and solvent ratio resulted in significant differences in thearubigin content.

Based on the results of the analysis of theaflavin content and thearubigin content of black tea extract products, it can be seen that all treatments of black tea extract produced higher levels of thearubigin than theaflavin levels. This is in accordance with the statement of Rohdiana (1999), the main product of oxidation in black tea extract is thearubigin which is brown in color and is strongly acidic. Thearubigin is the result of further oxidation of theaflavins, so the thearubigin content in tea will be higher than the theaflavin content.

According to Chaturvedula and Prakash (2011) in Rohdiana (2015), the color quality characteristics produced from thearubigin compounds are darker than theaflavin compounds so that the more thearubigin content, the more reddish-brown black tea color will be.

There is no direct relationship between strength and theaflavin or thearubigin individually, but it is directly related to both. Steep color is always associated with the presence of theaflavins and thearubigins, while briskness is always associated with the combination of theaflavins and caffeine. The decrease in briskness due to the length of the enzymatic oxidation process is due to a decrease in the amount of theaflavin and caffeine complex compounds, and this will increase the amount of caffeine-thearubigin complex.

Organoleptic Response

Color

Based on the results of analysis of variance (ANOVA) showed that the quality of black tea, the ratio of solvents, and their interactions had a significant effect on the color of the black tea extract powder, so Duncan's further test was carried out. The effect of interaction between black tea quality and solvent ratio on color attributes can be seen as follows:

Table 12. Results of the Effect of Interaction between Types of Black Tea Quality and Solvent Ratio on Organoleptic Test of Color Parameters

Black Tea Quality	Solvent Ratio		
	1:10	1:20	1:30
Q_I	4.23 A a	4.59 C c	4.32 A b
Q_{II}	4.36 B a	4.43 B b	4.52 B c
Q_{III}	4.38 B b	4.28 A a	4.67 C c

Note: The average value marked with the same letter notation in the row and column shows no significant difference at the 5% level. Lowercase letters are read horizontally, uppercase letters are read vertically.

The results of the analysis showed that the interaction between solvent concentration and extraction time resulted in significant differences in color parameters. The color difference is caused by the different types of black tea quality. This is because the thearubigin content decreases with the low quality of black tea. Thearubigin has a reddish-brown color, while theaflavins have a yellowish-red color. The organoleptic results of this color

attribute showed that the treatment of type III black tea quality and solvent ratio of 1:30 was preferred by panelists because the color was brighter red than the other treatments.

Aroma

Based on the results of analysis of variance (ANOVA) showed that the type of black tea quality, duration of the solvent ratio, and their interactions had a significant effect on the aroma attributes of black tea powder extract, so Duncan's further test was carried out. The effect of the interaction between types of black tea quality and the ratio of solvents to aroma attributes can be seen as follows:

Black Tea Quality	Solvent Ratio		
	1:10	1:20	1:30
Q_I	3.91 A a	4.95 C c	4.75 C b
Q_{II}	4.70 C c	4.45 B b	4.25 A a
Q_{III}	4.37 B b	3.97 A a	4.36 B b

Table 13. Results of the Effect of Interaction between Types of Tea Quality and Solvent Ratio on Organoleptic Tests of Aroma parameters
Note: The average value marked with the same letter notation in the row and column shows no significant difference at the 5% level. Lowercase letters are read horizontally, uppercase letters are read vertically.

Based on table 13, the analysis results show that the interaction between solvent concentration and extraction time produces significant differences in aroma attributes.

The organoleptic test results of this aroma attribute indicate that the treatment of type I black tea and a solvent ratio of 1:20 is preferred by the panelists, this is due to the composition of the type of quality black tea I which has high polyphenol content. The aroma in tea is caused by the presence of volatile aromatic compounds, the extraction process of chemical components of herbal teas such as carbohydrates, proteins, sugar reduction groups when the tea is brewed, as well as the oxidation of polyphenolic compounds and their derivatives such as catechins into theaflavins and thearubigins which give a distinctive aroma.

