Research Article **Open Access**

Bioactive Compounds in Health and Disease

An evaluation of the cognitive effects of malt extract and sucrose in school-aged Malaysian children

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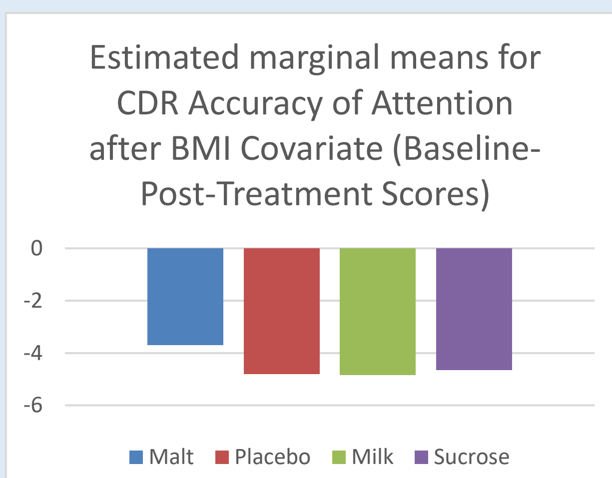
Submission Date: April 20th, 2020; **Acceptance Date:** September 13th, 2020; **Publication Date:** October 16th, 2020

Please cite this article as: Stough C., Scholey A., Gentile-Rapinett G., Schmidt, J., Goh A., Wesnes, K., Kras, M., Kwek, K., Camfield D.A. An evaluation of the cognitive effects of malt extract and sucrose in school-aged Malaysian children. *Bioactive Compounds in Health and Disease* 2020. 3(10): 179-193. DOI: https://www.doi.org/10.31989/bchd.v3i10.754

This article is a part of special issue of ICoFF/ISNFF 2019, Kobe, Japan. Special issue editors: Yasuhito Shirai, PhD, Professor, Graduate School of Agricultural Science, Department of Agrobioscience, Kobe University, Kobe, Japan and Hiroshi Yoshida, MD, PhD, Professor, The Jikei University School of Medicine, Tokyo, Japan

ABSTRACT

The effect of carbohydrates and sucrose on cognitive performance in children has been the subject of several trials. Some studies have found both positive and negative effects of glucose and carbohydrates on cognitive function in school children. These studies are important in terms of designing functional foods that can assist children in learning throughout the day, and in particular, within a school-educational context. In this study we conducted a 4-way repeated measures within subject crossover randomized controlled trial in which we compared an acute administration of malt, sucrose,



milk and water in 58 Malaysian children aged 10-12 years on performance on a battery of cognitive and mood measures before and after exercise. Results indicated that there was a beneficial effect of malt on attention suggesting the importance of carbohydrates to alleviate attentional changes due to exercise in children.

Keywords: Malt, Sucrose, Attention, Children

INTRODUCTION

As the primary fuel for the brain, an adequate supply of glucose is necessary for optimal functioning across a number of cognitive domains, particularly memory ability [1]. This is especially true in children whereby cerebral glucose utilization is at least double that of adults [2]. Research in young adults has suggested that the acute cognitive benefits associated with glucose supplementation follows an inverted U-shaped curve, with 25g being optimal [3]. However, clinical evidence as to the optimal dose of glucose necessary to enhance cognition in children is yet to be determined. An early study by Benton et al. (1987) reported that 25g glucose resulted in improvements to sustained attention in 6-7 year olds [4]. In a subsequent study by Wesnes et al. (2003) negative effects on cognitive performance were found after intake of a drink containing 37.5g glucose [5]. A more recent study by Benton and Stevens (2008) found positive effects on memory after the consumption of a drink containing 25g of glucose compared to placebo in 9-10 year-olds [6].

In addition to the question of optimal dosing, the form of carbohydrate from which glucose is derived also needs to be considered in this age group. Mahoney et al. (2005) administered a low versus high GI breakfast to children aged 6-11 years, and found that performance on a short-term memory task was enhanced in girls following the low GI breakfast [7]. Similarly, Ingwersen et al. (2007) reported that in children aged 6-11 years the consumption of a low GI breakfast cereal prevented performance declines throughout the morning on certain measures of attention and memory [8]. Malt extract, which originates from malted barley and contains a mix of several carbohydrates including sugars and polysaccharides [9], has received comparatively little research attention as to its effects on cognition. In comparison to glucose, there is evidence to suggest that malt may have better intestinal absorption and be associated with higher glycogen deposition in muscles [10]. Due to the different carbohydrate properties of Malt it could be expected that it has a differential influence on cognition and mood in children.

