

THE EFFECT OF STRAWBERRY ON POSTPRANDIAL GLYCAEMIA AND HUNGER

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Abstract

This study trial tested the capability of the phenolic compounds of strawberry to assuage the postprandial effects of glycaemia and hunger. Participants for the study were 8 non – diabetic adult volunteers with weights above 60kg, picked according to specific criteria. The volunteer subjects control consumed a 51.3g bowl of corn flakes breakfast cereal with 150 ml semi – skimmed milk which provided a total of 50g of carbohydrate and consumed another meal of 43.1g corn flakes breakfast cereal with 150ml semi-skimmed milk and a 100g added strawberries the following week as the test meal. For the determination of Blood Glucose levels, fingertip-pricked blood samples were collected after volunteers fasted overnight and then 15 minutes after the meal and later 30 minutes, 60 minutes, 90 minutes and 120 minutes respectively; timing distributed within a period of 2 hours after consuming the test meal. Both groups had a significance ($P < 0.05$) increase in blood glucose levels at 30 and 60 minutes respectively after consuming the test meal with respect to the control meal; thus, emphasizing the significance of strawberries in managing glycaemic status. Consuming more strawberries could be a plan of action to improve the quality of life of people with type 2 diabetes.

Keywords: *Strawberries, Postprandial Glycaemia, Hunger, Cornflakes Breakfast Cereal.*

Introduction

Strawberries are fruits people eat for various reasons such as natural weight loss, stimulating metabolism, fever, anaemia, arthritis, diarrhoea, liver diseases, jaundice, inflammation of respiratory tract lining, kidney ailments involving gravel and stones, sluggish intestines and a host of others (Hannum, 2004; Cheel, Theoduloz, Rodriguez, Saud, *et al*, 2005, in their studies believes that strawberries contain antioxidant compounds known as polyphenols that might keep cancer cells from multiplying and other chemicals (phytonutrients) contained may slow down the speed at which the nervous system ages. Although strawberries contain a good amount of sugar, they can help in regulating blood glucose in the body. Amidst common fruits and vegetables consumed in the United Kingdom, strawberries include those ranked as highest in phenolic contents such as kaempferols, anthocyanins, quercetin, ellagic acid and catechins; with ellagic acid (ellagitannins) playing a crucial role in blood glucose regulation by the inhibition of the activity of the α – amylase enzyme (an enzyme liable for the breakdown of amylose starch into simple sugars). The inhibition of the activities of α – amylase also moderates the

release of simple sugars into the blood stream. Vitamin C and glutathione are potent antioxidants of which strawberries are great sources of thus making them excellent in antioxidants activities (Törrönen, Sarkkinen, Tapola *et al*, 2010). Glycaemia is all about the presence of glucose in the blood. Glycaemic index (G.I.) is an index that classifies carbohydrate foods based on the effect they have on the body and how it affects blood glucose response over 2 hours. It is used to tell whether an ingested food raises blood glucose slowly, moderately, or quickly, in other words, the glycaemic index can be useful in diabetes management. Though different carbohydrates are digested and absorbed at different rates, the glycaemic index determines how each carbohydrate-based food or drink raises blood glucose levels after eating them. After a meal, the digestion of complex sugars creates a spike in the blood glucose concentration that lasts only a short while. This postprandial glycaemic response is affected by a number of manageable determinants which include dietary carbohydrate profile and the schedule of meal ingestion. Testing blood glucose both before and after a meal grant one a clear understanding of how the ingested meal affects blood glucose levels and also what meals are best

for the control of blood glucose (Pinto, De Carvalho, Lajolo, *et al*, 2010).

This study is set to describe the effect of strawberries on postprandial glycaemia of fasted individuals under two (2) experimental conditions: 1, using a control (corn flakes breakfast cereal with semi-skimmed milk) and, 2, using the control meal supplemented with strawberry the week after; a controlled randomized counterbalanced cross-over study. The volunteers are healthy adults of over 60kg in weight of which 2 are male and 6 females.

Experimental Methods Subjects

A total of eight volunteers were engaged from the department of Nutrition with Public Health Management, Sheffield Business School of Sheffield Hallam University United Kingdom. The health status of the volunteers was checked using a structured questionnaire on allergies, previous and current diseases, current medication, weight, and height. The volunteers were weighed using the Seca – weight model 899 Germany and their heights using the Vernier height gauge. Two healthy adult males and six females aged 25.1 (SD 4.3) years, with weights 67.3 (SD 13.3) kg, BMI 23.6 (SD 4.4), fasting blood glucose levels (test meal) 4.78 (SD 0.08) mmol/l; control meal 5.04 (SD 0.15) mmol/l and, heights 168.8 (SD 12.3) cm respectively, were qualified for this study.

