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Research Article

Consumption of Hibiscus Reduces the Quality of Ocular Tear Film in Normal Eye Subjects

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Abstract

Aim: To investigate the effect of the consumption of a hot hibiscus drink on the ocular tear film in subjects with normal eyes.

Method: A group of 45 normal eye subjects (12 male and 33 female) with an age range from 21 to 40 years (28.5 ± 5.3 years) were included in the study. The non-invasive tear break-up time (NITBUT), phenol red thread (PRT), and tear ferning (TF) tests were performed in the right eye of each subject 30 minutes before consumption of the drink and repeated 60 minutes after consumption of the hot hibiscus drink.

Results: The median NITBUT and PRT scores were significantly lower after consumption of hibiscus [7.5 (4.2) s and 25.0 (10.0) mm, respectively] as compared to those before consumption of the drink [10.0 (7.0) s and 30.0 (10.00) mm, respectively]. The average TF grade was significantly higher after hibiscus consumption than before consumption (0.6 ± 0.4 versus 1.3 (0.8), respectively). These findings suggest that the majority of subjects developed dry eye after the consumption of hibiscus. A strong correlation (r = 0.521; P = 0.001) was found between the scores obtained from the NITBUT test before and after consumption of the hibiscus drink. Medium correlations were found between the scores recorded from the PRT (r = 0.406; P = 0.006) and TF (r = 0.353; P = 0.017) tests before and after consumption of the hibiscus drink.

Conclusion: The consumption of hot hibiscus exerts a negative effect on the ocular tear film, resulting in reduced quality of and total aqueous content within the eye. It is possible that the high levels of polyphenols present in hibiscus disrupt both the lipids and electrolyte contents within the tear film. Similar observations have been made after the consumption of hot green and peppermint teas.

Keywords: *Hibiscus Drink; Lipid Layer; Tear Ferning Test; Dry Eye Diagnostic Tests; Polyphenols*

Introduction

The *Hibiscus sabdariffa* plant is grown in many countries and belongs to the Malvaceae family. *Hibiscus sabdariffa* flowers have many health benefits [1] and is used as a traditional medicine, as a drink in hot or cold beverages, and a flavoring agent in ice cream, jam, cakes, and puddings [2-4]. The hibiscus flowers are rich in carbohydrates, fibers, ash, and proteins [5]. *Hibiscus sabdariffa* is an antioxidant and has been shown to protect against the development of cancer and cardiovascular disease due to its high levels of polyphenols [6-8], which have been shown to reduce the metabolic accumulation of triglycerides [9], prevent hepatic steatosis in hyperlipidemic mice [10], lower blood pressure [11], and reduce oxidative stress [12]. In addition, hibiscus also has antimicrobial, anti-inflammatory, antihyperlipidemic, and antihypertensive activities [3]. However, a low degree of toxicity has been associated with *Hibiscus sabdariffa*, and it is recommended

that a safe dose should not exceed 180 mg/kg in a single day [13]. The most common phenols in *Hibiscus sabdariffa* are protocatechuic acid, caffeic acid, catechins, and epigallocatechin gallate (Figure 1) [6]. In addition, *hibiscus sabdariffa* contains polyphenolic flavonoids, such as (−)-epicatechin gallate (Figure 1), ellagic acid, quercetin, and ferulic acid [14]. Reports suggest that polyphenols in other substances, such as green and peppermint teas, have negative effects on the ocular tear film among patients with normal eyes [15,16].