In a pilot study from our laboratory (Scholey et al. 2008 unpublished findings), the cognitive and mood effects of 20g glucose, 40g glucose, 20g Malt extract and a placebo (saccharine) were examined in ten year-old children. It was found that administration of glucose at a dosage of 20g had negative effects upon aspects of cognitive function in this age group. In contrast, 20g malt extract did not impair performance to the same degree. Although the malt extract had no cognitive benefits, when compared to placebo it was associated with better performance in comparison to equivalent levels of glucose on some measures – particularly those assessing attention and aspects of working memory (WM) and executive function. A recent study by Kuriyan et al, 2016 chronically administered either a micronutrient enriched malt or a cocoa based mild drink to 7-10 year old Indian children for 5 months (6 days a week) [11]. Although both groups improved in terms of cognition, there was no difference between the interventions indicating that at least chronically both groups improved cognitively over this period. However, without a placebo group it is difficult to know whether both interventions are efficacious or whether there is a practice effect.

The aim of this study was to compare the effects of a malt extract in a milk matrix with sucrose in a milk matrix on cognition and mood in children. Moreover, these ingredients were compared to milk alone and water alone in order to separate the contribution of milk and hydration on cognition and mood. An exercise protocol was also introduced, due to the fact that exercise may potentially increase the effects of the treatment and there is preliminary evidence from the adult literature that exercise may increase the effect of carbohydrates on the brain and cognition (Kennedy et al., 2010) in which case malt and sugar extracts may be beneficial [12].

METHODS

Participants: Fifty-eight children aged between 10 and 12 years were recruited from schools in Kuching, Sarawak, Malaysia. All children were screened according to the following criteria: 10-12 years of age with no birthday during the study period, normal static binocular acuity (corrected or uncorrected), no history of diabetes, glucose intolerance or any other metabolic disorder, no current or history of cardiac, hepatic, renal, pulmonary, neurological, gastrointestinal, haematological or psychiatric illness, not currently using prescription medication, illicit, herbal or recreational drugs, including alcohol and tobacco, no use of dietary mineral and/or vitamin supplements within the last month, no sensory or motor deficits that could reasonably be expected to affect test performance, allergy or hypersensitivity to any ingredients in the investigational products, not currently participating or having participated in another clinical trial during the previous 2 months. The children were also screened according to body mass index (BMI). Using norms provided by the World Health Organization for Boys and Girls aged 5 to 19 years, the following inclusion criteria for BMI were used (corresponding to the 5^{th} – 95^{th} percentile for each year): *Boys:* 10 years; 14.1 to 21, 11 years; 14.5 to 22 and 12 years; 14.9 to 23.1. *Girls:* 10 years; 13.9 to 22.1, 11 years; 14.4 to 23.2 and 12 years; 14.9 to 24.3.

Design: A double-blind, randomized, placebo-controlled, four treatment crossover design was used. Various cognitive and mood/appetite outcomes were assessed. The participants were randomly allocated to one of 4 possible Williams Latin-Square sequences in which a different treatment was administered in a different order.

Malt, glucose and sucrose treatments

- *Treatment 1:* 11g malt extract and 6.5g milk (and 0.44g sucralose);
- *Treatment 2:* 11g sucrose and 6.5g milk;
- *Treatment 3:* 6.5g milk (and 0.56g sucralose);
- *Treatment 4(placebo):* 150ml water (and 0.56g sucralose).

MATERIALS

Arrow Flankers (Attention) task: In this computerized version of the task five symbols were presented on the screen, with the centre symbol always being an arrow pointing to the left or the right. The task involved pressing the right or left arrow key which corresponded to the direction of the central arrow. The flanking pairs of symbols could be squares, congruent arrows (pointing in the same direction), or incongruent arrows (pointing in the opposite direction). Inter-stimulus duration was between 1 and 3 seconds. Outcomes included accuracy in terms of number of correct responses and reaction (msecs).

Cognitive Drug Research (CDR) Battery: Attention and memory was assessed using the CDR Computerised Assessment Battery [5, 13]. Tasks from the CDR assessment battery were presented in the following order: picture presentation, simple reaction time, choice reaction time, digit vigilance, numeric working memory, spatial working memory and delayed picture recognition.

On the basis of performance on these tasks, scores on five cognitive factors were calculated [13]. *(i) Speed of Attention:* sum of the reaction times from Simple RT, choice RT and digit vigilance. *(ii) Speed of Memory:* sum of the reaction times from numeric WM, spatial WM, delayed word recognition and delayed picture recognition. *(iii) Accuracy of Attention:* sum of the percentage accuracy for choice RT and digit vigilance with adjustment for false alarms from the latter task. *(iv) Secondary memory:* The percentage accuracy score for Delayed picture recognition (adjusted for novel and original stimuli). *(v) Working memory:* Sum of percentage accuracy scores for spatial WM and numeric WM.

