

# Results from the Dietary Intervention on the effects of Apples on cardioVascular function And Gut health (AVAG study)

This newsletter has been written to inform you of the results of the AVAG study. Since the study ended we have been busy analysing the large quantities of data and are currently in the process of publishing our results in scientific journals. Below is an overview of what we did, why we did it and what we found out...

## **Background of the AVAG study**

Cardiovascular disease (CVD) is the no. 1 cause of death in the UK. Our risk of developing CVD is influenced by diet. Many studies have shown that a regular consumption of fruits and vegetables may improve human health and reduce the risk of CVD as well as other chronic diseases such as certain cancers and type 2 diabetes. Apples are among the most frequently consumed fruits in the world and an important source of polyphenols and fibre. Polyphenols are a complex class of organic molecules that can protect the human body from oxidative damage and, thus, could protect us against chronic diseases. Fibre, on the other hand, is an indigestible carbohydrate (that is usually part of plant foods) with many health effects, mainly by feeding the good bacteria in our gut and easing bowel movements.



## **The purpose of the AVAG study**

The aim of this study was to explore whether daily intake of 2 apples (Renetta Canada variety) reduces the risk of CVD and improves human health compared to 500 ml of an apple beverage/juice (sugar matched control) by:



### **i. Lowering cholesterol levels**

Cholesterol is a fat-like substance that is found in all the cells of the human body. We need cholesterol to make several hormones, vitamins and substances that help us digest our food, called bile acids. Cholesterol can only be carried around the body when it is covered by proteins, forming particles known as lipoproteins (cholesterol on the inside and proteins on the outside). The two main types of lipoproteins that carry cholesterol throughout the body are LDL (low density lipoprotein) cholesterol, also known as bad cholesterol, because it is associated with the blockage of the blood vessels and HDL (high density lipoprotein) cholesterol, known as good cholesterol because it is related with the removal of cholesterol from tissues. High levels of LDL cholesterol in our blood could lead to plaque formation in heart arteries which could increase the chance of heart disease. Hypercholesterolemia (high blood cholesterol) is a condition with no signs or symptoms thus, it is important to check our cholesterol levels often. Some studies indicate that apple polyphenols could bind to our cholesterol and/or bile acids and enhance its excretion through faeces which could result in lower cholesterol levels in the human body.

### **ii. Improving gut bacterial composition**

The human gut is colonised by trillions of beneficial and harmful bacteria which can affect numerous processes in our body. Through our diet by consuming food products rich in fibre and polyphenols, such as apple, we may increase the beneficial bacteria such as Bifidobacterium and Lactobacillus and decrease harmful bacteria such as certain clostridia and enterobacteria and thus, improve our health.

### **iii. Improving vascular function**

Apple polyphenols have been shown to increase nitric oxide levels in our blood. Our arteries produce nitric oxide which improves blood flow and lowers blood pressure by increasing the diameter of the vessels and maintaining healthy blood vessels.

## Volunteer profile

Our volunteers were non-smoking healthy men and women aged 23-69 years (average 51 years). In total, 43 volunteers participated with 40 completing all 20 weeks.



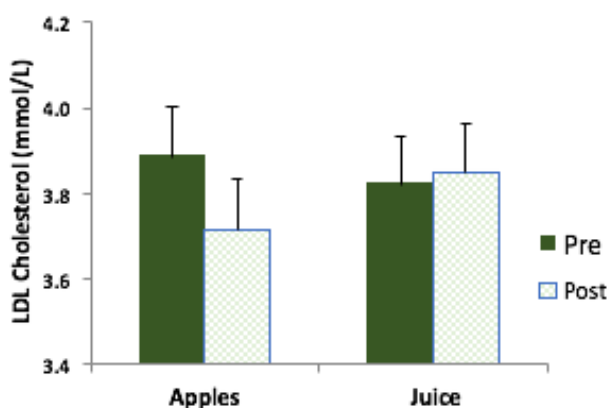
## Study design

Volunteers were asked to consume daily 2 apples or 500 ml of a control apple beverage, each for 8 weeks in a random order with a 4 week wash out period between treatments.