Taste

Based on the results of analysis of variance (ANOVA) showed that the quality of black tea, the ratio of solvents, and their interactions significantly affected the taste of black tea extract powder, so Duncan's further test was carried out. The effect of interaction between black tea quality and solvent ratio on taste attributes can be seen as follows:

Table 14. Results of Interaction Between Types of Tea Quality and Solvent Ratio on Organoleptic Tests for Taste Parameters

Black Tea Quality	Solvent Ratio		
	1:10	1:20	1:30
Q_I	4.18 A a	5.01 C b	4.58 A a
Q_{II}	4.18 A a	4.29 A b	4.34 B b
Q_{III}	4.10 B b	4.16 B a	4.45 A a

Note: The average value marked with the same letter notation in the row and column shows no significant difference at the 5% level. Lowercase letters are read horizontally, uppercase letters are read vertically.

Based on table 14, the results of the analysis show that the interaction between solvent concentration and extraction time produces significant differences in taste attributes.

The organoleptic test results showed that the treatment of quality I black tea and a solvent ratio of 1:20 was preferred by the panelists because the quality type of black tea I had a strong tea taste seen from the content of theaflavin and thearubigin compounds, as well as a solvent ratio of 1:20 which tended to extract more many flavor compounds from black tea. This is because the higher the quality of the tea and the higher the solvent ratio, the higher the amount of flavor content extracted.

CONCLUSION

1. Types of black tea quality significantly affect on solubility, content of water, caffeine, theaflavin, thearubigin, and organoleptic tests.
2. The ratio of solvents has a significant effect on content of water, caffeine, theaflavin, thearubigin, and organoleptic, but has no significant effect on solubility.
3. The interaction of the type of black tea quality and the ratio of solvents there is a significant difference in content of

theaflavin, thearubigin, and organoleptic, but there is no significant difference in solubility, content of water and caffeine.

REFERENCE

Adnan, M., Ahmad, A., Ahmed, A., Khalid, N., Hayat, I., and Ahmed,I. 2013. *Chemical Composition and Sensory Evaluation of Tea (Camellia sinensis) Commercialized in Pakistan*. Pakistan Journal of Botany, 45(3): 901-907.

Anonimus. 2014. SNI 3753:2014. *Teh Hitam Celup*. Badan Standar Nasional, Jakarta.

Anonimus. 2016. *SOP : Teh Hitam PT. Bali Cahaya Amerta*. Bali Cahaya Amerta, Bali.

Association of Official Analytical Chemist (AOAC). 2005. *Official Methods of Analysis of AOAC International.* 18th ed. AOAC International, USA.

Carloni, P., Tiano, L., Padella, L., Bacchetti, T., Customu, C., Kay, A., and Damiani, E. 2012. *Antioxidant Activity of White, Green, and Black Tea Obtained from the Same Tea Cultivar*. Food Research International, 53(2): 900-908. doi: 10.1016/j.foodres.2012. 07.057.

Chandini, S. K., Rao, L. J., and Subramanian, R. 2011. *Influence of Extraction Conditions on Polyphenols Content and Cream Constituents in Black Tea Extracts*. International Journal of Food Science and Technology, 46(4): 879-886. doi: 10.1111/j.1365-2621.2011.02576.x.

Chaturvedula, V. S. dan Prakash, I. 2011. *The Aroma, Taste, Color, and Bioactive Constituents of Tea*. Journal of Medical Plant Research, 5(11): 2110-2124.

Cleverdon, R., Elhalaby, Y., McAlpine, M. D., Gittings, W., and Ward, W. E. 2018. *Total Polyphenol Content and Antioxidant Capacity of Tea Bags: Comparison of Black, Green, Red Rooibos, Chamomile, and Peppermint over Different Steep Times*. Beverages (MDPI), 4(15):1-13. doi: 10.3390/beverages 4010015.

Food and Agriculture Organization of the United Nations. 2015. *World Tea Production and Trade Current and Future Development*. Food and Agriculture Organization of the United Nations, Roma.

