
Effect of Ginger Tea Consumption on the Tear Film Parameters in Subjects with Healthy and Dry Eyes

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Abstract: *Background:* To assess the tear film in normal and dry eye subjects after the consumption of hot ginger tea. *Methods:* Forty subjects (25 males and 15 females) aged 18–36 years (mean \pm standard deviation = 23.5 ± 5.2 years) were enrolled in the current study. Written informed consent was obtained from each participant prior to the start of the research. Temperature and humidity were controlled during the measurement. Phenol red thread (PRT) test was performed first, followed by tear ferning (TF) and noninvasive tear breakup time (NITBUT) tests. A 10 min gap was allowed between tests. Measurements were obtained 30 min before the consumption of ginger tea and repeated 60 minutes after the drink. *Results:* TF grades increased for a majority of subjects ($N = 34$; 85%), remained unchanged for two subjects (5%), and decreased for four subjects (10%) after the consumption of hot ginger tea. NITBUT scores decreased for 31 subjects (77.5%), remained unchanged for 7 subjects (17.5%), and increased for two subjects (5%) after the drink. Mean TF scores were significantly (Wilcoxon test; $p < 0.001$) higher after the consumption of ginger tea compared to those obtained before the drink. For the NITBUT test, the median score was significantly (Wilcoxon test; $p < 0.001$) lower after the drink. No significant (Wilcoxon test; $p = 0.623$) difference was found between the median scores obtained from the PRT test before and after the consumption of ginger tea. Strong correlations were found between the scores obtained from the PRT ($r = 0.978$; $p < 0.001$) and TF ($r = 0.685$; $p = 0.001$) tests before and after the consumption of a hot ginger drink. *Conclusion:* Consumption of ginger tea has a negative effect on the tear film and seems to reduce the quality of tears.

Keywords: Tears, Ginger Tea, Tear Ferning Patterns, Dry Eye, Tear Film Stability

1. Introduction

Ginger, *Zingiber officinale*, is a common spice that is produced at over three million tons a year, with India as the leading producer (34%) [1]. Ginger contains mainly carbohydrates, along with lipids, fibers, terpenes, and polyphenols [2, 3]. The most common polyphenols in ginger are gingerol, shogaol, and paradol (Figure 1) [4–6]. Gingerol and shogaol are more predominant and represent around 50% of the total polyphenols in ginger [3]. In addition, ginger contains volatile components, such as ginger oil [7]. Polyphenols can be easily extracted from ginger using hot water [8].

Polyphenols can have simple or complex structures with high molecular weights, depending on the type of plant from which they are extracted. Polyphenols are an important class of phytochemicals that are beneficial to health and have

curative effects against many illnesses [9, 10]. In addition, they act as antioxidants that are capable of neutralizing the harmful free radicals produced within the human body by oxidation processes [11]. Ginger also has antimicrobial, anti-inflammatory, and anticancer activities [12–15].

On the other hand, the tear film provides protection and lubrication for the ocular surface. The stability of the tear film is vital for healthy eyes and vision [16]. The tear film has a complex structure and contains fluid, mucins, proteins, and lipids. The lipid phase plays an important role in stabilizing the tear film. It spreads over the tear film fluid after the eye blinks and reduces the evaporation of aqueous content [17, 18]. Excessive tear evaporation and low tear secretion lead to a disruption in the tear film. Tear film instability then leads to dry eye [19]. The most common symptoms of eye dryness are

discomfort, inflammation, irritation, light sensitivity, and poor-quality vision [20]. The lipid layer is secreted by meibomian glands, and therefore, any dysfunction in such glands leads to a high tear evaporation rate. Evaporative dry eye is widespread and represents a majority of eye dryness cases [21]. Lacrimal glands are responsible for the secretion of the aqueous layer within the tear film, and thus a disruption in lacrimal gland secretion leads to eye dryness due to aqueous content deficiency [21]. Dry eyes due to a dysfunction of the lacrimal glands represent around 10% of eye dryness cases [22]. It has been estimated that up to 5 million individuals suffer from eye dryness in the US, with females and the elderly representing the majority of cases [23].



