

## Physicochemical Characteristic of Tea Infusion Yoghurt Inoculated with Caspian Sea Yoghurt

(Ciri Fizikokimia Yogurt Seduhan Teh yang Diinokulasikan dengan Caspian Sea Yoghurt)

SHINTA MAHARANI\*, NANDA ANGGITA SARI, ANITA RAHAYU, M IQBAL PRAWIRA-ATMAJA & ANA A

### ABSTRACT

*Application inoculum from Caspian Sea Yoghurt to produce yoghurt containing tea infusion have not been developed thoroughly, until recently. This study aimed to determine the physicochemical characteristic and sensory evaluation of tea infusion yoghurt inoculated with Caspian Sea Yoghurt. Green, white, and black tea infusion were added to UHT milk inoculated with Caspian Sea Yoghurt inoculum and incubated at 30 °C for 12 h. The yoghurt was analyzed at 0, 6, and 12 h of fermentation including pH, acidity, viscosity, colour (L, a\*, b\*), total polyphenol, and sensory evaluation. The result showed additional tea infusion on manufacturing yoghurt significantly affected on pH, percentage of acidity, viscosity, and colour parameter of yoghurt. During the fermentation process, the prolonged incubation time resulted in increased acidity and viscosity, while simultaneously decreased the pH value. At the end of the fermentation (at 12 h) of yoghurt with 10% tea infusion had a lower pH and a higher percentage of acidity compared to the yoghurt control. Addition of tea infusion on yoghurt has a lower viscosity than yoghurt without tea infusion at the end of the fermentation. Additional tea infusion on yoghurt affected reduced Lightness (L\*) value but increased a\* and b\* value. The results of the present study indicate that additional tea infusion on yoghurt inoculated with Caspian Sea Yoghurt should be considered not only in terms of physicochemical and sensory during manufacturing and storage but also functional properties to improve human health.*

*Keywords: Caspian Sea Yoghurt; infusion tea; physicochemical characteristic; total polyphenol*

### ABSTRAK

*Penggunaan inokulum daripada Caspian Sea Yoghurt untuk menghasilkan yogurt yang mengandungi seduhan teh belum dikembangkan secara menyeluruh sehingga baru-baru ini. Kajian ini bertujuan untuk mengetahui ciri-ciri fizikokimia dan penilaian deria yogurt seduhan teh yang diinokulasikan dengan Caspian Sea Yoghurt. Seduhan teh hijau, putih dan hitam ditambahkan ke dalam susu UHT yang diinokulasi dengan inokulum Caspian Sea Yoghurt dan diinkubasi pada suhu 30 °C selama 12 jam. Yogurt dianalisis pada 0, 6 dan 12 jam fermentasi termasuk pH, keasidan, kelikatan, warna (L, a\*, b\*), polifenol total dan penilaian deria. Hasilnya menunjukkan seduhan teh tambahan pada pembuatan yogurt secara signifikan mempengaruhi pH, peratusan keasidan, kelikatan dan parameter warna yogurt. Selama proses fermentasi, waktu inkubasi yang berpanjangan menghasilkan peningkatan keasidan dan kelikatan, sementara secara bersamaan menurunkan nilai pH. Pada akhir fermentasi (pada 12 jam) yogurt seduhan 10% teh mempunyai pH yang lebih rendah dan peratusan keasidan yang lebih tinggi dibandingkan dengan kawalan yogurt. Penambahan seduhan teh pada yogurt mempunyai kelikatan yang lebih rendah daripada yogurt tanpa seduhan teh pada akhir fermentasi. Seduhan teh tambahan pada yogurt mempengaruhi penurunan nilai kecerahan (L\*) tetapi meningkatkan nilai a\* dan b\*. Hasil kajian ini menunjukkan bahawa seduhan teh tambahan pada yogurt yang diinokulasikan dengan Caspian Sea Yoghurt harus dipertimbangkan bukan hanya daripada segi fizikokimia dan deria semasa pembuatan dan penyimpanan tetapi juga sifat fungsian untuk meningkatkan kesihatan manusia.*

*Kata kunci: Caspian Sea Yoghurt; jumlah polifenol; seduhan teh; sifat fizikokimia*

### INTRODUCTION

Yoghurt is a fermented milk drink that has health effects when consumed regularly. There are many variants of yoghurt with various flavours with the addition of plant or fruit components, so far (Moore et al. 2018). There are

various yoghurt fortification products such as chocolate yoghurt (Chatterjee et al. 2018), coffee (Tan & Korel 2007), moringa leaves (Shokery et al. 2017), the avocado pulp (Atmanaji et al. 2019), banana flour (Batista et al. 2017) and red-fleshed dragon fruit (Maleta & Kusnadi 2018).

