

# The acute effect of a single dose of green tea on the quality and quantity of tears in normal eye subjects

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**Objective:** The study aimed to investigate the acute effect of a single dose of green tea on the quality and quantity of tears in normal eye subjects.

**Methods:** Forty normal eye subjects (22 men and 18 women) aged 19–39 years were enrolled in the study. Also, an age matching control group (20 males and 20 females) was enrolled for comparison. McMonnies dry eye symptoms questionnaire and slit lamp were used for the exclusion criteria determination. Phenol red thread (PRT) test was performed on both eyes of each subject. A tear sample was collected from the lower tear meniscus of the right eye of each subject for the tear ferning (TF) test, which was performed before (30 minutes) and after (60 minutes) drinking green tea.

**Results:** The median PRT measurement after green tea consumption was lower (median [IQR]=23.50 [8.00] mm) compared to that before consumption (median [IQR]=27.00 [8.75] mm). In contrast, the median TF grade was significantly higher following green tea consumption than that before consumption (median [IQR]=2.65 [1.23] vs 1.50 [0.88] mm, respectively). The results show that TF grades increased in 97.5%, and the red phenol thread scores decreased in 80% of the subjects after green tea consumption compared to those before consumption. The PRT readings and TF grades were significantly different ( $P<0.05$ ) before and after green tea consumption.

**Conclusion:** Drinking green tea could have a significant effect on the eye tear film quality. Tear quality appeared to decrease after green tea consumption.

**Keywords:** dry eye, tear ferning test, green tea, phenol red thread test, tear film, polyphenols

## Introduction

Tea is produced from *Camellia sinensis* and is one of the most highly consumed drinks worldwide, following water. The chemical structure of green tea is complex. It contains polyphenols (30% dry weight), fibers (26%), proteins (15%), carbohydrates (7%), lipids (7%), minerals (5%), amino acids (4%), pigments (2%), and others components.<sup>1,2</sup> Green tea contains numerous types of polyphenols, such as low molecular weight phenols (eg, catechins),<sup>3</sup> which account for approximately 25% of the dry weight of green tea. The most common catechins are epigallocatechin-3-gallate (60%), epigallocatechin (19%), epicatechin-3-gallate (13.5%), and epicatechin (6.5%).<sup>3,4</sup> Catechins have various biological activities,<sup>5,6</sup> such as hypoglycemic,<sup>7</sup> hypotensive,<sup>8</sup> anticancer,<sup>9</sup> antioxidant,<sup>10,11</sup> and antiviral activities.<sup>12</sup> In addition, green tea has beneficial effects against degenerative diseases,<sup>13</sup> oxidative stress,<sup>14</sup> and chronic diseases,<sup>15</sup> and decreases the body fat,<sup>4</sup> lipid profile,<sup>16</sup> and body weight.<sup>17</sup>

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The tear film is very important to the health of the eye as well as vision. It consists of three different layers and serves as the first line of defense against foreign bodies. In addition, it lubricates the eye and keeps the surface clean and smooth.<sup>18</sup> The instability of the tear film function, as well as reduction in tear volume, excessive tear evaporation, or both, can lead to dry eye (DE). There are approximately 30 million patients with DE disease worldwide.<sup>18</sup> Evaporative and aqueous production deficiency are the most common types of DE disease. The causes of DE are variable,<sup>19</sup> and it is more common in the elderly<sup>20</sup> and in women compared to men.<sup>21</sup> Artificial tears can be used to reduce DE symptoms such as redness, burning sensations, and irritation. A combination of various diagnostic tests along with DE questionnaires<sup>22</sup> can be used to detect dryness of the eye and its severity. These tests can measure the quantity or quality of tears. The most widely used techniques include the tear evaporation rate,<sup>23</sup> tear film breakup time,<sup>24</sup> meibomian gland dysfunction,<sup>25</sup> tear osmolarity,<sup>26</sup> tear ferning (TF),<sup>27–30</sup> Schirmer test,<sup>29</sup> phenol red thread (PRT) test,<sup>29</sup> and tear meniscus height.<sup>30</sup> The TF test is simple, quick, and can be used efficiently in eye clinics.<sup>31</sup> Moreover, its validity has been established.<sup>32</sup>

In this study, we report the assessment of the quality and quantity of tears after a single dose of green tea consumption. High polyphenols content in green tea is hypothesized to disturb the tear film stability. To the best of our knowledge, this is the first study to report the effect of green tea on the ocular tear film.