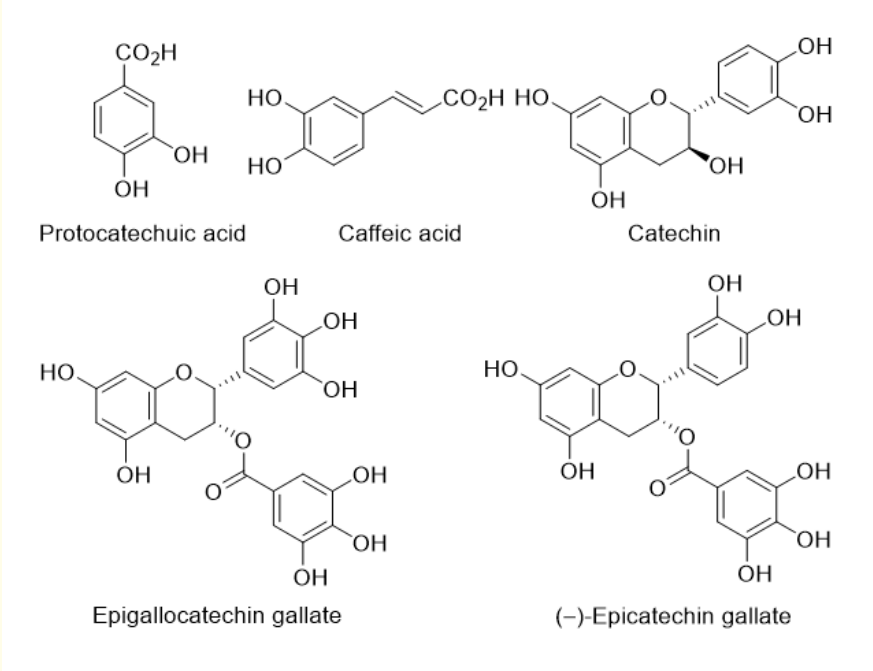

Figure 1: *Common polyphenols in Hibiscus sabdariffa.*

Dry eye is a common disorder that affects many individuals worldwide [17]. Dry eye symptoms vary from discomfort to fluctuating vision, pain, and vision-related problems [17]. Dry eye has a negative effect on the quality of life, and can affect ability to read, use computers or other digital screens, drive, and perform recreational tasks [18]. The indirect costs and reduced productivity that are associated with dry eye amount to more than $55 billion in the USA alone [19]. The tear film mainly comprised of mucin, lipids, and aqueous contents [17]. The conjunctival goblet cells are responsible for the production of mucin, while the lacrimal and meibomian glands are responsible for the secretion of the aqueous and lipid contents of the tear film, respectively [17]. Meibomian gland dysfunction alters lipid content, leading to excessive evaporation of tears [17]. The loss of tear film homeostasis leads to hyperosmolarity, instability, damage, and inflammation on the ocular surface [20].

Dry eye diagnosis is complex, as there is not always a consistent correlation between the signs observed and the symptoms reported [21]. Dry eye can be assessed using different diagnostic tests, including questionnaires, which can detect dry eye symptoms and their impact on quality of life, the Schirmer test, which assesses tear volume, the tear break-up test, which tests the tear film stability, and the osmolarity test, which measures the salinity content within the tear [22, 23]. In the present study, we report the effect of consumption of

a hibiscus drink on the ocular tear film using non-invasive tear break-up time (NITBUT), phenol red thread (PRT), and tear ferning (TF) tests. This is the first report, to our knowledge, that investigates the effects of hibiscus drink consumption on tear film.

Materials and Methods

Subjects

Forty-five normal subjects (12 male and 33 female), ranging in age from 21 to 40 years (28.5 ± 5.3 years) of age were enrolled in the study. The subjects were healthy, with no ocular diseases, did not wear contact lenses, and did not recently consume medications. The exclusion criteria included subjects who recently had eye lubricants, eye surgery, those with eye abnormalities or low blood pressure. The PRT and NITBUT tests were performed before the collection of the tear sample for the TF test to avoid disturbance of the tear film. The NITBUT test was performed first, followed by the PRT and TF tests. A resting period of 5 minutes was taken between each test [24]. Ethical approval was obtained from the IRB Committee. All human research procedures followed were in accordance with the Helsinki Declaration.

Hibiscus

Organic hibiscus was obtained from the Traditional Medicinal (Sebastopol, USA). A hibiscus bag (1.75g) in hot water (65°C; 150 mL) in a sealed cup, to avoid the effect of vapor, was consumed by each subject within 5 minutes in a controlled environment. The tests were performed in the right eye for each subject 30 minutes before and 60 minutes after the consumption of the drink.