Tea (*Camellia sinensis*) is a beverage that contains bioactive compounds with health benefits (Zhang et al. 2019). Catechins are the main bioactive compounds in green tea while in black tea the bioactive compounds are theaflavin and thearubigin (Katergaris et al. 2015; Sing et al. 2015). Tea has been widely used for food, pharmaceutical and cosmetic products (Prawira-Atmaja & Rohdiana 2018). Tea can be added to yoghurt directly in the form of leaves, extracts or water tea infusion (Muniandy et al. 2017). Development of tea fortified yoghurt enriched tea phytochemicals with health benefits was possible (Ochanda et al. 2015).

Recently, only a few studies have reported the utilization of bacteria isolated from Caspian Sea Yoghurt to produce yoghurt with a tea infusion. Previous studies reported that some lactic acid bacteria can be used as inoculum in fermented tea yoghurt with various temperature variations. *Streptococcus thermophiles*

and *Lactobacillus delbrueckii* subsp. *bulgaricus* is used in yoghurt fermentation with the addition of green tea extract at 43 °C (Shokery et al. 2017). Yoghurt with the addition of infusion Pu-erh tea fermented at 37 °C using *Lactobacillus acidophilus* La-5 inoculum, *Bifidobacterium animalis* ssp. *lactis* BB-12 and *Streptococcus thermophilus* (Najgebauer-Lejko 2019). *Lactobacillus delbrueckii* subsp. *bulgaricus* 1.1480, *L. acidophilus* ys2, *S. thermophilus* ys14 and *Bifidobacterium bifidum* 1.1852 were used in yoghurt fermentation at 42 °C with the addition of brick-tea Fuzhuan leaves (Liu 2018). Yoghurt with the addition of green, black, red, and white tea extracts was fermented at 45 °C with the addition of *Lactobacillus acidophilus* LA-5, *Bifidobacterium animalis* subsp. *lactis* BB-12, and *Streptococcus thermophilus* TH-4 45 (Glibowski et al. 2019). Information on the previous study on developing yoghurt enriched tea and different types inoculum as shown in Table 1.

TABLE 1. A previous study on developing yoghurt product with tea and different types inoculum

| No | Inoculums  | Type of tea   | References              |
|----|--|---|-------------------------|
| 1  | <i>Lactobacillus delbrueckii</i> subsp. <i>bulgaricus</i> (LB) and <i>Streptococcus thermophilus</i> (ST)  | extract: thyme, mint, rheum, grape seeds, and green tea                         | (Alwazeer et al. 2020)  |
| 2  | Kombucha inoculum, <i>Lactobacillus dulbrueckii</i> sub sp. <i>bulgaricus</i> <i>Streptococcus salivarius</i> sub sp. <i>thermophilus</i> (YC-280)             | bergamot tea, camomile tea, green tea, cardamom tea, moringa tea, and black tea | (Ayah & Gehan 2018)     |
| 3  | <i>Streptococcus thermophilus</i> and <i>Lactobacillus bulgaricus</i>  | green and black tea   | (Ünal et al. 2018)      |
| 4  | <i>Streptococcus thermophilus</i> and <i>Lactobacillus bulgaricus</i>  | green tea and green coffee powders  | (Dönmez et al. 2017)    |
| 5  | DVS ABT-1 culture ( <i>Lactobacillus acidophilus</i> LA-5, <i>Bifidobacterium animalis</i> subsp. <i>lactis</i> BB-12, <i>Streptococcus thermophilus</i> TH-4) | extract: black tea, red tea, green and white tea                                | (Glibowski et al. 2019) |
| 6  | <i>S. thermophilus</i> and <i>L. bulgaricus</i>  | green and black tea infusion  | (Jaziri et al. 2009)    |
| 7  | Caspian Sea Yoghurt  | Red-fleshed dragon fruit  | (Maleta & Kusnadi 2018) |

There are other types of bacteria isolated from Caspian Sea Yogurt that can be used in yoghurt fermentation. Caspian Sea Yogurt is a Japanese fermented milk product that contains *Lactococcus lactis*

ssp. *cremoris* and *Acetobacter orientalis* (Ishida et al. 2005). *Lactococcus lactis* ssp. *cremoris*, lactic acid bacteria, are facultatively anaerobic while *Acetobacter orientalis*, acetic acid bacteria, is aerobic. Both of these

bacteria can grow at a temperature of 30 °C. Temperature fermentation is one of crucial parameters that affected the growth of lactic acid bacteria and the production of exopolysaccharides during yoghurt production (Vaningelgem et al. 2004). This study aims to determine physicochemical characteristic and sensory evaluation of yoghurt with tea infusion (green, white, and black tea) inoculated with Caspian Sea Yoghurt during 12 h fermentation.