## Methods

Signed informed consent was obtained from each participant before the initiation of the study. The subjects were treated based on the Declaration of Helsinki.<sup>33</sup> Ethical approval (ethics number CAMS-085-3637) was obtained from the College of Applied Medical Sciences Ethics Committee, King Saud University. Measurements were carried out by the same examiner under normal conditions. A slit-lamp was used to examine abnormalities of the eyelids, eyelashes, conjunctiva, cornea, and iris. McMonnies DE symptoms questionnaire was completed by all participants, and the scores were recorded. DE was diagnosed based on a score  $>14.5$ .<sup>23,34</sup>

Forty normal eye subjects (22 males and 18 female subjects) aged 19–39 years ( $25.98 \pm 6.05$  years) were enrolled in the study. An age matching control group, consisting of 40 subjects (20 males and 20 females) aged between 20 and 38 years ( $23.7 \pm 2.95$  years), was enrolled to test the effect of hot water (150 mL) on the tear film. The green tea and

hot water (approximately 70°C) were consumed within approximately 5 minutes. All subjects were healthy, had no ocular diseases, did not wear contact lenses, and were non-pregnant or breast-feeding. The exclusion criteria include subjects who recently had eye lubricants, ocular surgery, or medications. McMonnies DE symptoms questionnaire and slit lamp were also used for the exclusion criteria determination. The PRT test was performed for both eyes of each subject 30 minutes before a Lipton green tea consumption (2.0 G in 150 mL of hot water). The hot green tea drink was provided in sealed cups to eliminate the effect of the green tea steam. A tear sample was collected from the right eye of each subject for the TF test. The PRT and TF tests were repeated 1 hour after green tea consumption. All tests were performed in the same room, which was equipped with a central air conditioner at room temperature (23°C) in which humidity was less than 40%.<sup>35</sup>

The PRT test was performed first, followed by the collection of a tear sample for the TF test, and a 10-minute break was allowed between the tests.<sup>29</sup> The PRT test was performed using a standard procedure<sup>29</sup> using PRT strips (Zone-Quick, Showa Yakuhin Kako Co, Ltd., Tokyo, Japan). DE was confirmed if the length of the red portion of the PRT third was  $<10$  mm. A glass capillary tube (10  $\mu$ L, Sigma-Aldrich Chemical Company, Gillingham, UK) was used to collect a tear sample (1  $\mu$ L) from the lower meniscus of the right eye of each subject. Proper extraction of the tear sample was performed in order to prevent tear reflex. The tear sample was dried under normal conditions (23°C temperature and  $<40\%$  humidity).<sup>35</sup> A digital microscope (Olympus DP72, Tokyo, Japan) at a magnification of 10 $\times$  was used to observe the TF patterns. The ferns were graded according to the five-point TF grading scale<sup>31</sup> using 0.1 increments.

The data were collected using the Microsoft Excel program (Microsoft Office 2010, Microsoft Corp., Redmond, WA, USA). The statistical package for the social sciences (SPSS) software (version 22, IBM Corp., Armonk, NY, USA) was used to analyze the data. The data were not normally distributed (Kolmogorov-Smirnov test,  $P < 0.05$ ) for the McMonnies scores, PRT measurements, and TF grades and the median (IQR) was used to describe the results. Correlation coefficients were described as small (0.10–0.29), medium (0.30–0.49), and strong (0.50–1.00).<sup>36</sup> The PRT test was performed for both eyes, and there were no significant differences in measurements (using the paired sample *t*-test,  $P > 0.05$ ) between the two eyes. The data of both eyes were highly correlated and, therefore, the measurements from the right eye were used.<sup>37</sup>

## Results

Twenty-two male and 18 age-matched female subjects were enrolled in the study. Their ages varied from 19 to 39 years (mean $\pm$ SD=25.98 $\pm$ 6.05 years). An age-matched controlled group (40 subjects; 20 males and 20 females), with a mean of 23.50 $\pm$ 3.70 years, was enrolled to study the effect of hot water. The median (IQR) values for McMonnies questionnaire scores, PRT measurements, and TF grades for both the study and the control groups are shown in Table 1. For the control group, there were no significant differences between the median scores for the same tests before and after the hot water consumption. The median value of the PRT measurements taken before green tea consumption was higher (median [IQR]=27.00 [8.75] mm) than that obtained after consumption (median [IQR]=23.50 [8.00] mm). In contrast, the median value of the TF grades was significantly higher after green tea consumption (median [IQR]=2.65 [1.23]) than it was before the consumption (median [IQR]=1.50 [0.88] mm).