## What did our research show?

### Blood results

Using your fasted blood samples, we analysed blood lipids and other markers of cardiovascular health. These included **total cholesterol** and **low-density lipoprotein cholesterol (LDL-C** or 'bad' cholesterol), both of which are linked to an increased risk of CVD when present at high levels. We have found that LDL-C significantly decreased by 4.3% after the daily intake of the 2 Renetta Canada apples compared to the control juice (Figure 1). Based on findings by others, we were able to estimate that these reductions in LDL-C could potentially reduce the risk of developing CVD by 6.5-7 %.



**Figure 1.** Change in LDL-Cholesterol after the daily intake of 2 apples or a control juice each for 8 weeks.

We also analysed a number of blood biomarkers that are involved in the onset of atherosclerosis (i.e. clogging



of the arteries). Following the apple diet a significant reduction in a protein called **vascular cell adhesion molecule-1 (VCAM-1)** was observed. High levels of VCAM-1 are often associated with poor blood vessel health.

### Faecal results

Using your faecal samples, we explored potential changes in gut bacteria population. We have found that the Enterobacteriaceae population decreased significantly after the daily intake of 2 Renetta Canada apples compared to the control juice. Enterobacteriaceae is a family that includes, along with harmless bacteria, many potential pathogens.

### Urine results

Using your 24-hour urine, we have identified several metabolites related to the polyphenols found in apples. Some of them are products of gut microbiota activity showing that a major amount of apple polyphenols is reaching the colon where they are modified by gut bacteria producing phenolic metabolites. These are absorbed, appear in blood circulation possessing potential beneficial effects, and then excreted in urine where we could detect them.

### Vascular function and blood pressure

During the study visits we measured the health of your arteries using **Laser Doppler Imaging** (where your forearm blood vessels were monitored in response to chemical stimuli). We also measured the stiffness of your blood vessels using **Pulse Wave Analysis** (pulse in your wrist). Finally, **blood pressure** was measured for 30 minutes using an ambulatory blood pressure monitor. Our results showed that apple diet did not affect these measurements. It has since then been speculated that dietary changes of longer than 8 weeks may be required for any changes to be observed on blood flow or apples may possess beneficial effects through other mechanisms.



### Dietary intake and Compliance

To assess the success of the AVAG diets, we recorded your dietary macronutrient intake (lipids,

proteins and carbohydrates) as well as the fibre and polyphenol intake using **4-day diet diaries**.

We have shown that during the apple intervention, daily intake of fibre and polyphenols significantly increased by 26% and 68% respectively. Moreover, your daily energy, carbohydrate, fat and protein intake did not change throughout the interventions nor did your weight or body fat % (measured with **Tanita body composition analyser**).

### **What do these results mean?**

With your help, we demonstrated that incorporating 2 apples daily in your normal habitual diet can have beneficial effects on human health by:

1. Decreasing blood LDL cholesterol and improving markers related to blood vessel health.
2. Inhibiting potential pathogenic gut bacteria.
3. Producing beneficial metabolites in the gut which also appear in blood circulation.

Therefore, eating more apples could reduce the risk of developing CVD but also improve gut health.

It is important to note that the World Health Organization recommends eating a minimum of 400 g or 5 portions of fruits and vegetables a day to lower the risk of serious health problems such as heart disease, stroke and some cancers.

To get maximum benefits, you also need to eat different types of fruit and vegetables. This is because different fruit and vegetables contain different combinations of fibre, polyphenols, minerals and other nutrients.

### **Once again, thank you!**

Thank you for participating in the AVAG study; your contribution to our research is incredibly valuable. We hope that you enjoyed your experience as volunteers on the AVAG study and that you will consider taking part in our future research. Details of current studies can be found below.