Experimental Design

Each subject participated in the 2 hours' test meal on separate visits of a week apart. Test meals were served in a randomized order and the design was open labelled. Participating subjects were asked to keep habits, body weights and living habits normal (just as it has been before the study commenced) and return fasted on the next following week. The blood glucose tests were carried out between the hours of 09:15 and 11:15am after a 9 – 10 hours overnight fast. Blood samples and tests for baseline was done 10 minutes before the test meal and at 15 minutes, 30 minutes, 45 minutes, 60 minutes, 90 minutes, and 120 minutes respectively after consuming the meals in order to measure the increasing or decreasing blood glucose levels. The meal was to be consumed in 15 minutes' maximum.

Blood Samples and Analysis

Pre-injection swabs (Alcotip) was used to sterilize the fingertip to be pricked, using an Accu- check lancet, the fingertip of the subjects was pricked to collect the blood sample and blood glucose analysed using a glucometer (one touch ultra-2) and test strip (one touch ultra-glucose test strip). Medical wipes (Kimberly - Clark) was then used to wipe off the excess blood on the fingertip and a sterile adhesive placed on the pricked finger after the blood sample has been collected, test done, and finger wiped to stop blood flow.

Test Meals

The study included corn flakes breakfast cereal with semi – skimmed milk and strawberries and a control meal without strawberries. The strawberry meal comprised of a bowl of cornflakes breakfast cereal (43.1g) with 150ml semi – skimmed milk and 100g strawberries. The natural sugar composition of the strawberry was 7.4g. the control meal comprised of 51.3g corn flakes breakfast cereal to counterbalance the carbohydrate content as provided by the strawberry meal; and 150ml semi – skimmed milk. Table 1 shows the nutrient composition of the test meal. Hunger levels of each volunteer were calculated using a 15cm Helix rule. Hunger levels were calculated before the consumption of meals and then at 30 minutes, 60 minutes, and 120 minutes respectively after meals consumption.

Calculations and Statistical Analysis

Data were calculated using the Statistical Package for the Social Sciences (SPSS); a program for windows (SPSS 24.0 (SPSS Inc., Chicago, USA), and results translated as means and standard deviations showing *P* values less than 0.05 which is significant statistically. The overall difference of the statistical significance of the meal variables in normal distributions was evaluated with a general linear model for measures repeated and then was followed by paired sample *T* - tests to analyse the differences at changed time points between the test meals. By subtracting the fasting values from the highest value, the maximum increase from baseline concentrations was calculated. Paired sample *T* - tests was used to determine the differences between the test meals. The statistical concentrations were almost 30% lower after

consumption of the strawberry meal compared to the control meal consumed. The AUC (0 – 120 minutes) of the strawberry's meal blood glucose levels was higher than the control's meal AUC (0 – 120 minutes) though the difference statistically was not significant (table 3). The differences in the blood glucose levels were statistically significant. Although the values for blood glucose doubled after the strawberry meal was consumed compared to the control meal values.

Results

The control meal was consumed in 10.32 minutes and the strawberry meal in 11.23 minutes although the consumption order of the meals did not have any statistical effect on the overall results. There was no significant difference in the blood glucose levels of both the control and test meals. The consumption of the strawberry meal leads to a significantly higher blood glucose level ($P = 0.449$) in the early postprandial phase at 15 minutes' time point than the control meal. Furthermore, 90 minutes after blood glucose level of the strawberry meal was significantly lower than the control meal. The mean AUC (0 – 120 minutes) of blood glucose after the strawberry meal were higher than the mean AUC (0–120 minutes) after the consumption of the control meal though the differences were not significant statistically. The glycaemic values were doubled after consumption of the strawberry meal likened to after the control meal was consumed. Compared to the strawberry meal, the control brought about a significantly lower concentration at 15 minutes and then the concentrations became significantly high at 90 minutes and 120 minutes respectively, although there was no observed difference in the AUC.