Gupta, V. K., Zhao, Y., Shoyama, Y., Pryme, I. F., Li, G. Q., and Serkedjieva, J. 2016. *Camellia sinensis (L.) Kuntze: A Review of Chemical and Nutraceutical Properties*. Natural Products, 4(2): 21-62.

Hayat, K., Iqbal, H., Malik, U., Bilal, U., and Mushtaq, S. 2015. *Tea and Its Consumption: Benefits and Risks.* Critical Reviews in Food Science and Nutrition, 55(7): 939-954. doi: 10.1080/10408398. 2012.678949.

Hilal, Y. and Engelhardt, U. 2007. *Characterisation of White Tea-Comparison To Green Tea And Black Tea*. J. verbr. Lebensm 2 : 414-421.

Karori, S.M, Wachira, F. N, Wanyoko, J.k and Ngure, R. M. 2007. *Antioxidant Capacitiy of Different Type of Tea Products*. African journal of Biotechnology, Vol 6: 2287-2296

Kodagoda, K.H.G.K. and Wickramasinghe, I. 2017. *Health Benefits of Green and Black Tea: A Review*. International Journal of Advanced Engineering Research and Science, 4(7): 107-112. doi: 10.22161/ijaers. 4.7.16.

Lantano, C., Rinaldi, M., Cavazza, A., Barbanti, D., and Corradini, C. 2015. *Effects of Alternative Steeping Methods on Composition, Antioxidant Property, and Colour of Green, Black, and Oolong Tea Infusions.* Journal of Science and Technology, 52(12): 8276-8283. doi: 10.1007/s13197-015-1971-4.

Leung, K. L., Yalun, S., Ruoyun, Zesheng, Z., Yu, H., and Zhen-Yu, C. 2001. *Theaflavin in Black Tea and Catechins in Green Tea Are Equally Effective Antioksidants.* The Journal of Nutrition. 131,9;pg 2248-2251.

Li, S., Lo, C. Y., Pan, M. H., Lai, C. S., and Ho, C. T. 2012. *Black Tea: Chemical Analysis and Stability.* Food and Function, 4:10-18. doi: 10.1039/c2fo30093a.

Liang, Y., Lu, J., Zhang, L., Wu, S., and Wu, Y. 2005. *Estimation of Tea Quality by Infusion Colour Difference Analysis*. Journal of Science and Agriculture, 85: 286-292. doi: 10.1002/jsfa.1953.

Lunkes, L.B.F. and Hashizume, L.N. 2014. *Evaluation of the pHand Titratable Acidity of Teas Commercially Available in Brazilian Market*. Revista Gaucha de Odontologia, 62(1): 59-64.

McAlpine, M. D. and Ward, W. E. 2016. *Influence of Steep Time on Polyphenol Content and Antioxidant Capacity of Black, Green, Rooibos, and Herbal Teas.* Beverages (MDPI), 2(17): 1-12.

Meilgaard, M., G. V. Civille and B. T. Carr. 2000. *Sensory Evaluation Techniques*. Boca Raton. CRC Press.Florida.

Murugesan, P.,Venkateswaran, G., Sathish, G., and Shanmugaselvan, V. 2020. *Enhancing the Quality of Naturally Oxidized Tea with Ascorbic Acid.* International Journal of Advanced Engineering Research and Science, 7(4): 403-409. doi: 10.22161/ijaers.74.50.

Muzolf-Panek, M., Gliszczynska-Swiglo, A., Szymusiak, H., and Tyrakowska, B. 2012. *The Influence of Stereochemistry on the Antioxidant Properties of Catechin Epimers.* Europe Food Research Journal,235: 1001-1009. doi: 10.1007/s00217-012-1826-4.

Nadiah, N. I. and Uthumporn, U. 2015. *Determination of Phenolic and Antioxidant Properties in Tea and Spent Tea Under Various Extraction Method and Determination of Catechins, Caffeine and Gallic Acid by HPLC*. International Journal on Advanced Science Engineering and Information Technology, 5(3): 158-164.