Coding-Digit Symbol (WISC-IV): In this test, numbers 1-7 are paired with symbols on a key that is presented to the child. The child is then allowed 120 seconds to go through a grid of 90 numbers and place the correct symbol below each number. The test is scored for the total number of correct responses and errors.

Speed of Information processing task: The task is similar to the Sky Search task from the TEAch battery of tests [14] (Manly *et al.*, 2001) and the computerized rapid visual information processing (Bakan) task. It has been used by Rogers *et al.* (1995)[15], and Heatherley *et al.* (2005) [16] with children. The participants are presented with one page of numbers. They are asked to circle any blocks of three consecutive odd numbers, working from left to right and row by row as quickly and as accurately as they can. Three minutes are allowed to complete this task. The test is scored for the number of correct answers, misses and errors.

Mood and satiety scales: Participants are required to indicate their current mood and hunger/thirst state using visual analogue scales labelled as: 'hungry' and 'full', 'thirsty', 'awake' and 'sleepy' "alert" "happy and sad" "rested and tired" with the end points labelled as 'not at all' and 'very'.

Exercise protocol: The children were randomly divided into 2-4 groups per session, and completed a 30 minutes exercise protocol. The exercises were designed to be fun and entailed physical activity equivalent to mild exertion. The total time spent on the 4 exercise tasks was 24 minutes with 90 seconds allocated for transition time between each task; with total transition time of 6 minutes and an overall exercise protocol time of 30 minutes. The following four activities were conducted in the following order:

1. *Badminton relay (timed) 6 minutes:* One at a time the children were required to hit a birdie into 1 of 3 hula hoops at varying distances from the starting line. The hoops were worth 1, 2 and 3 points respectively, which corresponded to their distance from the starting line. They were required to retrieve another birdie at the side of the court and aim at a target again. The children repeated this 3 times in total (moderate activity) and then returned to the back of the line to let the next child begin.
2. *Squash ball and spoon relay race (timed) 6 minutes*: One at a time the children were required to run through a course of 3 witches hats each placed 5 meters apart while balancing a squash ball on a plastic spoon (moderate). Once they reached the other end of the room (approximately 20 meters away) they placed the ball in a bucket and then raced back to their team (high) where the next team member was waiting to take over.
3. *Football relay (timed) 6 minutes:* One at a time the children dribbled a soccer ball through a course of 3 witches hats as described above for the squash ball relay (moderate activity) and then turned around and kicked and aimed at a target adjacent to the starting line. After this they raced back to their team (high intensity) where the next team member was waiting to take over.
4. *Hopping relay (timed) 6 minutes:* Children (1 per team) have their legs loosely tied together using a piece of fabric and then hop to a predetermined target and back (high intensity). Once they have returned to the front of the line, the next child in line (moderate intensity) hops to the target and back while the other children encourage (low intensity). This is repeated for a "race" of 90 seconds followed by 30 seconds of rest between races. A total of three 90-second races will be performed for a total of 6 minutes.

Procedure: All testing was performed at the Swinburne University Sarawak campus Malaysia between March and June 2010. Participants visited the laboratory on five separate occasions (V0 - training day, V1-4 study days from original protocol). The training day visit comprised of: Obtaining informed consent; health screening; collection of demographic data; random allocation to treatment order and full training consisting of two completions of all the tasks. Following the training day participants attended the laboratory at 9:30am on each of the study days in a well-rested state after

