Relationship Between Coffee Drinking and Reduction of Mental Stress in Young Women

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The relationship between ingestion of coffee and reduction of mental stress was investigated in 256 young Japanese women. Among the 68% of subjects whose questionnaire responses indicated that they liked coffee, 68% indicated they feel relaxed when they drink coffee. In an organoleptic test, coffee extracted at 80°C exhibited a greater relaxation effect than coffee extracted at 65 or 95°C. This effect showed a significant negative relationship to sourness, suggesting that the relative lack of sourness enhances feelings of relaxation. Coffee drinking also decreased experimentally-induced mental stress evaluated by chromogranin A concentrations.

Keywords: coffee, relaxation, mental stress, questionnaire, young women

Introduction
Coffee is among the most common luxury beverages for Japanese consumers. The unique flavors of coffee are strongly affected by the variety (species cultivated), place of cultivation, and roasting conditions, as well as by the methods used to grind, store, and extract the roasted beans (Nakabayashi et al., 1995; Czerny et al., 1999).

The smell of coffee has been demonstrated to activate brain function. Coffee consumption has been found to promote control of emotion, relaxation, and mental focus (Koga, 1990). However, the mechanisms underlying these effects have not been clarified.

We previously reported the effects of coffee and its major components (caffeine and chlorogenic acid) on stress responses in rats subjected to restraint stress (Fredholm, 1995) involving immobilization in a 9×7×15 cm clear plastic box for 100 min (Yamato et al., 2002a; Yamato et al., 2002b). A stress-induced increase in cerebral neurotransmitter concentrations was inhibited by administration of coffee to rats, suggesting that coffee reduces stress.

In the present study, we investigated whether coffee exhibits a similar relaxation effect in humans. We administered a questionnaire to young women about preference for coffee and associated feelings of relaxation. An organoleptic test also was performed. Finally, the effects of coffee were investigated after the subjects were placed under mental stress.

Methods
Subjects and Questionnaire Subjects who participated

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in the study were 256 female college students 19.5±0.9 years old, who anonymously completed questionnaires after receiving a thorough explanation of the study objectives and procedures. Questionnaire items assessed their like or dislike of coffee; preferred type of coffee (“regular” coffee freshly prepared by extraction of roasted, ground coffee beans vs. instant coffee or canned coffee); daily volume of intake; and how subjects felt while drinking coffee (degree of relaxation). The survey was conducted in early June 2004. Responses were collected immediately after completion (100% recovery).

Organoleptic Test An organoleptic test was conducted on 20 female students who drink one or more cups of regular, instant, or canned coffee daily. The beans used were Coffea arabica, medium roast Columbia Excelso, ground to a particle size of 3.5 (medium size) using a coffee mill (HighCut Mill H, Kalita, Tokyo, Japan) to achieve a medium grind. A commercially available paper filter (number 102, Kalita, Tokyo, Japan) was positioned in a Kalita dripper (102D, Kalita, Tokyo, Japan), and 36 g of medium grind coffee was added. Coffee was extracted at three temperatures: 95°C, 80°C, and 65°C. The hot water was prepared for three subjects at a time (420 mL) at each extraction temperature. The ground coffee was steamed for 30 s with a minimum volume of hot water to moisten the ground coffee, followed by careful pouring of the hot water. The extract was gently poured into cups after an extraction time of 2 min 40 s. A single trained server carried out the above extraction procedure in order to standardize preparation.

For the drinking phase of the organoleptic test, temperatures of the three coffee extracts were all adjusted to 60°C using a thermostat (NB-10F, Annaka, Tokyo, Japan). Room temperature and relative humidity during the test
were 26.1 ± 0.5°C and 51.0 ± 7.7%, respectively. Each subject evaluated six items (aroma, bitterness, sourness, aftertaste, composite impression of satisfaction based on these qualities, and degree of relaxation) using a five-step preference scale with "like it fairly well" and "fairly strong" scored as 5 and "dislike it pretty strongly" and "quite weak" scored as 1. For the degree of relaxation, "very relaxed" and "very slightly relaxed" were rated 5 and 1, respectively. Scores were subjected to a one-way analysis of variance (ANOVA) and Tukey’s multiple comparison test using SPSS statistical software (SPSS 13.0J for Windows, SPSS, Tokyo, Japan). A p value less than 0.05 was regarded as indicating significance.