NITBUT test

The tear film stability was been detected by measuring the tear break-up time, as described previously [25]. The NITBUT test was performed using EASYTEARview+ (EASYTEAR S.R.L., Via Maioliche, Trento, Italy). The corneal reflection was established using white illumination to confirm regular mires and a grid on the ocular surface. In this test, each subject blinked once and the time between the blink and the appearance of mires and grid distortion was calculated. The test was performed three times and the average score was calculated for each subject. Dry eye was considered a NITBUT score less than 10 seconds [26].

PRT test

The aqueous content within the eye was measured using the PRT test, as described previously [27]. The PRT test involves use of Zone-Quick PRT strips (Showa Yakuhin Kako Co, Ltd., Tokyo, Japan). A 3-millimeter (mm) length of the cotton thread was folded and inserted one-third of the distance from the temporal canthus of the lower eyelid, with the eye in the primary position. After 15 seconds, the thread was removed and the wet red colored portion was measured in mm. Dry eye was considered having a length less than 10 mm [24].

TF test

A small tear sample (1 µL) was collected from the lower meniscus of the right eye in each subject using a glass capillary tube (10 µL, Merck, Gillingham, UK). The tear sample was dried under normal conditions (23°C and humidity < 40%) on a glass slide. An Olympus DP72 digital microscope (Tokyo, Japan) at a magnification level of 20X was used to observe and capture the TF image. The ferns were graded according to the five-point TF grading scale using 0.1 increments [28]. Dry eye was considered a TF grade ≥ 2 [28].

Statistical analysis

Microsoft Excel 2010 (Microsoft Office, Microsoft Corp., Redmond, WA, USA) was used to record the data. The data were analyzed using the Statistical Package for the Social Sciences software (IBM Software, version 22, Armonk, NY, USA). A correlation coefficient, either

strong (0.50 - 1.00) or medium (0.30 - 0.49), was used to describe the correlation between parameters [29]. The data collected from the TF before the consumption of hibiscus and those from the PRT and NITBUT tests before and after consumption of the drink did not have normal distribution (Kolmogorov-Smirnov test; $P < 0.05$) and the median (interquartile range, IQR) was used to represent the averages. The TF grades after the consumption of the hibiscus drink were normally distributed (Kolmogorov-Smirnov test; $P = 0.084$) and mean ± standard deviation (SD) was used.

Results

The averages [mean ± SD or median (IQR)] for the scores obtained from the PRT, TF, and NITBUT tests, before and after the consumption of the hibiscus drink, are shown in table 1.

Test*	Average	P-Value
PRT1 (mm)	30.0 (10.0)	0.001
PRT2 (mm)	25.0 (10.0)	
TF1	1.3 (0.8)	< 0.001
TF2	1.6 ± 0.4	
NITBUT1 (s)	10.0 (7.0)	< 0.001
NITBUT2 (s)	7.5 (4.2)	

Table 1: *The average [mean ± SD or median (IQR)] PRT, TF, and NITBUT scores (N = 45) before and after the consumption of hibiscus. *Significant difference (Wilcoxon test; P ≤ 0.001). PRT1 and PRT2 are the median score from the phenol red thread measurements before and after the consumption of the hot hibiscus drink, respectively; TF1 and TF2 are the average grade from the tear ferning test before and after the consumption of the hot hibiscus drink, respectively; NITBUT1 and NITBUT2 are the median scores from the non-invasive tear break-up time test before and after the consumption of the hot hibiscus drink, respectively.*

The average scores collected from the PRT and NITBUT tests were significantly (Wilcoxon test; $P \leq 0.001$) lower after the consumption of hibiscus as compared to those obtained before the drink. For the TF test, the average grade after the consumption of the drink was significantly (Wilcoxon test; $P < 0.001$) higher as compared to median obtained before the consumption of hot hibiscus. Representative TF images obtained pre and post consumption of the hot hibiscus drink from two subjects are shown in figure 2.