Figure 1. Common polyphenols in ginger.

Dry eyes can be evaluated using various diagnostic tests to detect tear film instability. For example, phenol red thread (PRT) and Schirmer tests are used to assess the volume of tears [24], whereas the noninvasive tear break-up time (NITBUT) test can be used to measure the time it takes for the tear film to break up [25]. Recently, the tear ferning (TF) test has been used as an effective tool for determining the quality of tears [26–30]. Dry eye cannot be assessed using a single test because each test detects a specific parameter.

Dry eye symptoms can be managed via the use of artificial tears, identification and treatment of the causes of dryness, the use of medications to reduce inflammation and stimulate tears, and massage on the eyelid [31, 32]. Recently, green and peppermint teas have been reported to have negative effects on tear film in terms of tear quality due to the high levels of polyphenols (e.g., catechins) they contain [33, 34]. Therefore, investigating the effect of the consumption of a single dose of hot ginger tea, which contains high levels of different types of polyphenols, on the tear film stability was certainly of interest.

2. Methods

2.1. Subjects

Forty subjects (25 males and 15 females) aged 18–36 years (mean \pm standard deviation = 23.5 \pm 5.2 years) were enrolled in the study. Written informed consent was obtained from each

participant prior to the start of the research. The current study is an observational, case-control, and non-randomized comparative. The study was approved by the Institutional Review Board at King Saud University (E-22-6861). The subjects were treated based on the Helsinki Declaration tenets [35]. All tests were performed on the right eye of each subject by the same examiner. Temperature and humidity were controlled during the measurement. PRT test was performed first, followed by TF and NITBUT tests. A 10 min gap was allowed between tests. A single dose of organic ginger tea (Traditional Medicinals; 1.5 G) in hot water (150 mL) was provided in a sealed cup to each subject to eliminate the steam effect. The measurements were obtained 30 min before the consumption of ginger tea and repeated 60 minutes after the drink.

2.2. PRT Test

A sterile cotton thread (Zone-Quick, Menicon, Nagoya, Japan; obtained from Showa Yakuhin Kako Co, Ltd., Tokyo, Japan) was inserted in the lower lid and gently removed after 15 s. The red portion of the thread was measured in mm [24].

2.3. TF Test

A glass capillary tube (10 μ L) (Merck, Schnellendorf, Germany) was used to collect a tear sample (1 μ L) from the lower meniscus of the right eye of each subject. The tear sample was dried at room temperature and with a humidity of less than 40% for 10 min. The TF patterns produced were inspected using a digital microscope (Olympus DP72, Tokyo, Japan). The five-point TF grading scale was used to grade the TF patterns in 0.1 increments [36].

2.4. TBUT Test

A corneal topographer (OCULUS Keratograph® 4, OCULUS Inc., Wetzlar, Germany) was used to measure the tear break-up time in seconds. After the addition of fluorescein into the subject's eye, the subject refrained from blinking while the tear film was observed. The visibility of the tear film break-up was enhanced via the use of a yellow barrier filter. The tear break-up time is the number of seconds that elapsed between the last blink and the appearance of the first dry spot in the tear film [37].

2.5. Statistical Analysis

Data were collected using spreadsheet software (Microsoft Excel 2010, Microsoft Corp., Redmond, WA, USA). Statistical analysis software (Statistical IBM Software Package for the Social Sciences software version 22, Armonk, NY, USA) was used to analyze the data. The Pearson correlation coefficient was categorized as either strong (0.50–1.00) or medium (0.30–0.49) [38]. The data collected from the TF test were normally distributed (Kolmogorov–Smirnov test; $p > 0.05$), and the mean \pm standard deviation (SD) was used to represent the average. Meanwhile, the data collected from both PRT and NITBUT tests were not normally distributed (Kolmogorov–Smirnov test; $p < 0.05$),

and the median (interquartile range; IQR) was used to represent the average.