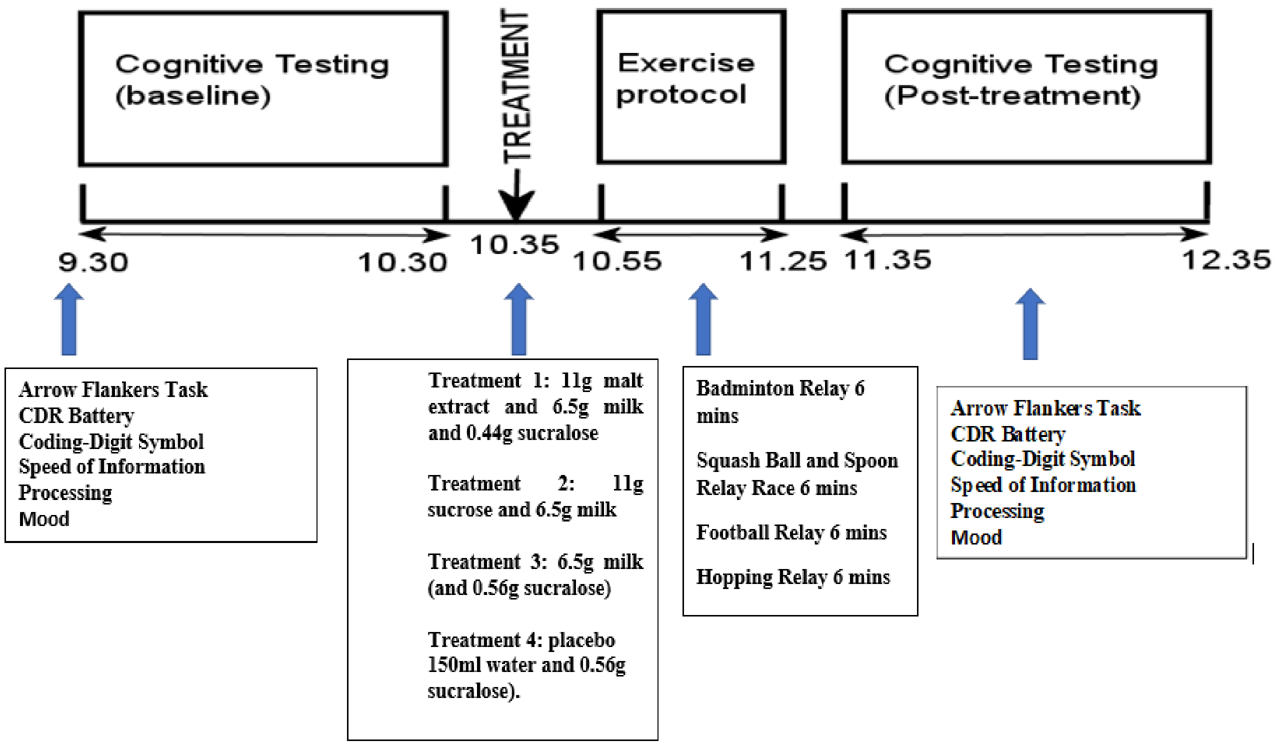


Figure 1. Timeline for study day visits (including tests, treatments and exercise).

having consumed a standardized breakfast between 7:00 and 7:30am of either bread/crackers with spread (e.g. butter, peanut butter, jam, kaya) or soft boiled eggs (with soya sauce). The breakfast choices were based on traditional Malaysian dietary habits, and the children were instructed to consume the same breakfast at each and every study visit. Food diaries for the 24 hours prior to each study visit were also collected at this point. Each study visit's testing protocol was then conducted according to the following time scale: 9:30am - 10:30am baseline cognitive testing, 10:35am - 10:40am treatment drinks consumed, 10:55am - 11:25am exercise protocol, 11:25am - 11:30am water consumed, 11:35am - 12:35pm post-dose cognitive testing. The time between consuming the treatment drink and beginning the post-dose cognitive testing was always kept invariant at exactly one hour. The timeline of study day events is displayed in Figure 1.

Statistics: For all cognitive outcome measures and mood scales, difference scores were calculated by subtracting the baseline (pre-dose) score from the post-dose score. Body Mass Index (BMI) was found to be significantly correlated with a number of outcome measures at baseline, and for this reason was included as a covariate in all subsequent analysis. A two-way mixed ANCOVA (Treatment condition x Gender) with repeated measures on the treatment condition (Placebo, Malt, Milk and Sucrose) and BMI as a covariate was conducted using pre-post difference scores on all outcome variables.

RESULTS AND DISCUSSION

Table 1. CDR Factor score mean change from baseline scores (SD) by treatment

			Treatment				ANCOVA[a]	
		N	Placebo	Malt	Milk	Sucrose	F	p
Speed of attention	Male	20	3.056 (135.94)	86.424 (160.24)	-3.370 (184.48)	59.252 (175.11)		
	Female	30	26.983 (189.15)	-17.677 (216.37)	88.767 (223.83)	15.015 (194.27)		
	Total	50	17.412 (168.76)	23.963 (200.79)	51.913 (211.96)	32.710 (186.29)	0.661	0.577
Accuracy of attention	Male	15	-5.533 (17.73)	-5.066 (15.90)	-6.467 (9.52)	-4.268 (14.63)		
	Female	22	-3.409 (7.733)	-2.091 (8.135)	-3.228 (6.87)	-4.864 (9.38)		
	Total	37	-4.270 (12.580)	-3.297 (11.79)	-4.541 (8.09)	-4.622 (11.60)	**2.881**	**0.040**
Working Memory	Male	12	0.0913 (0.222)	-0.0882 (0.185)	0.0008 (0.218)	-0.1450 (0.163)		
	Female	17	-0.0887 (0.239)	-0.0776 (0.244)	-0.0592 (0.184)	-0.0429 (0.131)		
	Total	29	-0.0142 (0.245)	-0.0820 (0.218)	-0.0343 (0.198)	-0.0852 (0.151)	0.448	0.720