#### MATERIALS AND METHODS

Culture starter of *Caspian Sea (Lactococcus lactis* subsp. *Cremoris FC* and *Acetobacter orientalis FA*) from Fujikko *Caspian Sea Yoghurt Handmade Inoculum* was used for the production of yoghurt. Black tea, green tea, and white tea were obtained from Indonesia Research Institute for Tea and Cinchona (RITC). Other ingredient UHT milk full cream (contained 3,1% of fat), sugar, packaging material (plastic bottles) were obtained from a local retail shop.

#### PREPARATION OF TEA INFUSION

The preparation of black tea and green tea infusion was carried out to the method described by SNI 1902:2016 for black tea (Badan Standardisasi Indonesia 2016) and SNI 3945:2016 for green tea (Badan Standardisasi Nasional 2016). Briefly, 10 g of tea was added 100 mL of boiled water and steep for 6 min, and for white tea steeping time for 10 min. The water of tea was filtered and cooled until further uses in manufacturing yoghurt.

#### PREPARATION OF INOCULUM

For activation of Caspian Sea Yoghurt starter, 3 g of inoculum were dissolved in 500 mL of UHT milk and incubated at 30 °C for 24 h. Activated cultures were used for yoghurt manufacturing at 10% (v/v) containing  $6.18 \times 10^7$  CFU/mL.

#### MANUFACTURING OF YOGHURT

Manufacturing of yoghurt was carried out the method describe by Najgebauer-Lejko et al. (2011) with slight modification. Yoghurt was prepared by dissolved 10 g of sucrose in UHT milk. Tea infusion 10% and activated culture of Caspian Sea (10% v/v) were transferred into 90 mL of milk containing sucrose. After completely mixed, it was then incubated at  $30 \pm 1$  °C for 12 h in a jar. Yoghurt sample was analyzed at 0, 6, 12 h of fermentation.

#### MEASUREMENT OF PH AND ACIDITY

The pH of yoghurt samples was measured using a pH meter (Ohaus, Germany) with a glass electrode (SNI

06-6989). Acidity was determined by titration with 0.1 N NaOH using phenolphthalein 1% as an indicator of colour (Izadi et al. 2015).

#### DETERMINED OF VISCOSITY

Viscosity was measured using a viscometer model *Brookfield Viscometer* using a glass tube and a normalized ball equipped with speed 30 rpm. Viscosity was expressed as a cP value (Dahlan & Sani 2017).

#### COLOUR ANALYSIS

The colour of yoghurt was measured using chromameter with operation following the instruction of the manufacture. The colour was expressed as L (darkness/whiteness), a (greenness/redness), and b (blueness/yellowness) (Glibowski et al. 2019).

#### DETERMINATION TOTAL POLYPHENOL IN YOGHURT PREPARATION OF EXTRACT YOGHURT

10 g of yoghurt was added with 2.5 mL of aquadest. Adjust the pH of the solution at 4 using 1 mL HCl. Yoghurt then incubated at 45 °C for 10 min, centrifuges (4000 rpm, 20 min). After filtered, the supernatant was added NaOH until reach of pH neutral and centrifuges for 20 min (4000 rpm). The supernatant was used to determining total polyphenol.

#### ANALYSIS OF TOTAL POLYPHENOL

Total polyphenol was determined using Folin-Ciocalteu method. 1 mL of homogenized yoghurt was transferred into tube flask. The sample then added with 1 mL ethanol 95% and 5 mL of aquadest to make dilution concentration at 1000 ppm. The sample was further reacted with 0.5 mL of Folin-Ciocalteu's reagent (50%, v/v) for 5 min to form a blue-coloured solution.