**Effect of Coffee on Mental Stress** Subjects were 13 female students who drink and like coffee. The stress testing was performed between May and July 2004 between 10 AM and 3 PM. Measurements were performed in a quiet room (temperature, 25.1 ± 1.2°C; relative humidity, 55.2 ± 5.5%) with limited numbers of individuals entering and leaving the room. To ensure consistent saliva sampling conditions, subjects were prohibited from eating or drinking for 2 hr before initiation of the experiment. To induce mental stress, subjects performed the New Stroop Test II (Toyo Physical, Fukuoka, Japan) for 4 min, followed by the Uchida-Kraepelin test (Nisseiken, Tokyo, Japan) for 30 min. Saliva was sampled before and after the stressor, and again after subjects drank hot water or coffee extract. The effect of coffee on the degree of mental stress was evaluated by comparing hot water- vs. coffee extract-induced changes in salivary chromogranin A.

Salivary chromogranin A concentrations were measured using a YKO70 human chromogranin A enzyme immunoassay (EIA) kit (Yanaihara, Shizuoka, Japan). For saliva sampling, a cotton ball was removed from a saliva sampling tube (Salivette, Sarstedt, Germany). The subject chewed the cotton ball for 1 min. The cotton ball then was centrifuged (3000 rpm, 10 min) using a multi-basket desktop centrifuge (KS-5000P, Kubota, Tokyo, Japan). Specific times when saliva was collected were 30 min before the experiment (resting state), immediately after completion of the New Stroop Test II and the Uchida-Kraepelin test, and finally at 60 min after the subject drank 100 mL of the hot water control (distilled water at 60°C) or coffee at 60°C that had been extracted at 80°C for 3 min. Subjects drank one of these immediately after the second (post-stressor) saliva sampling.

In evaluating the degree of mental stress, the chromogranin A concentration 30 min before the experiment was regarded as indicating mental stress grade 1 in each subject. The degrees of stress immediately after completion of the stressful task and 60 min after drinking the test beverage are presented relative to the grade 1 value. Results of measurements are presented as means ± SEM. Comparisons used Student’s t test. A p value less than 0.05 was regarded as indicating significance.

**Results**

**Questionnaire** Figure 1 shows the results of the coffee preference survey completed by 256 female students. To the question concerning like or dislike of coffee, these respective answers were given by 68.0% and 32.0% of subjects (Fig. 1A). As for what type of coffee subjects drink, approximately half (50.4%) drink instant coffee, followed by regular extracted coffee (23.8%), and canned coffee (15.2%; Fig. 1B), respectively. Subjects who did not drink coffee accounted for 10.6% of the students. As for the number of cups consumed daily, 68.2% of subjects drink one cup, and 24.8% drink two cups. Subjects who drink 1 or 2 cups accounted for 93.0% of coffee drinkers, indicating that female students who like coffee typically drink 1 or 2 cups daily (Fig. 2). Figure 3 presents findings about relaxation and coffee. Students who felt relaxed accounted for 68.0% of all subjects (Fig. 3A), while approximately 64% of those feeling relaxed described their relaxation as ‘very relaxed’ or ‘fairly relaxed’ (Fig. 3B).

**Organooleptic Test** Figure 4 shows the results of the organoleptic test of coffee extracts conducted on 20 subjects (experiment 2). Bitterness and sourness were strongest in coffee extracted at 95°C, and were indicated significantly more frequently by the students than for coffee extracted at the lowest temperature (65°C; p < 0.05). Aroma, aftertaste, and favorability of characteristics considered together were greatest with the 80°C extract, which was rated better overall than the 95°C extract (p < 0.05) in which bitterness and sourness were strongest.

![Figure 1](image1.png)

*Fig. 1.* Questionnaire results concerning preference for coffee and types of coffee. A: Proportions of subjects reporting they like or dislike coffee. B: Proportions of coffee types most frequently consumed by subjects.
Accordingly, the 80°C extract was preferred with regard to taste. Subjects reported the greatest relaxation upon drinking the 80°C extract, followed by the 65°C extract and the 95°C extract, respectively. A significant difference was observed between the 80°C and 95°C extracts (p<0.05); therefore, the 80°C extract was used in the subsequent experiments.

Table 1 shows Pearson correlation coefficients for the organoleptic test items regarding relaxation. The degree of relaxation was positively correlated with overall satisfaction with the coffee and the acceptability of the aftertaste (r=0.664 and 0.593, respectively and p<0.01 for both). Relaxation was negatively correlated with sourness (r=−0.542; p<0.05). Overall satisfaction with the characteristics was positively correlated with aftertaste (r=0.779; p<0.01), and negatively correlated with sourness (r=...
Effect on Mental Stress  Results concerning the salivary marker of mental stress are shown in Figure 5. Given that each subject’s salivary chromogranin A concentration 30 min before the stressful task had a relative value of 1, the relative value approached 0.769 immediately after the task in subjects who later receive either coffee or hot water. Sixty minutes after drinking the test beverage, coffee had decreased chromogranin A concentrations (relative value, −0.542; p<0.05) significantly more than the hot water control (relative value, 0.041; p<0.01).