Data are mean unadjusted difference scores plus standard deviation of differences.
[a]ANCOVA on Treatment, including Body Mass Index (BMI) as a covariance

The unadjusted means and standard deviations for changes from baseline according to treatment for the CDR Factors Speed of Attention, Accuracy of Attention and Working Memory are displayed in Table 1, together with the results of repeated measures ANCOVA on treatment, with BMI as a covariate.

Repeated measures ANCOVA on CDR Accuracy of Attention revealed that the main effect for Treatment (Milk, Malt, Sucrose or Placebo) was significant ($\underline{F}_{(3,102)}$=2.881, p=.040, partial η^2=.078). No significant interactions between Treatment and Gender were found for any CDR factor, and no significant main effect of treatment was found for either Speed of Attention or Working Memory factors from the CDR battery. Within-subject contrasts on mean data adjusted for BMI, revealed that the decrease from baseline for CDR Accuracy of Attention was significantly greater for Placebo in comparison to Malt ($\underline{F}$(1,34)=6.089, p=.019, partial η^2=.152), whereas the decrease from baseline for CDR Accuracy of Attention was significantly less for Placebo in comparison to Sucrose ($\underline{F}$(1,34)=6.247, p=.017, partial η^2=.155), and Placebo in comparison to Milk ($\underline{F}$(1,34)=4.170, p=.049, partial η^2=.109). This suggests that after controlling for differences in BMI that Sucrose and Milk attenuated the exercise impairments associated with accuracy in attention. The estimated marginal means for CDR Accuracy of Attention factor, adjusted for BMI, are displayed in figure 2 according to each treatment. This suggests that after controlling for BMI that Malt administration was able to significantly improve the decrease in accuracy of attention due to the exercise compared to the placebo condition. This may suggest that the available carbohydrates in Malt may be utilized in times of need ie post physical exercise for children in terms of attentional processes.

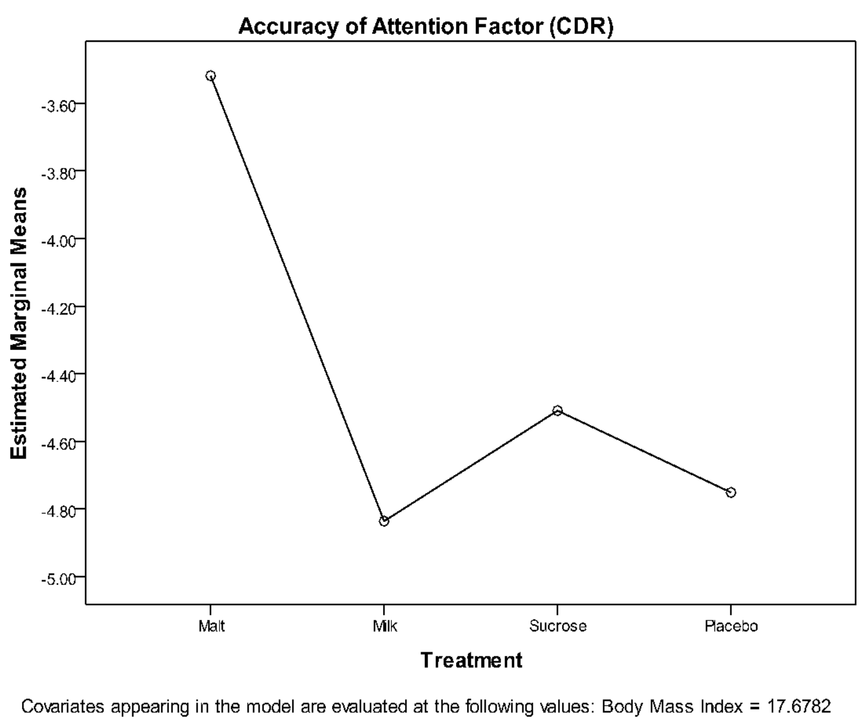


Figure 2. Estimated marginal means for CDR Accuracy of Attention

Table 2: Visual Analogue Mood Scale (VAMS) mean change from baseline scores (SD) by treatment.