Then, 1 mL of  $\text{Na}_2\text{CO}_3$  5% to stabilize the colour formed. The blue colour was allowed to develop for at least 2 h and its absorbance then measured at 725 nm, using UV-vis Spectro. The amount of total polyphenol obtained from the standard curve equation of gallic acid solution with a concentration range of 1-100 ppm.

#### SENSORY EVALUATION

Sensory quality of yoghurt products was evaluated by 20 semi-trained panellists with a 7-point hedonic scale and involved the following parameters: aroma, colour, viscosity/texture, and taste. Panellists tested the samples and were asked to keep the yoghurt in the mouth for 12 s before scoring. The yoghurt samples were presented in random order. Water was used for rinsing mouth between samples.

## STATISTICAL ANALYSIS

All data were evaluated using descriptive statistic for average  $\pm$  standard deviation. One-way analysis of variance (ANOVA) was carried out. Differences between sample assessed on a confident interval using Duncan Multiple Range Test (DMRT) at the level of significance was  $p \leq 0.05$  was used to analyse the data.

## RESULTS AND DISCUSSION

## PH AND ACIDITY OF YOGHURT

Acidity and pH are the main parameters of the yoghurt product. Figure 1 shows the result of pH and per cent acidity of yoghurt containing water infusion of tea during

fermentation 0, 6, and 12 h. During fermentation, all pH of yoghurt decreased significantly (Figure 1(a)). Addition tea infusion on yoghurt resulted in the lowest pH value than yoghurt control. Yoghurt with 10% white tea infusion has the lowest pH value than yoghurt with 10% green tea infusion, black tea infusion, and control with a pH value: 4.45, 4.46, 4.47, and 4.49, respectively. Decreasing in pH in yoghurt during fermentation is correlation to the increase in the percentage of acid. Decreased pH value on yoghurt also reported by Najgebauer-Lejko et al. (2011) that addition yoghurt with 10% of green tea at 12 h fermentation reached 4.46, lower than control. Duration time of fermentation/incubation also significantly affected pH value and acidity of yoghurt with the addition of brick-tea Fuzhuan (Krisnaningsih et al. 2019; Liu 2018).

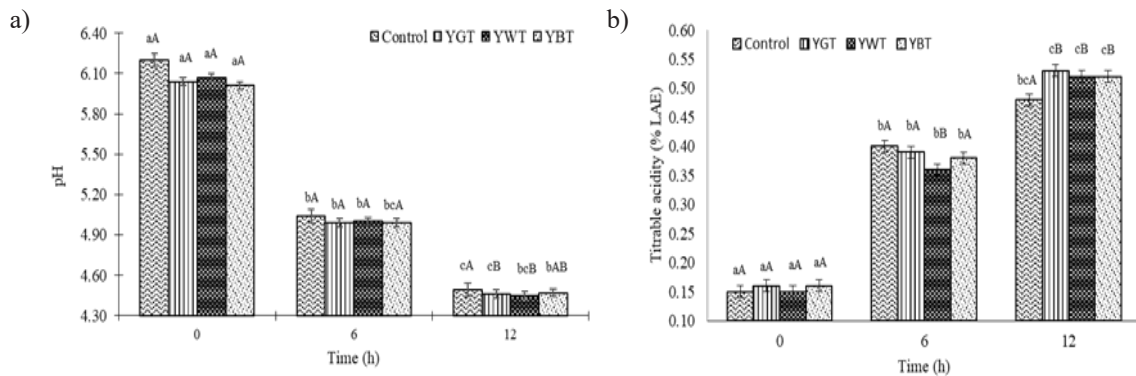


FIGURE 1. Change of a) pH and b) titrable acidity (% LAE) of yoghurt contains a different type of tea infusion during 12 h fermentation. Control: yoghurt plain; YGT: yoghurt with 10% green tea infusion; YWT: yoghurt with 10% white tea infusion; and YBT: yoghurt with 10% black tea infusion

Data are represented as mean  $\pm$  SD (standard deviation) of three replications. Different superscript letters (a-c) indicate significant differences between fermentation time. Different superscript letter (A-C) indicates significant differences between the type of tea infusion tea and control at  $P < 0.05$  according to a DMRT

The percentage of acidity is assumed as lactic acid during yoghurt fermentation at a temperature of 30 °C. The acidity of yoghurt increases significantly at 6 h of fermentation from 0.15-0.17% at 0 h to 0.37-0.40% at 6 h fermentation. Percent acidity of yoghurt at 12 h fermentation is 0.48, 0.53, and 0.52 on yoghurt without added tea infusion (control), yoghurt with green, white, and black tea infusion, respectively. A previous study reported by Maharani et al. (2014) that acidity increased during fermentation of black soy yoghurt with inoculum Caspian Sea Yoghurt with per cent acidity of 0.30-0.40% at 6 h of fermentation.