Discussion

This study confirms the findings of similar studies of Rosén, Blanco, Andersson, *et al.*, (2009); and Törrönen, Sarkkinen, Tapola, *et al.*, (2010) and also the confirmatory studies of Törrönen, Sarkkinen, Tapola, *et al.* (2011) which showed the valuable effects of various types of berries of which strawberry was inclusive on postprandial glycaemia induced by Rye bread and sucrose respectively. The afore-listed studies found a significantly low blood glucose level at 15 minutes after the berry meal was consumed and a significantly higher blood glucose levels at 90

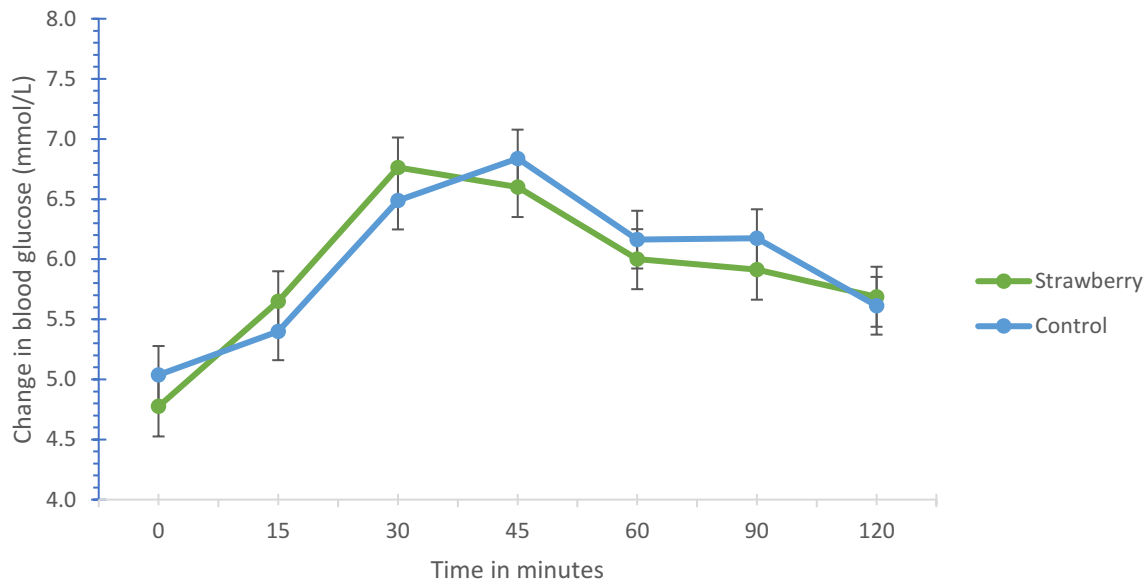
minutes compared to the controlled meal, but this study found a significantly high blood glucose level at 15 minutes after the strawberry meal was consumed and a significantly lower blood glucose levels at 90 minutes as against the control meal. This variation is because in the other studies, various types of berries were used and the population type differed in health status (not all participants were healthy adults; some were diabetic) whereas this study's research was narrowed down to healthy adults. There was a significant difference in blood plasma concentration in the study of Törrönen, Sarkkinen, Tapola, *et al.*, (2010) but in their second study in 2011 (Törrönen, Sarkkinen, Tapola, *et al.*, 2011), the capillary plasma glucose concentration after the berry meal at 30 minutes decreased and was lower than the control meal consumption; likewise the study of Rosén, Blanco, Andersson, *et al.* 2009; this study results, however, are in accord with the aforementioned studies that investigated postprandial glucose insulin and glucagon-like peptide 1 responses to sucrose ingested with berries (Törrönen, Sarkkinen, Tapola, *et al.* 2011), and Endosperm and whole grain rye bread characterized by low postprandial insulin response Rosén, Blanco, Andersson, *et al.* 2009. Though this difference in blood glucose was not significant statistically.

In this study, blood glucose was determined from fingertip pricked glucometer tests. The glucose level maximum increase from the baseline was lower in the hunger response as described in the graphs due to high carbohydrate contents. Brouns, Bjorck, Frayn, *et al.* (2005), believes that glucose sensitivity measurement is more when capillary blood sampling is used. In this study, the different blood glucose levels of the test meals were also reckonable from fingertip pricked blood samples. There was a clear variance in the shape of the blood glucose response curve with an attenuated rise in the early postprandial stage and also a less speedy fall below the fasted level after the strawberry meal was consumed. As a result of the less speedy fall, there was no difference statistically in the 0 – 120 minutes AUC of the test meals as it was also observed by the study of Törrönen, Sarkkinen, Tapola, *et al.* (2010). To illustrate the course of the postprandial glycaemia, Johnston, Clifford & Morgan, (2002), in their study