			Treatment				ANCOVA[a]	
		N	Placebo	Malt	Milk	Sucrose	F	p
Hungry	Male	21	-27.476 (36.279)	-39.238 (48.247)	-22.429 (42.787)	-25.810 (45.836)		
	Female	25	-41.760 (31.777)	-33.290 (38.241)	-33.920 (38.241)	-38.280 (35.302)		
	Total	46	-35.239 (34.282)	-28.674 (40.338)	-28.674 (40.338)	-32.587 (40.470)	0.060	0.981
Full	Male	21	5.381 (31.789)	9.143 (40.098)	19.476 (48.746)	7.286 (39.335)		
	Female	25	18.240 (31.613)	26.640 (39.373)	34.960 (35.799)	13.040 (38.337)		
	Total	46	12.370 (32.001)	18.652 (40.237)	27.891 (42.431)	10.413 (38.469)	0.819	0.485
Thirsty	Male	21	10.381 (32.240)	3.429 (40.642)	-5.619 (42.405)	-6.095 (41.118)		
	Female	25	0.480 (36.859)	4.160 (42.923)	4.160 (37.276)	6.720 (36.937)		
	Total	46	5.000 (34.805)	3.826 (41.435)	-0.304 (39.554)	0.870 (38.997)	1.418	0.244[†]
Awake	Male	18	-6.500 (19.806)	-9.889 (26.850)	-9.444 (25.801)	-9.222 (29.012)		
	Female	18	-2.722 (18.899)	-1.444 (14.366)	-10.000 (17.925)	-5.611 (12.876)		
	Total	36	-7.417 (22.197)	-5.667 (21.650)	-9.722 (21.897)	-7.417 (22.197)	0.084	0.912[†]

The unadjusted means and standard deviations for changes from baseline according to treatment for the Visual Analogue Scales (VAS) are displayed in Table 2, together with the results of repeated measures ANCOVA on treatment, with BMI as a covariate.

Table 2 continued.

			Treatment				ANCOVA[a]	
		N	Placebo	Malt	Milk	Sucrose	F	p
Alert	Male	20	-0.550 (19.378)	-1.850 (9.354)	-7.800 (15.969)	3.150 (14.840)		
	Female	25	-6.840 (12.284)	-2.840 (29.450)	-17.120 (25.406)	-2.880 (29.247)		
	Total	45	-4.044 (15.952)	-2.400 (22.608)	-12.978 (22.003)	-0.200 (23.892)	**3.981**	**0.022**[†]
Happy	Male	21	1.095 (12.720)	-3.429 (15.145)	-7.048 (16.129)	-0.095 (15.267)		
	Female	25	-1.480 (17.139)	1.840 (16.408)	-10.960 (18.472)	-0.600 (27.247)		
	Total	46	-0.370 (22.352)	-0.565 (15.892)	-9.174 (17.363)	-0.370 (22.352)	1.385	0.250
Rested	Male	21	-17.571 (41.984)	-23.667 (35.556)	-7.524 (30.122)	-13.524 (41.393)		
	Female	25	-15.840 (28.597)	-22.920 (45.936)	-14.000 (22.589)	-17.160 (32.062)		
	Total	46	-16.630 (34.933)	-23.261 (41.078)	-11.044 (26.192)	-15.500 (36.237)	0.088	0.966

Data are mean unadjusted difference scores plus standard deviation of differences.
[a]ANCOVA on Treatment, including Body Mass Index (BMI) as a covariate
[†]Greenhouse-Geiser-corrected.

Repeated measures ANCOVA on VAS Alertness revealed that the Greenhouse-Geisser-adjusted main effect for Treatment, (Milk, Malt, Sucrose or Placebo) was significant ($\underline{F}_{(3,85.53)}$=3.981, p=.022, partial η^2=.087). No significant interactions between Treatment and Gender were found for any VAS, and no significant main effect of treatment was found for any scale other than Alertness. Within-subject contrasts on mean data adjusted for BMI, revealed that the decrease from baseline for VAS Alertness was significantly greater for Malt in comparison to Sucrose ($\underline{F}$(1,42)=4.168, p=.048, partial η^2=.090), for Milk in comparison to Sucrose ($\underline{F}$(1,42)=5.806, p=.020, partial η^2=.090), and for Milk in comparison to Placebo ($\underline{F}$(1,42)=7.130, p=.011, partial η^2=.145). The marginal means for VAS Alertness, adjusted for BMI are displayed in figure 3 according to each treatment. These results may be somewhat consistent with the attentional effects reported above with increases in alertness possibly related to improvements in attention due to the Malt administration.