3. Results

The PRT, TF, and NITBUT tests were performed on 40 subjects (23.5 ± 5.2 years) to assess the effect of hot ginger tea consumption on the tear film. The averages for age and the scores obtained from the PRT, TF, and NITBUT tests are outlined in Table 1.

Table 1. Averages [mean \pm SD or median (IQR)] for age, PRT, TF, and NITBUT scores ($N = 40$).

Parameter	Pre-ginger tea	Post-ginger tea	p-Value
PRT (mm)	19.0 (16.0)	19.5 (15.0)	0.623
TF*	1.7 ± 0.9	2.4 ± 0.9	< 0.001
NITBUT (s)*	10.0 (3.5)	7.0 (3.0)	< 0.001

* Significant difference (Wilcoxon test; $p < 0.001$). 1: Before and 2: after ginger consumption.

The TF grades increased for a majority of subjects ($N = 34$; 85%), remained unchanged for two subjects (5%), and decreased for four subjects (10%) after the consumption of hot ginger tea. The NITBUT score decreased for 31 subjects (77.5%), remained unchanged for 7 subjects (17.5%), and increased for two subjects (5%) after the drink. The mean TF score was significantly (Wilcoxon test; $p < 0.001$) higher after the consumption of ginger tea compared to that obtained before the drink. For the NITBUT test, the median score was significantly (Wilcoxon test; $p < 0.001$) lower after the drink. No significant (Wilcoxon test; $p = 0.623$) difference was found between the median scores obtained from the PRT test before and after the consumption of ginger tea. Representative TF images that were obtained from the same subject before and after the consumption of hot ginger tea are shown in Figure 2. The side-by-side box plots for the scores obtained from the PRT, TF, and NITBUT tests are represented in Figures 3, 4, and 5, respectively.

Strong correlations (Pearson correlation coefficient, r) were found between the scores obtained from the PRT ($r = 0.978$; $p = 0.001$) and TF ($r = 0.685$; $p = 0.001$) tests before and after the consumption of hot ginger tea. The NITBUT scores pre-drink have medium correlations with the PRT pre-drink ($r = 0.749$; $p = 0.002$) and PRT post-drink ($r = 0.487$; $p = 0.001$). The TF scores pre-drink have strong negative correlations with PRT pre-drink ($r = -0.606$; $p = 0.001$) and PRT post drink ($r = -0.628$; $p = 0.001$).

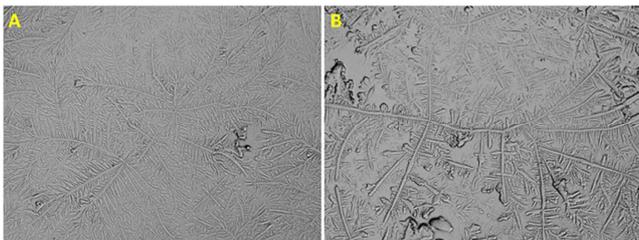


Figure 2. Images of TF obtained from the same subject (A): before and (B): after the consumption of hot ginger tea.

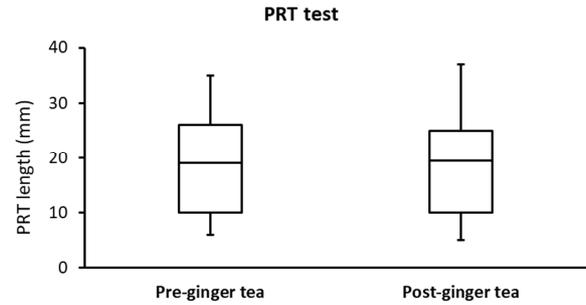


Figure 3. Side-by-side boxplots for the PRT scores pre- and post-ginger tea consumption. No statistically significant difference was found ($p = 0.623$).