Our results show that at the end of the fermentation (at 12 h) of yoghurt with 10% tea infusion had a lower pH and higher percentage of acidity compared to the yoghurt control. According to Alwazeer et al. (2020), lactic acid bacteria produce higher percentage of acidity in milk with the addition of various plant extracts. During fermentation, the pH of yoghurt declines in proportion to the increase in the percentage of lactic acid. Lactic acid is formed from the fermentation of milk lactose by lactic acid bacteria (Chen et al. 2017). The acidity in yoghurt with tea infusion increases due to the bioactive compound in tea (Najgebauer-Lejko et al. 2014). The bioactive compound of tea can increase the acidity of

yoghurt without disturbing the growth of lactic acid bacteria in yoghurt. Tea can stimulate bacterial growth during fermentation and support lactic acid production (Najgebauer-Lejko et al. 2011). The antimicrobial activity in tea only affects the growth of pathogenic bacteria such as *E. coli*, *B. cereus*, *S. aureus*, and *C. albicans* without disturbing the growth of lactic acid bacteria (Ünal et al. 2018).

#### VISCOSITY OF YOGHURT

The viscosity of yoghurt increased significantly during fermentation at 6 and 12 h. Yoghurt control has a higher

viscosity than yoghurt with a tea infusion. Addition tea infusion on manufacturing yoghurt affected on decreased of viscosity yoghurt at initial time fermentation and the end of fermentation (Figure 2). It can be seen that the addition of 10% of tea infusion has lowered viscosity 1535.50-1624.00 cP than yoghurt control with viscosity 1879.75 cP at 12 h fermentation. The apparent viscosity of yoghurt prepared from cow's milk with *Streptococcus thermophilus* and *Lactobacillus bulgaricus* was 173.50 cP at the end of fermentation (Atmanaji et al. 2019). The highest viscosity of yoghurt is obtained from the lower per cent acidity and higher the pH value of yoghurt (Krisnaningsih et al. 2019).

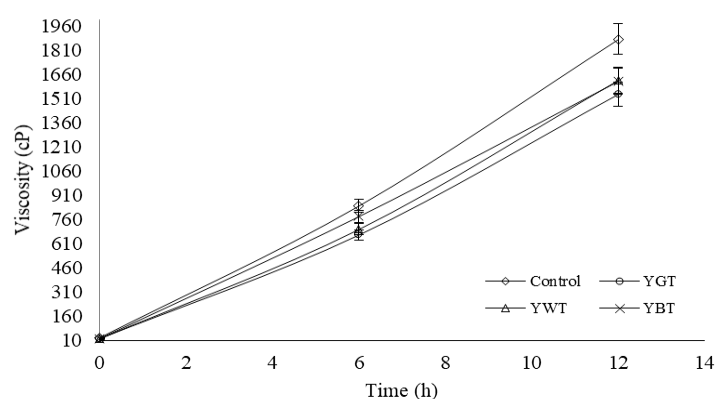


FIGURE 2. Change of viscosity (cP) of yoghurt contain a different type of tea infusion during 12 h fermentation. Control: yoghurt plain; YGT: yoghurt with 10% green tea infusion; YWT: yoghurt with 10% white tea infusion; and YBT: yoghurt with 10% black tea infusion.

Data are represented as mean  $\pm$  SD (standard deviation) of three replications. Different superscript letters (a-c) indicate significant differences between fermentation time. Different superscript letter (A-C) indicates significant differences between the type of tea infusion tea and control at  $P < 0.05$  according to a DMRT

Addition of tea infusion on yoghurt has a lower viscosity than yoghurt without tea infusion at the end of the fermentation (Ünal et al. 2016). It also reported that addition 4% of green tea on yoghurt has a lower viscosity than yoghurt with the infusion of black tea. Caspian Sea Yoghurt has a higher viscosity because *Lactococcus* (L) lactic ssp. *cremoris* produces exopolysaccharides (EPS) (Uchida et al. 2009). EPS production of starter cultures significantly improved apparent viscosity and sensory attributes of yoghurt (Madhubasani et al. 2020). The duration of fermentation also affected on yoghurt viscosity.