Discussion

In the present study we investigated the effect of coffee drinking on mental stress in young women, concluding that regularly drinking coffee reduces stress. According to questionnaire responses, 68% of the subjects like coffee. Approximately half prefer instant coffee (Fig. 1B), which yields consistent results with constant amounts of coffee powder and hot water. The strength therefore can be adjusted easily to suit preferences. Approximately half as many subjects (24%) drink regular (extracted) coffee. Variation in particle size of ground coffee, extraction temperature, and extraction time pose difficulties in preparing an extract with consistent qualities, which may have limited the popularity of regular extracted coffee. Preparation of extraction implements and washing them after drinking the coffee may also have limited the popularity of extracted coffee.

Most young women who like coffee (93%) drink 1 to 2 cups daily (Fig. 2), confirming that coffee is a popular luxury beverage for young women, who do not necessarily drink a large volume of coffee.

Some 68% of subjects indicated that they feel relaxed when they drink coffee (Fig. 3A), similar to data shown in Figure 1A. Approximately two-thirds of these subjects (Fig. 3B) indicated feeling moderate relaxation while drinking coffee.

As described in the Introduction, the unique flavor of coffee varies with specific conditions related to roasting, grinding, storage, and extraction (Ohta and Ishii, 2000; Ohta and Ishii, 2003), causing considerable difficulty in brewing coffee with a consistent taste. Control of the volume of hot water in extraction is relatively difficult, while variation of rhythm and speed in pouring hot water affect extraction time, resulting in variable coffee preparation (Taguchi, 2003). Standardizing the amount of hot water may help to stabilize the taste of the extract. In the present organoleptic test, the variety of coffee beans, degree of roasting, particle size, amount of powder, and volume of hot water used for extraction were kept constant, with only the extraction temperature being varied; the server was trained to produce a consistent coffee extract. Therefore, in the present study, extraction temperature had the greatest influence on the properties of the coffee extracts; the 80°C extract scored highest in overall satisfaction, followed by the 65°C extract and then the 95°C extract (Fig. 4). The results of our organoleptic test were consistent with a report stating that 80 to 82°C was the best temperature for the extraction of medium

<table>
<thead>
<tr>
<th>Aroma</th>
<th>Bitterness</th>
<th>Sourness</th>
<th>Aftertaste</th>
<th>Overall satisfaction</th>
<th>Degree of relaxation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.113</td>
<td>0.173</td>
<td>−0.724 **</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>0.150</td>
<td>−0.158</td>
<td>−0.769 **</td>
<td>0.779 **</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>0.430</td>
<td>0.041</td>
<td>−0.542 *</td>
<td>0.593 **</td>
<td>0.664 **</td>
<td>1</td>
</tr>
</tbody>
</table>

** p<0.01, * p<0.05
roast, medium grind coffee (Taguchi, 2003).

When correlations between organoleptic test items for the 80°C extract were investigated, the degree of relaxation and the aftertaste showed a significant positive correlation (p<0.01), suggesting that the relaxation effect increased when the aftertaste was more pleasing. In contrast, a significant negative correlation was observed between the degree of relaxation and sourness (p<0.05), suggesting that coffee with a less acidic taste is better suited to relaxation. We know of no previous report on the relationship between organoleptic test items for coffee extracted at different temperatures and the degree of relaxation.

Measures of biologic stress have included blood concentrations of the stress hormones cortisol and catecholamines (adrenaline and noradrenaline) (Nakane, 1999). Under stressful conditions, two stress response systems, the hypothalamic-pituitary-adrenocortical system and the sympathetic nervous-adrenomedullary system, are activated, resulting in the secretion of cortisol and catecholamines, which enhance cardiac function and increase blood glucose to enhance an individual’s ability to manage stress. Since the sympathetic nervous-adrenomedullary system is activated more rapidly than the hypothalamic-pituitary-adrenocortical system, catecholamine markers are more appropriate than cortisol for early detection of weak stresses (Nakane, 1999). Recently, measurement of chromogranin A, which is secreted with catecholamines in saliva, has been found to be useful for the clinical measurement of stress (Suzuki et al., 2005). As saliva is easy to sample noninvasively for serial comparison, the recently established salivary measurement of chromogranin A (Nishikawa et al., 1998; Nishimura et al., 2003) is expected to be come a widely used stress index reflecting sympathetic nerve activity (Nakane et al., 2002).

In the present study, we induced task-related mental stress in subjects in order to investigate changes in salivary chromogranin A as index of psychosomatic stress response. Toyota Central Laboratory R & D Review, 34, 17–22 (in Japanese).