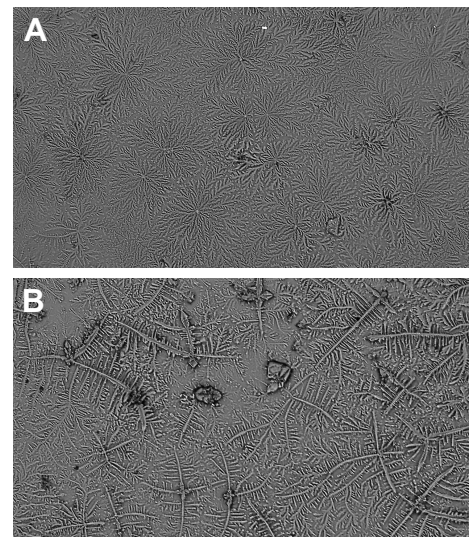
The results showed that the PRT measurements were unchanged in 15% of the subjects (N=6), increased in 5% (N=2), and decreased in 80% (N=32) after the subjects had consumed green tea compared to results before green tea consumption. The TF grades increased in 97.5% of the subjects (N=39) after green tea consumption. In addition, the TF grades clearly showed that the TF patterns were unhealthy in 67.5% of the subjects (N=27) after green tea consumption. Samples of the TF images obtained from the same subject before and after green tea consumption are shown in Figure 1. There were significant differences (Wilcoxon test,  $P<0.05$ ) between the PRT readings and TF grades before and after green tea consumption. The side-by-side box plots of the PRT readings and TF grades before and after green tea consumption are shown in Figures 2 and 3, respectively.

**Table 1** The median (IQR) for McMonnies questionnaire scores, PRT measurements, and TF grades

Test	Median (IQR)	
	Study group (N=40)	Control group (N=40)
McMonnies scores	4.00 (4.75)	3.05 (1.65)
PRT1 (mm)*	27.00 (8.75)	29.00 (9.15)
PRT2 (mm)*	23.50 (8.00)	28.00 (8.75)
TF1 grades*	1.50 (0.88)	0.78 (0.65)
TF2 grades*	2.65 (1.23)	0.82 (0.70)

**Note:** \* $P<0.05$ .

**Abbreviations:** PRT1, the median for phenol red thread measurements before the consumption of green tea; PRT2, the median for the phenol red thread measurements after the consumption of green tea; TF, tear ferning; TF1, the median for TF grades before the consumption of green tea; TF2, the median for the TF grades after the consumption of green tea.



**Figure 1** Images of TF obtained before and after green tea consumption for the same subject.

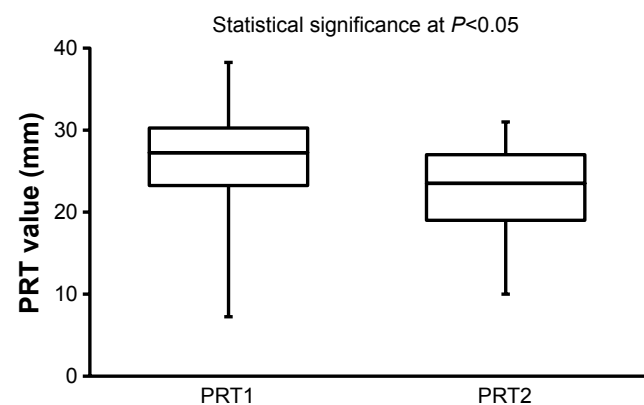
**Notes:** (A) before green tea consumption; (B) after green tea consumption.

**Abbreviation:** TF, tear ferning.

The correlation between age, sex, McMonnies questionnaire scores, PRT readings, and TF grades is shown in Table 2. There was a strong correlation ( $r=0.836$ ) between the PRT measurements, and a medium correlation ( $r=0.435$ ) between the TF grades before and after green tea was consumed. There was a medium correlation ( $r=0.497$ ) between age and McMonnies scores and slight negative correlations ( $r=-0.214$  to  $-0.167$ ) between age and the PRT measurements.

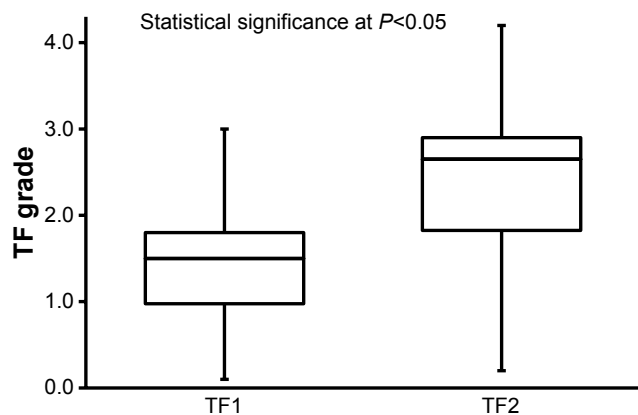
## Discussion

DE results from the dysfunction of the tear film, and symptoms range from discomfort to corneal damage depending on the severity of the dryness. Factors that cause tear deficiency



**Figure 2** Side-by-side boxplot for PRT1 and PRT2 scores.

**Abbreviations:** PRT1, the median for phenol red thread measurements before the consumption of green tea; PRT2, the median for the phenol red thread measurements after the consumption of green tea.