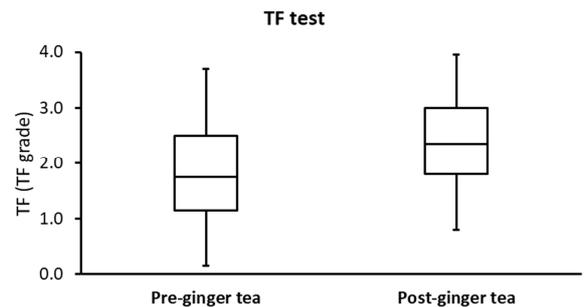


Figure 4. Side-by-side boxplots for the TF grades pre- and post-ginger tea consumption. Statistically significant difference was found at $p < 0.001$.

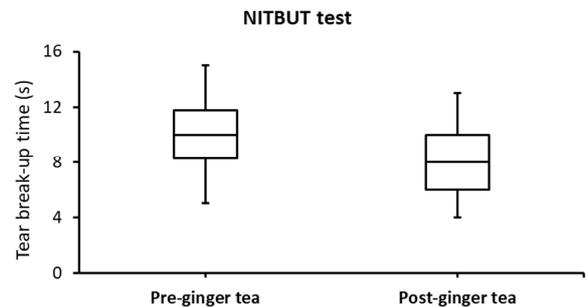


Figure 5. Side-by-side boxplots for the NITBUT scores pre- and post-ginger tea consumption. Statistically significant difference was found at $p < 0.001$.

The subjects ($N = 40$) were divided into two groups, normal ($N = 25$; 28.8 ± 5.1 years) and dry eye ($N = 15$; 23.1 ± 5.6 years), based on the scores from the different tests. The averages for the ages and scores collected from the PRT, TF, and NITBUT tests are recorded in Table 2.

Table 2. The median (IQR) for PRT, TF, and NITBUT scores for normal and dry eye groups.

Parameter	Normal eye (N = 25)	p-Value	Dry eye (N = 15)	p-Value
PRT1 (mm)	24.0 ± 6.5	0.962	9.3 ± 1.8	0.356
PRT2 (mm)	24.0 ± 6.6		8.9 ± 2.5	
TF1*	1.5 (0.8)	< 0.001	2.7 ± 0.5	0.073
TF2*	2.0 (1.0)		3.0 ± 0.8	
NITBUT1 (s)*	11.0 (2.0)	< 0.001	9.0 (1.0)	0.148
NITBUT2 (s)*	7.0 (3.0)		8.0 (3.0)	

* Significant difference (Wilcoxon test; $p < 0.001$). 1 Represents the scores pre-ginger tea consumption and 2 represents the scores post-ginger tea consumption.

For normal eye subjects ($N = 25$), significant differences (Wilcoxon test, $p < 0.001$) were seen between the measurements obtained from the TF and NITBUT tests before and after the consumption of hot ginger tea. For the PRT test, no significant (Wilcoxon test, $p = 0.962$) difference was found between the measurements before and after the consumption of the drink. For dry-eye subjects ($N = 15$), no significant differences (Wilcoxon test, $p > 0.05$) were noticed between the PRT, TF, and NITBUT measurements before and after the consumption of hot ginger tea.

For normal eye subjects, strong correlations (Pearson correlation coefficient, r) were present between the scores obtained from the PRT ($r = 0.955$; $p = 0.001$) and TF ($r = 0.528$; $p = 0.007$) tests before and after the consumption of hot ginger tea. For dry eye subjects, strong correlations were found between the scores obtained from the PRT ($r = 0.685$; $p = 0.005$), TF ($r = 0.649$; $p = 0.009$), and NITBUT ($r = 0.557$; $p = 0.031$) before and after the consumption of the drink. In addition, the TF2 grades have strong negative correlations with the PRT2 ($r = -0.741$; $p = 0.002$) and NITBUT1 ($r = -0.560$; $p = 0.030$) scores.