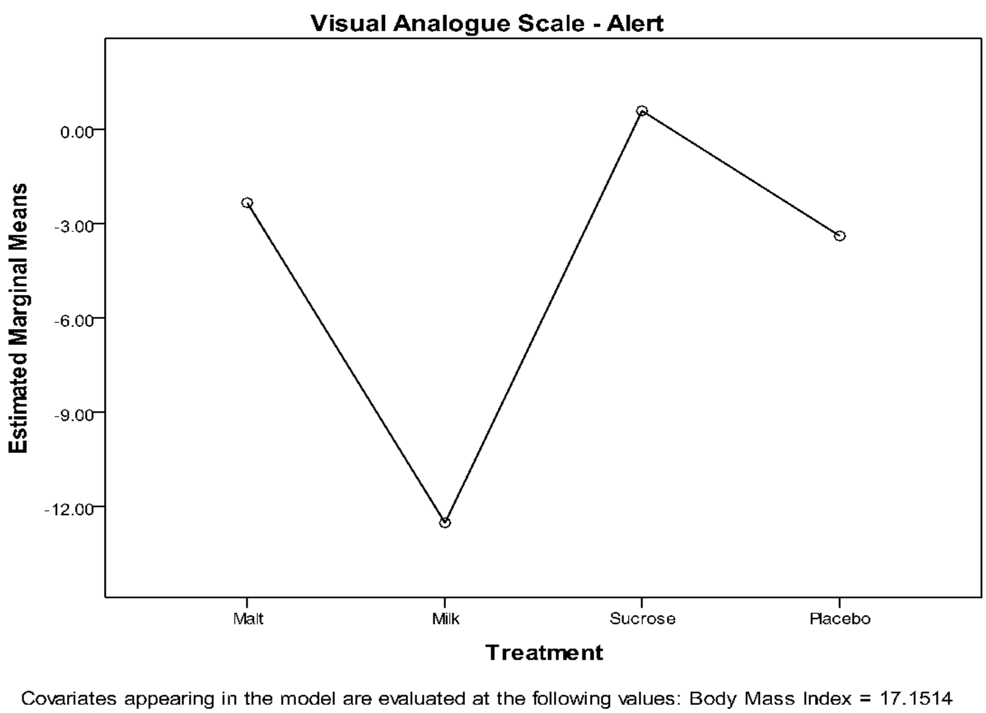


Figure 3: *Estimated marginal means for Alert visual analogue scale (VAS).*

The unadjusted means and standard deviations for changes from baseline according to treatment for the Arrow Flankers Task (accuracy and reaction time), Serial 3s and 7s (accuracy and reaction time), as well as Speed of Information processing (accuracy) and Coding (reaction time) are displayed in Table 3, together with the results of repeated measures ANCOVA on treatment, with BMI as a covariate. No significant main effect of treatment was found for any of these outcome measures. A significant interaction between Treatment and Gender was found for Serial 3s Reaction time, however when the data was analyzed separately for males and females the treatment main effect was found to be non-significant in both cases.

Table 3. Arrow Flankers, Serial Subtractions and Speed of Coding mean change from baseline scores (SD) by treatment.

			Treatment				ANCOVA[a]	
		N	Placebo	Malt	Milk	Sucrose	F	p
Arrow Flankers (total incorrect)	Male	19	-1.0000 (2.9814)	-1.0000 (2.3333)	-0.5789 (2.6010)	-0.9474 (4.4030)		
	Female	26	-0.1923 (2.3498)	-0.1538 (2.4445)	-0.6154 (2.2641)	-1.5000 (3.0232)		
	Total	45	-0.5333 (2.6337)	-0.5111 (2.4085)	-0.6000 (2.3875)	-1.2667 (3.6332)	1.721	0.166
Arrow Flankers RT (ms)	Male	23	27.3043 (69.7440)	-19.8696 (88.0017)	7.6957 (48.5812)	12.6087 (69.7440)		
	Female	28	5.1071 (66.8753)	28.3571 (69.3644)	13.3571 (57.5096)	7.7500 (54.9226)		
	Total	51	15.1176 (66.8753)	6.6078 (81.1976)	10.8039 (53.2214)	9.9412 (65.6519)	0.288	0.834
Serial 3s (total correct)	Male	23	-1.0435 (5.7956)	-0.3913 (5.4999)	-1.0870 (7.1663)	-0.7391 (7.0079)		
	Female	28	-2.2857 (5.6428)	-2.4286 (5.5739)	-1.7143 (5.3323)	-0.8214 (3.7619)		
	Total	51	-1.7255 (5.6889)	-1.5098 (5.5799)	-1.4314 (6.1685)	-0.7843 (5.4086)	1.857	0.140
Serial 3s RT (ms)	Male	21	572.33 (1574.08)	1469.952 (1402.88)	964.52 (2039.89)	757.48 (2079.36)		
	Female	22	1942.00 (2424.96)	1375.59 (1661.11)	814.23 (1503.21)	452.95 (901.78)		
	Total	43	1273.09 (2144.76)	1421.67 (1522.86)	887.63 (1765.53)	601.67 (1577.74)	1.828	0.146