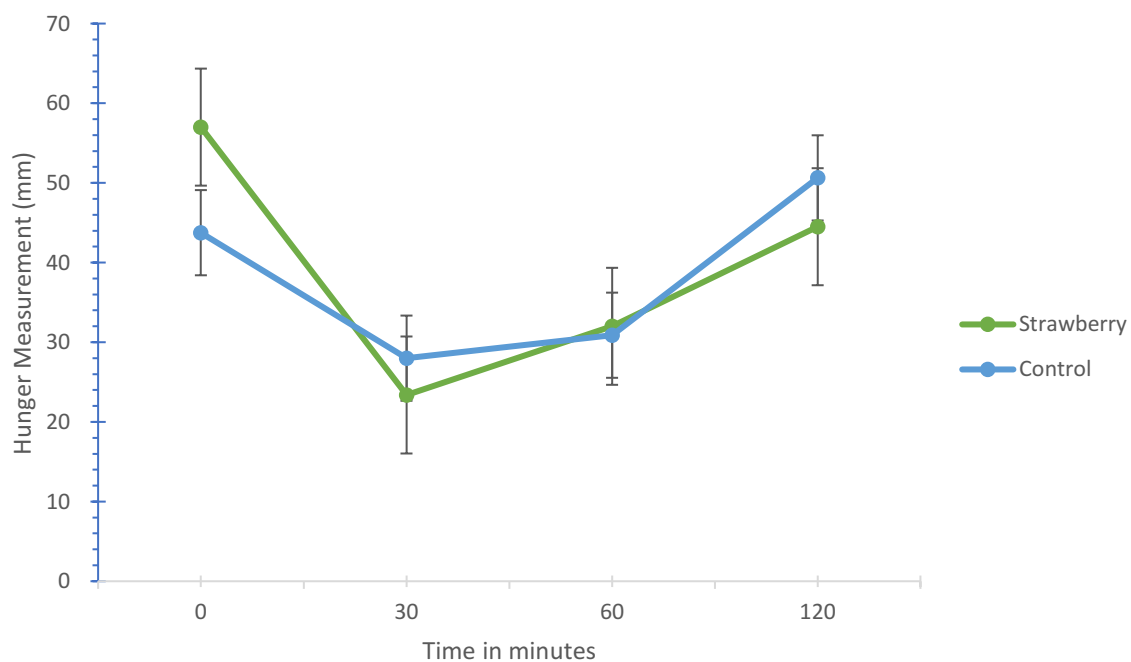
presented a new quantitative feature, “the glycaemic profile” defined as the interval of the incremental postprandial blood glucose response divided by the blood glucose incremental peak. An increased value of the glycaemic profile shows enabled postprandial glycaemic regulation with a reduced glucose peak and a less noticeable hypo-glycaemia. The glycaemic profile for the test meal

was calculated and significantly higher values were observed for the strawberry meal (measured from the fingertip prick sample). Thus, the consumption of strawberries with corn flakes breakfast cereal and semi – skimmed milk clearly enhanced the postprandial glycaemic regulation compared to only corn flakes breakfast cereal and semi – skimmed milk.

Blood Glucose Response



Hunger Responses



Conclusion

In conclusion, from this study; there was a significantly high blood glucose level in the early postprandial phase at 15 minutes time point in the test meal than the control meal and a significantly lower blood glucose levels at 90 minutes as against the control meal though the differences was not significant statistically thus $P < 0.05$ and a 95% confidence interval of the difference which therefore implies that strawberry plays a vital role in glycaemia regulation at a time point after fasting due to the high content of polyphenols especially ellagitannins (in strawberries) that inhibit the activities of α – amylase enzyme which breaks down amylose starch into simple sugars thus decreasing the release of simple sugars into the blood stream thereby regulating blood glucose.

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Conflict of interest

None.

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APPENDIX

Table 1. Nutrient composition of the test and control meals

	Strawberry meal	Control Meal
(g)*	43.1	51.3
Glucose (g) †	7.4	6.2
Fructose (g) †	4.7	0.7
Total fibre (g) ‡	3.4	1.6
Insoluble fibre (g) ‡	3.7	3.6
Carbohydrate (g) *	50	50
Fat (g) ‡	0.23	2.3
Protein (g) ‡		0.9
Vitamin C (mg) ‡	91.0	27.3

* Added to the meal.

† Analysed from the strawberry.

‡ Data from the database of Finland food composition (Fineli^W, Release 11; National Institute for Health and Welfare; www.fineli.fi).