The viscosity of yoghurt is influenced by the number and strength of the bonds between casein micelles in yoghurt. Casein aggregation occurs at isoelectric pH

<4.9 with maximum gel stiffness occurring at pH 4.6 (Phadungath 2005). Increasing viscosity is directly proportional to the production of exopolysaccharide by lactic acid bacteria during yoghurt fermentation (Madhubasani et al. 2020). During yoghurt fermentation, the increase in exopolysaccharide corresponds to a decrease in lactose and an increase in lactic acid in yoghurt (Vaningelgem et al. 2004).

Addition of tea infusion can affect the viscosity of yoghurt. Interactions between tea polyphenols and milk protein, at certain concentration, can improve the network structure of casein and the consistency of yoghurt (Dönmez et al. 2017). According to Phadungath (2005), the strength of casein gel in yoghurt is correlation with concentration of casein while according to the

Najgebauer-Lejko et al. (2014) interaction between protein and polyphenols are influenced by the concentration and ratio of protein and polyphenols, and conditions of pH and temperature, and the treatment of additional ingredients.

#### COLOUR OF YOGHURT

Colour is an important attribute in food that perceived by the consumer and often influences the consumer preference (Sah et al. 2016). Figure 3 shows the colour parameters of yoghurt containing tea infusion on yoghurt control at 0, 6, and 12 h fermentation. Yoghurt without addition tea infusion has L (lightness) value higher than yoghurt with addition 10% tea infusion with

L\* value 91 compared yoghurt with green, white, and black tea infusion with 88.33, 89.98, and 82.20 at 0 h fermentation, respectively. Addition black tea infusion on yoghurt produces L value lower than green and white tea infusion on yoghurt. Green tea and black tea yoghurt produce the same brightness as yoghurt control at 12 h of fermentation.

Values of a\* indicate red and green colour. Addition black tea infusion produces yoghurt with reddish colour while green and white tea produces yoghurt with a yellowish-green colour. Among the variations of type tea infusion yoghurt, yoghurt with the addition of black tea infusion water gives the highest yellow colour (b\*) at initial fermentation (0 h) until 12 h.

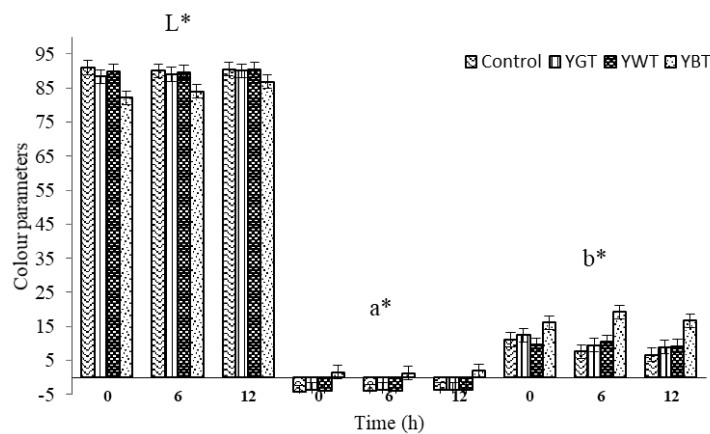


FIGURE 3. Change of colour profile parameters yoghurt contains a different type of tea infusion during 12 h fermentation. L\* – lightness, a\* – green-red colour, b\* – blue-yellow colour of Control: yoghurt plain; YGT: yoghurt with 10% green tea infusion; YWT: yoghurt with 10% white tea infusion; and YBT: yoghurt with 10% black tea infusion.; means  $\pm$  SD



FIGURE 4. Visual assessment of yoghurt contains a different type of tea infusion. Control: yoghurt plain; YGT: yoghurt with 10% green tea infusion; YWT: yoghurt with 10% white tea infusion; and YBT: yoghurt with 10% black tea infusion

The study results also supported by Glibowski et al. (2019) that yoghurt with the addition of 12% of black tea infusion produced the darkest colour (62.28) among the green tea yoghurt (71.04) and white tea yoghurt (68.35) thus lowering the colour brightness of yoghurt. Similar things occur in reddish and yellowish colour in yoghurt after 12 h of fermentation with the addition of 10% the Pu-er (Najgebauer-Lejko 2019). Our result showed that additional tea infusion on yoghurt reduced Lightness ( $L^*$ ) value but increased  $a^*$  and  $b^*$  value (Figure 4). Reddish value on yoghurt with tea infusion due to the presence of theaflavin and theobrownin while chlorophyll, flavonols, and flavones contribute to the

greenish and yellowish-green colour (Donlao & Ogawa 2019; Najgebauer-Lejko et al. 2014).