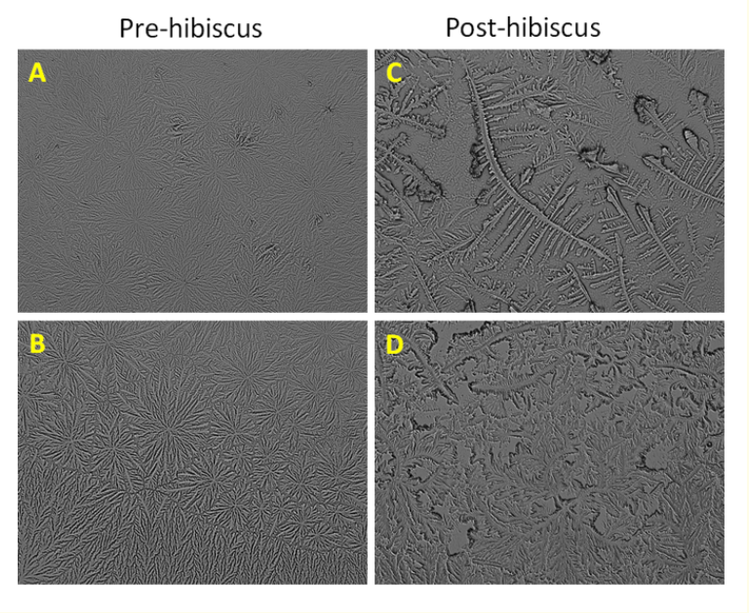

Figure 2: *Representative TF images obtained pre (A and B) and after the consumption (C and D) of the hot hibiscus drink from two subjects.*

The NITBUT score was decreased in 34 subjects (75.6%), remained unchanged in six subjects (13.3%), and increased in six subjects (13.3%) after consumption of the drink. The PRT test score decreased in 24 subjects (53.3%), remained unchanged in 13 subjects (28.9%), and increased in eight subjects (17.8%) after the consumption of hibiscus. The TF grades increased in the majority of subjects (N = 36; 80%), remained unchanged in two subjects (4.4%), and decreased in seven subjects (15.6%) after the consumption of the drink. The side-by-side box plots for the scores obtained from the PRT, TF, and NITBUT tests are represented in figure 3-5, respectively.