Table 2: Mean values, standard deviations and standard error of tests meal

Glucose mmol/l							
ID	Baseline	15	30	45	60	90	120
1	4.6	5.4	6.6	4.9	3.8	4.8	5.1
2	4.7	6.3	8.1	6.7	4.5	4.3	5.1
3	4.6	6.2	6.9	6.9	5.9	5.7	4.8
4	5.2	4.7	5.8	6.5	7.2	7.6	6.8
5	4.5	5.6	5.9	7	7.3	7.2	6.4
6	4.7	5.1	5.8	6.8	6.3	5.4	6.4
7	5	5.3	6.8	7.1	6.5	6.2	5.4
8	4.9	6.6	8.2	6.9	6.5	6.1	5.5
Time	0	15	30	45	60	90	120
Mean	4.78	5.65	6.76	6.60	6.00	5.91	5.69
SD	0.24	0.66	0.96	0.71	1.24	1.12	0.74
SEM	0.08	0.23	0.34	0.25	0.44	0.40	0.26

Table 3: Maximum increases from the hunger baseline and Area Under the Curve (AUC) for glycaemic profiles after consumption of the test meals

AUC	Max increase	Hunger (mm)				AUC
		Baseline	30	60	120	
42	2	100	4	21	43	-6105
94.5	3.4	82	26	29	54	-3690
158.3	2.3	34	24	40	55	195
162	2.4	22	44	54	63	2235
247.5	2.8	70	20	15	10	-4050
136.5	2.1	62	18	23	33	-2925
138.8	2.1	6	11	24	28	1020
186	3.3	80	40	50	70	-2250
Mean		57.00	23.38	32.00	44.50	
SD		32.85	13.51	14.32	19.96	
SEM		11.61	4.78	5.06	7.06	

Table 4: Statistics of Subjects

	Ht (cm)	Wt (kg)	Age	Sex	TREATMENT
	164	63	34	F	STRAWBERRY
	193	80	21	M	STRAWBERRY
	165	51	26	F	STRAWBERRY
	161	78.2	26	F	STRAWBERRY
	158	44.7	24	F	STRAWBERRY
	162.3	76.3	22	F	STRAWBERRY
	183	76	21	M	STRAWBERRY
	164	68.8	27	F	STRAWBERRY
Mean	168.79	67.25	25.13		
SD	12.35	13.28	4.29		

Table 5: Control Meal Glucose mmol/l

ID	Baseline	15	30	45	60	90	120
1	4.9	5.2	6.7	7	5.2	5.4	5.3
2	5.1	5.7	6.1	6.2	6.4	5.3	5
3	5.1	5.6	7.4	7.4	5.2	5.9	4.7
4	4.7	4.7	6.2	7.6	8.2	7.9	7.3
5	4.6	4.8	5.6	6.1	6.3	7.4	7.2
6	4.8	5.3	6.3	6	6.7	5.9	5.3
7	5.1	5.7	7.2	7.7	5.1	5.1	5
8	6	6.2	6.4	6.7	6.2	6.5	5.1
Time	0	15	30	45	60	90	120
Mean	5.04	5.40	6.49	6.84	6.16	6.18	5.61
SD	0.43	0.50	0.59	0.69	1.04	1.02	1.03
SEM	0.15	0.18	0.21	0.24	0.37	0.36	0.36

Table 6: Maximum increases from the hunger baseline and Area Under the Curve (AUC) for glycaemic profiles after consumption of the test meals

AUC	MAX INCREASE	Hunger (mm)							
		Baseline	30	60	120	AUC	Sex	TREATMENT	
90.75	2.1	100	36	39	57	-4395	F	CONTROL	
74.25	1.3	21	23	25	22	195	M	CONTROL	
96.75	2.3	20	15	32	52	690	F	CONTROL	
279.8	3.5	53	34	30	83	-810	F	CONTROL	
201.8	2.8	30	10	5	5	-1725	F	CONTROL	
131.8	1.9	65	17	10	49	-3330	F	CONTROL	
78	2.6	12	19	36	47	1445	M	CONTROL	
25.5	0.7	49	70	70	90	1875	F	CONTROL	
	Mean	43.75	28.00	30.88	50.63				
	SD	29.30	19.21	19.87	28.18				
	SEM	10.36	6.79	7.03	9.96				

Table 7: Mean glucose responses

	Strawberry	Control		Strawberry	Control
0	4.78	5.04	0	57.00	43.75
15	5.65	5.40	30	23.38	28.00
30	6.76	6.49	60	32.00	30.88
45	6.60	6.84	120	44.50	50.63
60	6.00	6.16			
90	5.91	6.18			
120	5.69	5.61			