Table 3 *continued.*

			Treatment				ANCOVA[a]	
		N	Placebo	Malt	Milk	Sucrose	F	p
Serial 7s (total correct)	Male	23	-0.3043 (4.2151)	-0.4348 (3.3687)	1.2609 (3.2082)	0.8696 (3.5330)		
	Female	29	-1.0690 (2.3593)	-0.5862 (4.5475)	-1.5517 (3.0070)	-0.9310 (3.9091)		
	Total	52	-0.7308 (3.2966)	-0.5192 (4.0317)	-0.3011 (3.3755)	-0.1346 (3.8196)	1.842	0.142
Serial 7s RT (ms)	Male	22	336.14 (4338.40)	1123.68 (3931.00)	1276.00 (4231.09)	113.50 (5283.56)		
	Female	26	933.31 (2151.21)	1527.54 (2811.22)	315.19 (4801.39)	560.31 (2899.47)		
	Total	48	659.60 (3310.84)	1342.44 (3339.09)	755.56 (4527.17)	355.52 (4122.56)	0.582	0.628
Coding (total correct)	Male	25	-3.1200 (7.0019)	-1.0400 (6.3277)	-2.4400 (6.1175)	-3.2000 (7.9792)		
	Female	32	-3.1250 (5.9065)	-1.3437 (12.3461)	-2.2188 (9.9344)	-3.8438 (6.5604)		
	Total	57	-3.1228 (6.3501)	-1.2105 (10.0778)	-2.3158 (8.4074)	-3.5614 (7.1565)	1.833	0.152 †
Speed Processing (total correct)	Male	25	-2.3200 (4.48813)	-0.6400 (4.71593)	-2.0400 (2.96479)	-1.6800 (4.81075)		
	Female	32	-3.0313 (4.33652)	-3.5313 (4.19665)	-3.5312 (4.36248)	-1.7187 (5.00474)		
	Total	57	-2.7193 (4.37833)	-2.2632 (4.62341)	-2.8772 (3.85482)	-1.7018 (4.87693)	1.227	0.302

Data are mean unadjusted difference scores plus standard deviation of differences.

[a]ANCOVA on Treatment, including Body Mass Index (BMI) as a covariate

†Greenhouse-Geiser-corrected.

Although these results contribute to our understanding of the effects of malt, milk and sucrose on cognitive processes and mood in children there are a number of limitations associated with the study. The study size is small and does not allow a full statistical analysis of all of the potential effects. There were several analyses that approached statistical significance. A larger sample would have provided more confidence in some of the analyses reported. The study was conducted on a sample of Malaysian children and therefore this may also limit generalizing to other populations and ages. Although we attempted to standardize breakfasts before testing, the effects of diet and the status of other nutrients on the results were not measured. Interestingly the most significant results were observed after BMI was used as a covariate. Increasingly BMI is being reported as a factor explaining cognition. For instance, Fard et al (2020) recently reported that BMI interacted with the relationship between inflammatory markers and cognition in the elderly [17]. Despite these limitations there were a number of positive aspects to the current trial. For instance, there are few trials examining the effect of malt and sucrose compared to placebo on standardized cognitive testing and mood in children. Furthermore, there are very few clinical trials on nutritional supplements conducted in Asia. The study also utilized a 4-way cross-over or within-subject design which minimizes between subject variance in terms of the effect of the intervention. In summary, the results of this study provide preliminary evidence that acute malt administration may ameliorate the attentional decrease after exercise in children. Future studies should replicate these results in larger samples and in children from other countries and across different ages.

Authors Contributions: All authors were involved in the planning, preparation, administration and conduct of the study; Camfield completed the statistical analyses and completed the first draft of the manuscript; all authors contributed to the final draft of the manuscript.

Acknowledgements and Funding: The study was funded by Nestle Research Centre (NRC)

Competing interests: The authors declare no competing interests.

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