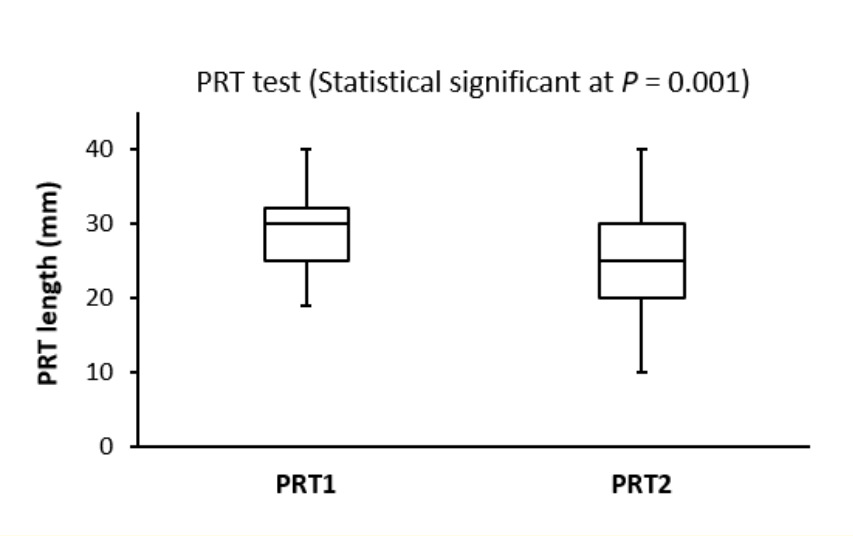

Figure 3: *Side-by-side boxplots of the PRT1 and PRT2 scores.*

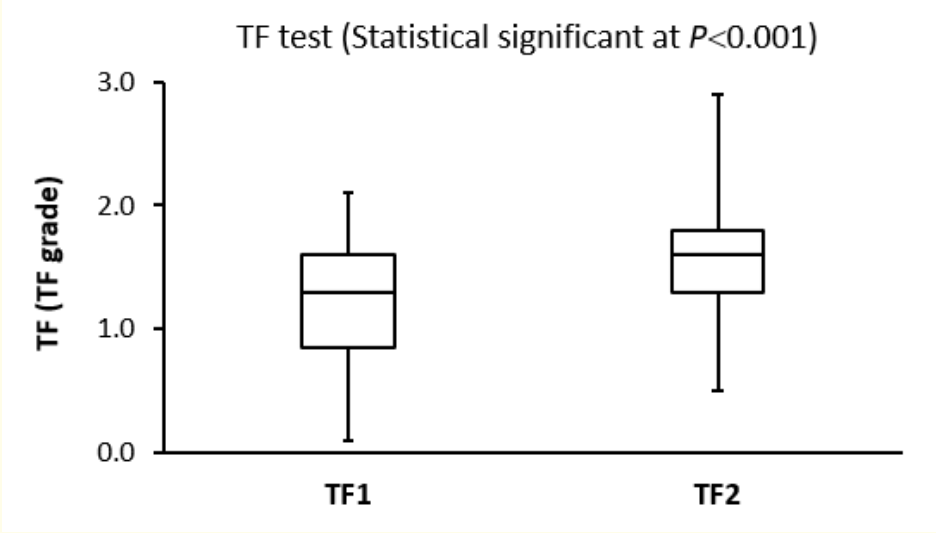

Figure 4: *Side-by-side boxplots of the TF1 and TF2 scores.*

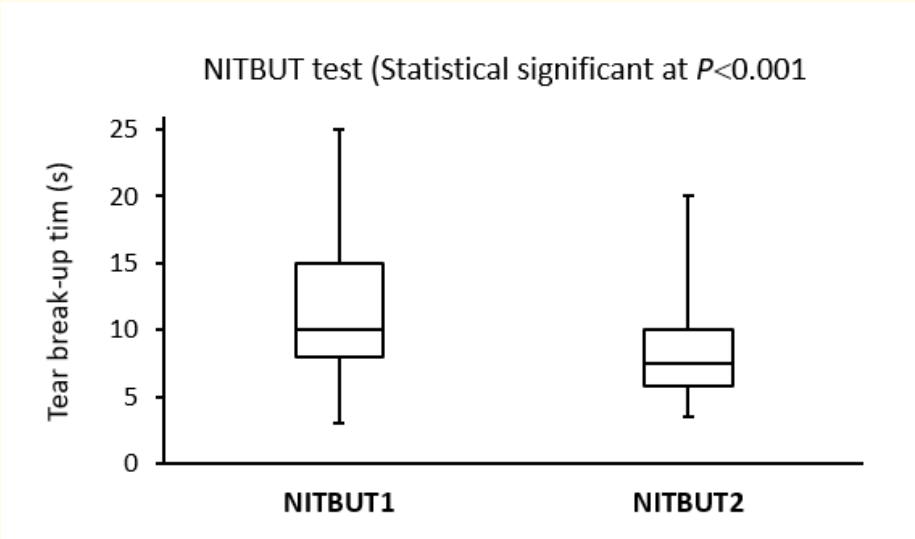

Figure 5: *Side-by-side boxplot of the NITBUT1 and NITBUT2 scores.*

The correlations among the scores obtained from the different tests are recorded in table 2. For example, a strong correlation (Pearson correlation coefficient, r) was found between the scores obtained from the NITBUT1 and NITBUT2 (r = 0.521; P = 0.001) tests. Medium correlations was observed between the scores obtained from the PRT1 and PRT2 (r = 0.406; P = 0.006) tests and between the scores from the TF1 and TF2 (r = 0.353; P = 0.017) tests.