#### TOTAL POLYPHENOL OF YOGHURT

The total polyphenols analyzed on yoghurt containing tea infusion at 12 h fermentation. Figure 5 shows total polyphenol content in three types of tea yoghurt. Yoghurt with green tea infusion has the highest total polyphenol when compared with other yoghurts. Total polyphenol contents are 30.42, 28.81, and 13.63 g GEA/g extract on yoghurt with green, black and white tea infusion, respectively.

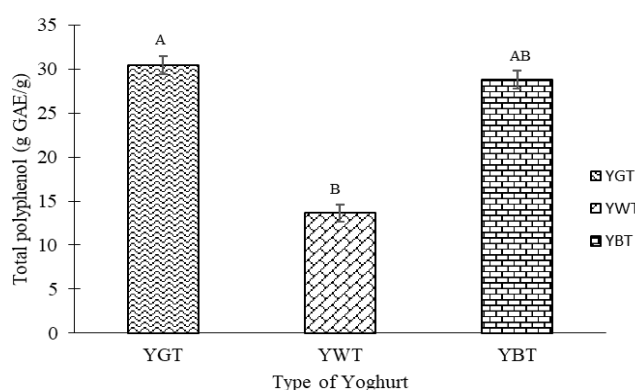


FIGURE 5. Total polyphenol of yoghurt contains a different type of tea infusion after 12 h fermentation. YGT: yoghurt with 10% green tea infusion; YWT: yoghurt with 10% white tea infusion; and YBT: yoghurt with 10% black tea infusion

Data are represented as mean  $\pm$  SD (standard deviation) of three replications. Different superscript letter (A-C) indicates significant differences between the type of tea infusion tea and control at  $P < 0.05$  according to a DMRT

In our results, it is shown that the total polyphenols in white tea yoghurt lower than black tea yoghurt. According to Muniandy et al. (2016), the total polyphenol of yoghurt with green tea infusion higher than yoghurt with white and black tea infusion. Result study also reported by Almajano et al. (2008) with the total polyphenol in green, white and black tea infusion were 2083, 2180, and 1844  $\mu\text{g GAE/L}$ , respectively. The lowest polyphenol content in yoghurt with white tea infusion might be affected by different forms between white (leaf) and black tea (powder), steeping time, water-to-tea ratio and extraction method during preparation of infusion. Particle size in the material is one of the factors that influence the efficiency of the extraction process (Zhang

et al. 2018). The observed effects of increasing phenols and antioxidant levels with increasing infusion times were also known to be influenced by stirring duration and intensity, leaf size, and tea bag porosity (Nikniaz et al. 2016). Optimization of tea polyphenol extraction is a complex mechanism and influenced by several factors such as extraction method, steeping time, temperature, tea-to-water ratio, solvent extraction, form and type of tea (Nikniaz et al. 2016).

#### SENSORY EVALUATION OF YOGHURT

The sensory evaluation of yoghurt was performed using 20 semi-trained panellists on yoghurt with 12 h fermentation. The parameters tested by the panellists

included aroma, colour, texture (viscosity), and taste. The results showed that the level of aroma preference between control yoghurt and yoghurt with the addition of tea was not significantly different statistically with values ranging from 4.55-4.75. Panellists, in colour parameters, tend to accept colour in control yoghurt and yoghurt with the addition of white tea with a score of 5.65 and 5.45, respectively.

Panellists showed little acceptance of the colour of yoghurt with the addition of black tea with a score of 4.35 while for texture or viscosity, panellists tend to accept control yoghurt, green and white tea when compared to yoghurt with black tea. In the taste parameter, yogurt with white tea gets the highest score of 5.16 when compared to other yoghurt products.