4. Discussion

Dry-eye disease has a negative effect on the quality of vision and leads to many uncomfortable symptoms [39, 40]. Therefore, early screening for such an illness, in particular, among the elderly and females, helps to improve their quality of life [41]. Symptoms associated with eye dryness have been suggested to be due to neuropathic ocular pain [42], which can be increased by somatosensory dysfunction [42]. For healthy eye subjects, the results obtained from the present study indicate that the mean value of the TF measurements after the consumption of hot ginger tea was significantly higher than that obtained pre-drink. The TF patterns show that 14 subjects (56%) have a dry eye after the consumption of ginger tea, where the TF grade was ≥ 2 . The average of the NITBUT scores was significantly lower after ginger tea consumption in comparison with that obtained before the drink. Such a result suggests that ginger tea may have a negative effect on the stability of tear film in terms of its quality. On the other hand, no significant difference has been seen in the PRT measurements between the subjects before and after the drink.

Ginger is a common dietary ingredient and has many useful applications. It can be easily absorbed by tissues compared to plasma. For example, its rapid absorption within plasma and tissues has been demonstrated in rats that have been given a dose, administered orally, of a ginger extract that contained a high (53%) proportion of polyphenol (gingerol). The highest concentration of gingerol was observed in most of the tissues within 30 minutes [43].

Polyphenols can oxidize lipids and therefore reduce the concentrations of lipids in the serum of rats [44–46]. Polyphenols can also reduce the concentration of iron within tissues via either coordination or interference with some medications that reduce the bioavailability of iron [47, 48]. In

addition, polyphenols within tea can lead to an increase in the level of aluminum [49]. Therefore, some side effects of ginger tea consumption could be expected on the ocular tear film due to disturbances within the lipid layer and on the electrolyte concentrations. Indeed, the consumption of green and peppermint teas, which contain high contents of polyphenols (e.g., catechins), leads to tear film instability [33, 34].

For green tea, the median score from the PRT test after the consumption of the drink was lower [23.2 (8.0) mm] compared to that obtained before the drink [27.0 (8.8) mm] [33]. The differences between PRT measurements before and after the consumption of the drink were significant ($p < 0.05$) [33]. According to these results, green tea clearly leads to a reduction in tear volume. On the other hand, the TF grades have increased significantly ($p < 0.05$) after the drink [2.7 (1.2)] compared to those obtained before the drink [1.5 (0.9)] [33]. Clearly, a decrease in the quality of tears was measured after the drink [33]. A strong correlation ($r = 0.836$; $p = 0$) was found between the PRT measurements before and after green tea consumption [33]. Meanwhile, a medium correlation ($r = 0.435$; $p = 0.005$) was found between the TF grades recorded before and after green tea consumption [34].

The effect of a peppermint drink on the tear film has been investigated using tear meniscus height (TMH), TF, and NITBUT tests [34]. The mean scores obtained from TF and TMH tests were significantly higher (2.1 ± 1.2 and 0.32 ± 0.07 mm, respectively) after the peppermint drink was consumed, compared to those recorded before the drink (0.8 ± 0.7 and 0.27 ± 0.04 mm, respectively) [34]. Meanwhile, the NITBUT mean score after the consumption of peppermint drink was significantly ($p < 0.05$) lower (11.6 ± 3.2 s) compared to the score recorded pre-drink (15.8 ± 3.4 s) [34]. Clearly, the quality of the tear has been reduced to a significant level after the consumption of the drink. Strong correlations are present between the scores collected from the TF ($r = 0.763$; $p = 0$), TMH ($r = 0.850$, $p = 0$), and NITBUT ($r = 0.562$; $p = 0.001$) tests before and after the consumption of peppermint drink [34]. According to these results, polyphenols that are present in ginger, green, and peppermint teas at high levels clearly have negative effects on tear film stability in terms of the quality of tears among normal eye subjects based on the TF test. However, future research should be conducted the test the effect of other drinks containing high content of polyphenols on the tear film parameters on a large population (males and females) and in particular dry eye subjects. In addition, a detailed study is still needed to understand better the mechanism by which polyphenols affect the tear film.

5. Conclusion

The consumption of hot ginger tea has a negative effect on tear film stability. The tear ferning test indicated a significant reduction in the quality of tears after the consumption of hot ginger tea compared with that obtained before the drink. The tear ferning grades were significantly higher after the consumption of hot ginger tea.

Conflicts of Interest

The author does not have any possible conflicts of interest.

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