Test/Correlation	PRT1	PRT2	TF1	TF2	NITBUT1	NITBUT2
PRT1						
PC	1	0.406	0.015	0.060	0.206	0.133
Sig.	—	0.006	0.998	0.697	0.175	0.383
PRT2						
PC	0.406	1	0.037	0.033	0.196	0.237
Sig.	0.006	—	0.809	0.827	0.198	0.118
TF1						
PC	0.015	0.037	1	0.353	0.142	0.155
Sig.	0.998	0.809	—	0.017	0.352	0.311
TF2						
PC	0.060	0.033	0.353	1	−0.086	−0.013
Sig.	0.697	0.827	0.017	—	0.574	0.933
NITBU1						
PC	0.206	0.196	0.142	−0.086	1	0.521
Sig.	0.175	0.198	0.352	0.574	—	0.001
NITBUT2						
PC	0.133	0.237	0.155	−0.013	0.521	1
Sig.	0.383	0.118	0.311	0.933	0.001	—

Table 2: *The correlation between the PRT, TF, and NITBUT scores (N = 45) before and after the consumption of the hibiscus drink.*

The TF test was used to assess the changes in ferning patterns in six subjects for up to 3 hours after the consumption of hibiscus. The results indicate that at least 3 hours are needed for the TF patterns to return to baseline.

Discussion

Dry eye is a multifactorial ocular surface disease characterized by the loss of tear film homeostasis and accompanied by undesirable ocular symptoms [30]. Environmental factors, such as dry air, smoke, allergens, systemic diseases, and age, are associated with dry eye. In addition, dry eye is common among diabetics [31], smokers [32], subjects with deficiency in vitamins A and D [33,34], those with thyroid gland disorder [35], those with elevated blood cholesterol levels [36], and those with a high body mass index [37]. Dry eye leads to tear film instability, hyperosmolarity, inflammation, ocular surface damage, and neurosensorial alterations [38,39].

The current study suggests an association between the consumption of hibiscus drink and dry eye. The findings suggest that hibiscus has a negative effect on the tear film in quality and quantity of the aqueous content within the eye. The scores recorded from the PRT, NITBUT, and TF tests after the consumption of hot hibiscus indicated that the majority of subjects developed dry eye (53.3 - 80.0%).

Similar observations were previously made after the consumption of green and peppermint teas [15,16]. A study conducted among 40 normal eye subjects (26.0 ± 6.1 year) indicated that there was decreased tear quality and quantity after green tea consumption [15]. The median for the measurements obtained from the PRT test after green tea consumption was significantly lower [23.5 [8.0] mm] than that before the consumption of the drink [27.0 (8.8) mm]. While the median score for the TF grades was significantly higher after green tea consumption [2.7 (1.2)] as compared with that before consumption of the drink [1.5 (0.9)] [15]. Another study conducted on 30 healthy subjects (23.2 ± 2.2 year) suggested that peppermint drink consumption leads to a significant increase in the average TF grades (2.1 ± 1.2) as compared to prior to consumption (0.8 ± 0.7). In addition, the average NITBUT score after hot peppermint consumption was significantly lower (11.6 ± 3.2s) as compared to that obtained before consumption (15.8 ± 3.4) [16]. Both green and peppermints teas contain high levels of polyphenols [15, 16]. Studies suggest that polyphenols can oxidize lipids, and therefore, reduce serum lipid levels [40-42]. Green and black teas, which are rich in polyphenols, reduce iron bioavailability and the levels of iron in the liver [43]. We hypothesize that the polyphenols in hibiscus disturb the ocular tear film, particularly the lipid layer, through oxidation. In addition, polyphenols may lead to a disturbance in the concentration of various electrolytes, including iron, within the aqueous media of tears. However, the exact molecular mechanisms through which consumption of hibiscus leads to dry eye must be further examined.

Conclusion

The consumption of hot hibiscus has a negative effect on the quality and the aqueous content of the ocular tear film within the eye. The high levels of polyphenols in hibiscus may disrupt both the lipid and electrolyte contents within the tear film, as similar observations have been made after the consumption of hot green and peppermint teas, which also contain high levels of polyphenols.

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Disclosure

The authors report no conflicts of interest in this work.

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