The Caffeine and Theanine Content of Matcha Tea in Relation to Reaction Time

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ABSTRACT

Matcha tea, an increasingly popular beverage in western culture, contains caffeine and theanine, which have stimulatory and cognitive benefits, respectively [1]. However, little is known about how matcha tea affects reaction time, especially in relation to grade type, preparation or chemistry. This investigation aimed to assess how differences in cultivation grade and brewing methods of matcha affected caffeine and theanine content, and how grade differences might impact reaction time and response accuracy. Two different grades of commercially available matcha tea (kotobuki and tsuru) were analysed using high-performance liquid chromatography (HPLC). Two grams of each were prepared either as a cold brew (4° C at 24 hours) or a hot brew (75° C at 4 minutes) [2]. The results indicated that cold-brewed kotobuki tea, which was shaded for longer and harvested earlier in the year from younger leaves, contained a significantly higher amount of theanine (44.30mg ± 1.31) and caffeine (68.80mg ± 2.10) compared to the other tea types (p <0.001). Subsequently, two cognitive experiments were performed at baseline and 60 minutes post-tea consumption. First, kotobuki cold brew beverage was tested against a spinach placebo in a randomised placebo-controlled single-blind crossover study (n=24). Secondly, the effects of the kotobuki cold brew tea was tested against the tsuru cold brew tea (n=10). Significant improvements in reaction time were found after kotobuki intake compared to the placebo (p <0.001), but score accuracy did not significantly improve (p >0.05). Reaction time was reduced in both matcha groups, although the change in reaction time was not significantly greater for those consuming higher caffeine and theanine content (p >0.05). These results suggest that matcha tea may have a positive stimulatory effect on the brain irrespective of the grade/quality and at low caffeine and theanine doses (21.90mg and 12.23mg respectively).

References

[1] Dietz, C., Dekker, M., and Piqueras-Fiszman, B. *Food Res. Int.* **2017,** *99*, 72–83

[2] Lin, S., Liu, E. and Mau, J. *LWT - Food Sci. Technol.* **2008**, *41*,1616–1623

MATERIAL & METHODS

1. Matcha tea preparation for HPLC

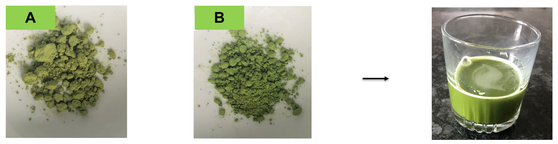

Figure 1. Tsuru matcha (A) industrial grade, limited shading, harvested from mature leaves and kotobuki matcha (B) premium grade, increased shading, harvested from fresh buds during first flush (April) used to produce matcha drinks (right).

Filter tea with syringe filter

HPLC analysis of caffeine and theanine

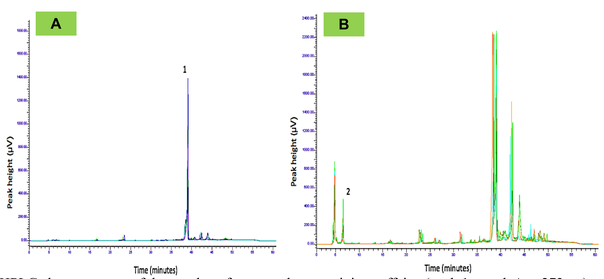

Figure 2. HPLC chromatogram of the overlay of tea samples containing caffeine (peak 1, graph A at 273nm) and theanine (peak 2, graph B at 210nm).

2. Caffeine and theanine structure

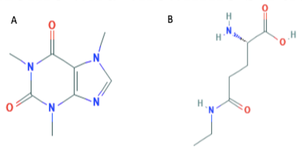

Figure 3. HPLC chromatogram of the overlay of tea samples containing caffeine (peak 1, graph A at 273nm) and theanine (peak 2, graph B at 210nm).

3. Choice reaction task

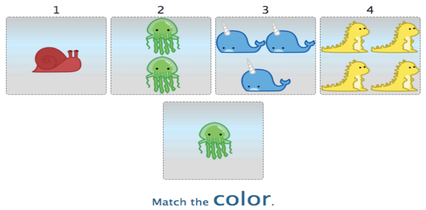

Figure 4: An example of a task in the visual choice reaction test, for this example participants (n=24) needed to coordinate the presented stimuli to the correct response by pressing key 2 on the keypads of their computers. Reaction time (seconds) and correct answers were measured.

RESULTS

4. HPLC analysis for caffeine and theanine extraction in matcha samples

Table 1. The theanine and caffeine content in a standard portion of 2mg of the four tea types, including the content of these compounds in the spinach placebo drink. (p <0.001)

Tea type	Theanine (mg/standard portion)	Caffeine (mg/standard portion)	Ratio of caffeine/theanine
Kotobuki cold brew	44.30 ± 1.31	68.80 ± 2.10	1.55
Kotobuki hot brew	29.90 ± 0.62	53.13 ± 1.33	1.78
Tsuru cold brew	12.23 ± 0.15	21.90 ± 0.79	1.79
Tsuru hot brew	14.53 ± 0.25	26.70 ± 0.44	1.84
Spinach hot brew	n.d.	n.d.	

n.d. = not detected

Values are expressed as (2g/100ml) = mean ± standard deviation.