Negukhula, S., Mudau, F. N., Mariga, I. K., and Liphadzi, K. B. 2011. *Effect of Soaking Conditions on Total Phenolic and Antioxidant Capacity of Black Tea and Black Tea Combined (50:50) with Bush Tea.* Indian Journal of Horticulture, 68(1): 91-95.

Obanda, M., Owuor, P. O., Mangoka, R., and Kavoi, M. M. 2004. *Changes in Thearubigin Fractions and Theaflavin Levels due Tovariations in Processing Conditions and Their Influence onBlack Tea Liquor Brightness and Total Colour*. Food Chemistry, 85(2): 163-173. doi: 10.1016/ S0308-8146(02)00183-8.

Palanivel, M., Gopal, V., Thevar, K. S., and Veilumuthu, S. 2018. *Impact of Different Steeping Time and Water Temperature on Tea Liqour.* International Journal of Technical Research and Science, 3(1): 15-18. doi: 10.30780/IJTRS. V3.I1.2018.005.

Rohdiana, D. 2015. *Teh: proses, karakteristik, dan komponen fungsionalnya*. Food review Indonesia 10 (8) : 34-37.

Sharif, M. K., Butt, M. S., Sharif, H. R., and Nasir, M. 2017. *Handbook of Food Science and Technology: Sensory Evaluation and Consumer Acceptability.* Research Gate, Pakistan.

Sinha, S. K. and Ghaskadbi, S. S. 2013. *Thearubigins Rich Black Tea Fraction Reveals Strong Antioxidant Activity*. International Journal of Green Pharmacy, 7(4): 336-344. doi: 10.4103/0973-8258.122099.

Skotnicka, M., Wynimko, J. C., Jankun, J., and Jankun, E. S. 2011. *The Black Tea Bioactivity*: An Overview. Central European Journal of Immunology, 36(4): 284-292.

SNI 03-3836-2012. 2012. *Standar Mutu Teh Kering*. Dewan Standarisasi nasional.Jakarta.

Su, Y.L., Leung,L.K., Huang,Y., and Chen, Z.Y. 2003. *Stability of Tea Theaflavins and Catechins*. Elsevier Food Chemistry, 83(2): 189-195. doi: 10.1016/S0308-8146(03)00062-1.

Sud and Asha. 2000. *Seasonal Variations In Theaflavin, Thearubigin, Total Colour and Brightness of Kangra Orthodox Tea (Camellia sinensis (L) OKuntze) In Himachal Pradesh*. Journal of The Science of Food And Agriculture. Volume80, P 1291 –1299.

Takemoto, M. and Takemoto, H. 2018. *Synthesis of Theaflavins and Their Functions.* Molecules, 23(4): 1-18. doi:10.3390/molecules2304091.

Vuong,Q.V., Golding, J. B., Stathopoulos, C. E., and Roach, P. D. 2012. *Effect of Aqueous Brewing Solutions pH on the Extraction of the Major Green Tea Constituents*. Food Research International, 53: 713-719.

Wan X., Li D., and Zhang Z. 2009. *Green tea and Black tea*. In: Ho CT, Lin JK, Shahidi F. (eds). USA:CRC Press, Taylor and Francis Group, pp 1-8.

Wikipedia. 2015. *Camellia sinensis (online)*. https://id.wikipedia.org/wiki/Camellia_sinensis. accessed : 07 May 2018.

Yuann, J. P., Wu, J., Chang, H., Liang, J. 2015. *Effects on Temperature and Water Steeping Duration on Antioxidant Activity and Caffeine Content of Tea.* MC Transaction on Biotechnology, 7(1): 22-32.

Zeng, L., Maa, M., Li, C., dan Luoa, L. 2017. *Stability of Tea Polyphenols Solution with DifferentpH at Different Temperatures*. International Journal of Food Properties, 20(1): 1-18. doi: 10.1080/10942912.2014.983605.