TABLE 2. Sensory evaluation of yoghurt contained a different type of tea infusion

| Parameters | Control                | Type of tea infusion   |                        |                        |
|------------|------------------------|------------------------|------------------------|------------------------|
|            |                        | Green tea              | White tea              | Black tea              |
| Aroma      | 4.63±0.11 <sup>a</sup> | 4.75±0.21 <sup>a</sup> | 4.68±0.32 <sup>a</sup> | 4.55±0.28 <sup>a</sup> |
| Color      | 5.65±0.07 <sup>a</sup> | 4.85±0.28 <sup>b</sup> | 5.44±0.05 <sup>a</sup> | 4.35±0.64 <sup>c</sup> |
| Texture    | 4.73±0.18 <sup>a</sup> | 4.75±0.21 <sup>a</sup> | 4.73±0.25 <sup>a</sup> | 4.60±0.21 <sup>b</sup> |
| Taste      | 4.76±0.19 <sup>a</sup> | 4.76±0.11 <sup>a</sup> | 5.16±0.15 <sup>b</sup> | 4.74±0.30 <sup>a</sup> |

Data are represented as mean ± SD (standard deviation) of three replications. Different letters in the line indicate significant differences between the type of tea infusion at  $P < 0.05$  according to a DMRT

The results study by Glibowski et al. (2019) states that yoghurt with the addition of 4% of green tea infusion is preferably panellist than yoghurt with the addition of 12% black tea infusion. Dyes in black tea affect the taste and colour of tea infusion (Liang et al. 2003). The taste of yoghurt is positively correlated to overall yoghurt reception (Dias et al. 2020).

The formation of the aroma of yoghurt comes from the metabolism of lactic acid bacteria such as glycolysis, proteolysis, and lipolysis (Moore et al. 2018). Lactose is hydrolyzed to the glucose monomer and converted into compounds that contribute to yoghurt flavours such as lactate, acetaldehyde, ethanol, and diacetyl. Free amino acids produced by proteolysis may be converted to various flavour compounds including ammonia, amines, aldehydes, phenols, indole, and alcohols. The principal cyclic compounds in yoghurt are  $\gamma$ - and  $\delta$ -lactones, which have 5 and 6-sided rings, respectively, and are stable and strongly fruity flavoured from lipolysis (Chen et al. 2017). Tea infusion also contributes to the aroma of yoghurt because tea contains high volatile compounds such as alcohols, aldehydes, and lactones, that originate from saturated and unsaturated fatty acids (Yang et al. 2013).

The taste of yoghurt is influenced by the formation of lactic acid during fermentation (Chen et al. 2017). Uchiyama et al. (2011) found that the astringency and umami level decreased, whereas the bitterness level increased during tea fermentation. Furthermore, other tea components such as thearubigins and theaflavins are also reported to affect the sensory characteristics of the tea especially the brightness of tea colour (Owuor & Obanda 2001). Caffeine is regarded as an important parameter for commercial tea sensory evaluation having a significant contribution to the development of taste. The quality of tea is strongly associated with the amount of caffeine content for the formation of flavoured precipitates during the infusion process (Smith et al. 1994). The chemicals responsible for the taste and appearance of black tea are the theaflavins and thearubigins. Theaflavins are responsible for the astringency, brightness, colour and briskness of the black tea, while thearubigins contribute to the mouthfeel (thickness) and colour of the tea (Biswas et al. 1973).

#### CONCLUSION

Additional tea infusion on manufacturing yoghurt significantly affected on pH, percentage of acidity,



viscosity, and colour parameter of yoghurt. Our result study showed that at the end of the fermentation (at 12 h) of yoghurt with 10% tea infusion had a lower pH and higher percentage of acidity compared to the yoghurt control. Yoghurt viscosity increases with increasing fermentation time. Addition of tea infusion on yoghurt has a lower viscosity than yoghurt without tea infusion at the end of the fermentation. Additional tea infusion on yoghurt affected reduced Lightness (L\*) value but increased a\* and b\* value. Sensory evaluation showed that all variation yoghurts was accepted by panellists. The results of the present study indicate that additional tea infusion on yoghurt inoculated with Caspian Sea Yoghurt should be considered not only in terms of physicochemical and sensory during storage but also in respect of the improved health-promoting properties attributed to yoghurt tea constituents.

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Shinta Maharani\*, Nanda Anggita Sari & Anita Rahayu  
Department of Agroindustrial Technology of Education  
Faculty Technological and Vocational Education  
Universitas Pendidikan Indonesia  
Bandung, West Java  
Indonesia

M Iqbal Prawira-Atmaja  
Department Postharvest & Engineering  
Research Institute for Tea and Cinchona  
Gambung, Kab. Bandung, West Java  
Indonesia

Ana A  
Department of Family Welfare Education  
Faculty Technological and Vocational Education  
Universitas Pendidikan Indonesia  
Bandung, West Java  
Indonesia

\*Corresponding author; email: shinta.maharani@upi.edu

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