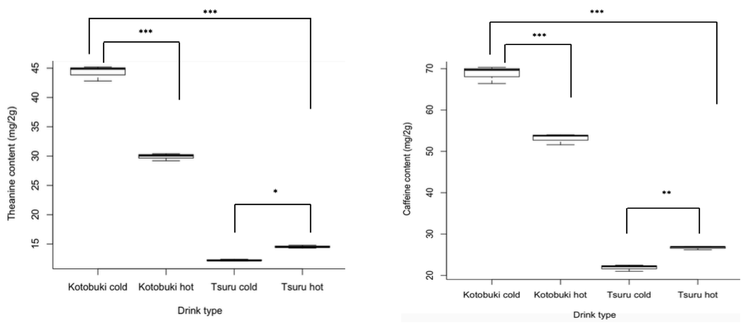

Figure 5. The theanine (left) and caffeine content in the different drink types. Significance of pairwise comparisons between cold and hot brews for individual matcha samples (one-way ANOVA with Tukey post-hoc test) ***, P < 0.001; ** P < 0.01; *, P < 0.05.

5. Experiment 1: Reaction time and response accuracy after consumption of kotobuki matcha and placebo (spinach) beverage

Table 2. Pre-drink baseline means and change in means ± SD, 60 min post drink intake, of the measured conditions (reaction time and response accuracy).

Measured condition	Pre-drink baseline score mean ± SD	Post drink score mean ± SD	Post-drink change from baseline score Δ mean ± SD
Reaction time (seconds)			
Spinach placebo	1.41 ± 0.44	1.38 ± 0.42	0.02 ± 0.09
Kotobuki	1.50 ± 0.48	1.19 ± 0.43	0.30 ± 0.19
Response accuracy (number of correct answers/20)			
Spinach placebo	17 ± 3	17 ± 3	0 ± 2
Kotobuki	17 ± 3	19 ± 2	1 ± 4

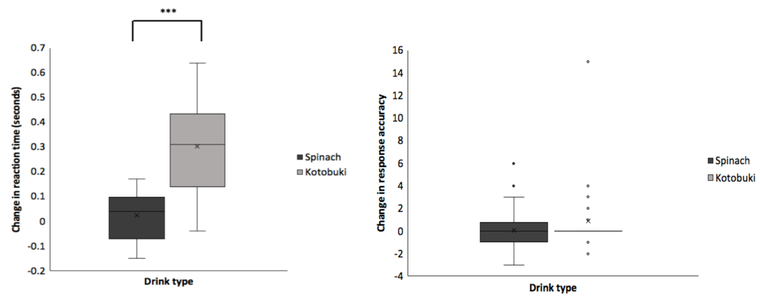

Figure 6. The change in reaction time (left) and change in the number of correct answers between the baseline and post drink results of the kotobuki and spinach beverages (n=24 for both groups). Significance: ***, P < 0.001 by independent t test (difference in means > zero).

6. Experiment 2: Reaction time and response accuracy after consumption of kotobuki matcha and tsuru matcha

Table 3. Pre-drink baseline means and change in means ± SD, 60 min post drink intake, of the measured conditions (reaction time and response accuracy).

Measured condition	Pre-drink baseline score mean ± SD	Post drink score mean ± SD	Post-drink change from baseline score Δ mean ± SD
Reaction time (seconds)			
Tsuru	1.22 ± 0.22	1.12 ± 0.22	0.11 ± 0.13
Kotobuki	1.33 ± 0.19	1.09 ± 0.21	0.25 ± 0.31
Response accuracy (number of correct answers/20)			
Tsuru	18 ± 2	18 ± 2	1 ± 1
Kotobuki	17 ± 3	19 ± 1	1 ± 2

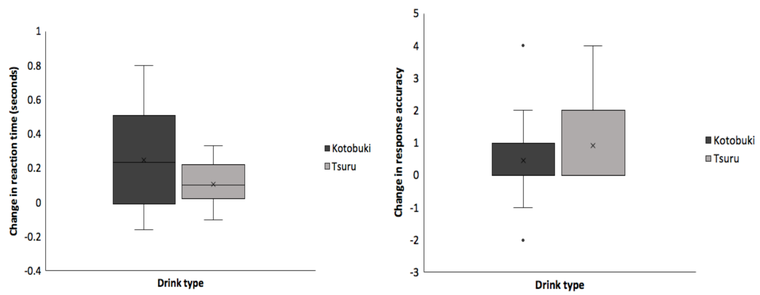

Figure 7. The change in reaction time (left) and change in the number of correct answers between the baseline and post drink results of the kotobuki and tsuru beverages (n=10 for both groups).

CONCLUSIONS

- As green tea leaves mature theanine and caffeine content decreases and theanine content increases during shade cultivation.
- Cold brewed matcha tea extracted more theanine and caffeine than hot brewed tea.
- Different grades of matcha tea were found to improve reaction speed during a choice reaction task, the results suggest that caffeine doses ranging from 21.90mg - 68.80mg in combination with theanine doses ranging from 12.23mg - 44.30mg may be able to improve reaction-related performance.
- Score accuracy during the cognitive task appeared to be unaffected by the consumption of either grade of matcha.

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