**Figure 3** Side-by-side boxplot for TF1 and TF2 grades.  
**Abbreviations:** TF1, the median for tear ferning grades before the consumption of green tea; TF2, the median for the tear ferning grades after the consumption of green tea.

could contribute to the dryness of the eye. Discomfort, redness, and inflammation could be controlled in most cases by the use of artificial tears. The current study showed that the median value for the PRT measurements after green tea consumption was lower than that before the tea consumption, but the PRT measurements were normal. The median value of the TF grades was significantly higher after green tea consumption than it was before consumption. The TF grades increased significantly in most of the subjects (97.5%) after

green tea consumption. In addition, unhealthy TF patterns were observed in 67.5% of the subjects with TF grades  $\geq 2$ . This result suggests that green tea could have a negative effect on the tear film quality.

Green tea has various health benefits,<sup>2</sup> including those shown by experiments such as activity against breast cancer<sup>38</sup> and fungi.<sup>39</sup> In addition, it acts as an antioxidant in animals<sup>40</sup> and reduces the body weight in humans.<sup>4,41</sup> However, high consumption of green tea can be cytotoxic to liver cells<sup>42</sup> and damage the pancreatic DNA in animals.<sup>43</sup> Polyphenols, which are the major components of green tea, have been reported to reduce serum lipids in rats<sup>44,45</sup> and contribute to the formation of oxidized lipids.<sup>4</sup> Tea leaves can accumulate aluminum at a high percentage.<sup>46</sup> Polyphenols have an affinity for iron and can significantly reduce its content.<sup>47</sup> Moreover, polyphenols could interfere with some medications that lead to the reduction in bioavailability of iron and enhance systemic toxicity risk.<sup>48</sup> Therefore, the harmful effects of green tea on the ocular tear film could be due to the high contents of polyphenols that damage the lipid layer through oxidation. In addition, polyphenols could reduce the concentration of electrolytes (eg, iron) through coordination bonds, and lead to an increased level of aluminum due to accumulation.<sup>2</sup> Caffeine could also have a similar effect,

**Table 2** The correlation between age, sex, McMonnies questionnaire scores, PRT, and TF grades (N=40)

Test/correlation	Age	Sex	McMonnies	PRT1	PRT2	TF1	TF2
Age							
PC	1	0.466 <sup>a</sup>	0.497 <sup>a</sup>	-0.214	-0.167	0.199	0.074
Sig.	-	0.002	0.001	0.184	0.303	0.219	0.649
Sex							
PC	0.466 <sup>a</sup>	1	0.136	-0.159	-0.140	0.020	0.297
Sig.	0.002	-	0.403	0.326	0.390	0.904	0.063
McMonnies							
PC	0.497 <sup>a</sup>	0.136	1	-0.046	0.132	0.144	-0.022
Sig.	0.001	0.403	-	0.778	0.417	0.375	0.891
PRT1							
PC	-0.214	-0.159	-0.046	1	0.836 <sup>a</sup>	-0.045	0.020
Sig.	0.184	0.326	0.778	-	0.000	0.782	0.902
PRT2							
PC	-0.167	-0.140	0.132	0.836 <sup>a</sup>	1	-0.069	0.016
Sig.	0.303	0.390	0.417	0.000	-	0.671	0.922
TF1							
PC	0.199	0.020	0.144	-0.045	-0.069	1	0.435 <sup>a</sup>
Sig.	0.219	0.904	0.375	0.782	0.671	-	0.005
TF2							
PC	0.074	0.297	-0.022	0.020	0.016	0.435 <sup>a</sup>	1
Sig.	0.649	0.063	0.891	0.902	0.922	0.005	-

**Note:** <sup>a</sup>Correlation is significant at 0.01 level (2-tailed).

**Abbreviations:** PC, Pearson correlation coefficient; PRT1, the median for phenol red thread measurements before the consumption of green tea; PRT2, the median for the phenol red thread measurements after the consumption of green tea; Sig., significance (2-tailed); TF, tear ferning; TF1, the median for TF grades before the consumption of green tea; TF2, the median for the TF grades after the consumption of green tea.



but not as significant as for polyphenols. The disruption in the proportions of lipids or electrolytes (eg, aluminum and iron) or both could contribute to the negative effects of green tea on the tear film.

The results of the current study suggest that green tea could negatively affect the tear film tear quality. However, detailed studies are still needed to establish a direct link between the quality and quantity of tears and green tea. Such studies should consider the limitations associated with the current study, such as a small sample size and the use of other tests to evaluate the tear film.

## Conclusion

Green tea has a significant effect on the tear film quality of the eye. Tear quality appeared to decrease after green tea consumption, possibly due to the disruption in lipids or electrolyte content or both. However, various studies have shown the beneficial effects of green tea, such as a reduction of blood sugar and pressure.

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## Disclosure

The authors report no conflicts of interest in this work.

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