



Health Benefits of Blackcurrants – a review of the research

1.0 How the review has been carried out

Blackcurrant extracts contain a range of antioxidant compounds, including anthocyanins, other polyphenols and vitamin C, which are reported to have a range of health benefits. The NZ Blackcurrant Cooperative Ltd (NZBC) has undertaken an independent review of some of these benefits to make more readily available the published scientific information on the health benefits of blackcurrants. This review is a collation and summary of this information and does not represent a claim by the NZBC with regard specific health benefits from the consumption of blackcurrants.

All information is based on sound science sourced from studies published in peer reviewed science journals and books. Evidence from clinical trials is reported where it exists. Clinical trial results reported here were obtained from randomised, double-blind, placebo-controlled, cross-over trials, and a treatment effect is only reported if it is statistically significant.

A detailed summary for each of the 13 clinical trials are presented in Section 2. A summary of laboratory studies on the effects of blackcurrants is presented in section 3.

Berry equivalence

Several studies report amounts of blackcurrant extract ingested that were between 50-80 mg anthocyanin in about 500 mg powder. To put this in perspective, this is equivalent to the anthocyanin in about 13 berries i.e. about a small handful.

This calculation is based on:

- There are a range of values for the anthocyanin content of NZ berries. However, 6mg anthocyanin per g fresh weight would be an average.
- A berry is about 1 g.
- Thus 13 berries contain about 78 mg.

Terms used

Polyphenol-the term is used broadly to include phenolics, flavonoids and anthocyanins

Placebo - a placebo is an inactive look-a-like.

Double blind - neither the individuals nor the researchers know who belongs to the control group and the experimental group.

in vitro - literally "in glass" and meaning in the laboratory.

in vivo – "in the living organism" and refers to studies performed on animals

Statistically significant - this means that there is a very low chance of the result having occurred randomly. For example; this may be shown by stating that the result is significant at the 1% level i.e. the chances of it happening randomly are 1 in 100. Alternatively a p value may be used e.g. $p < 0.008$ which means there is a 1 in 120 chance.

2.0 Summary of the individual clinical trials

A summary of each trial is presented below. The published paper they are based on is referenced by the number in brackets.

2.1 Cardiovascular Health and Vascular Inflammation

Many epidemiological studies have shown that an increased intake of polyphenols (including blackcurrant polyphenols) lowers the risk of cardiovascular disease, through an improvement in:

- blood pressure,
- lipid levels in the blood, and
- biomarkers such as
 - Nitric oxide, NO (a potent vasodilator)
 - Vascular inflammation and
 - Endothelial function (endothelium: the inner lining of blood vessels).

These are summarised in the review paper by Wallace 'Anthocyanins in Cardiovascular Disease' (1), and other papers (2, 3). Clinical trials with blackcurrants are reported below.

Clinical trials with blackcurrants for cardiovascular health (4, 5)

- In a short-term crossover study, 12 individuals with high levels of blood cholesterol consumed anthocyanins (320 mg) isolated from blackcurrants or a placebo. Brachial artery flow-mediated dilation (FMD) was assessed before and after the intervention.
- In a long-term intervention trial (12 weeks), 150 individuals with high levels of blood cholesterol were given anthocyanins (320 mg/day, n = 75) or placebo (n = 75), after which FMD, plasma cyclic guanosine monophosphate (cGMP), and other serum biomarkers were measured.
- Another short-term intervention was conducted in the presence of Nitric Oxide-cGMP inhibitors in 6 people and in a rat aortic ring model (n = 8).

RESULTS: Significant increases of FMD were observed after short-term anthocyanin consumption, with increases of plasma anthocyanin concentrations ($P < 0.05$). In the study participants who received long-term anthocyanin intervention, compared with the control group, observed significant increases in the FMD and HDL-cholesterol ("good" cholesterol) concentrations, and decreases in the serum soluble vascular adhesion molecule-1 and LDL cholesterol ("bad" cholesterol) concentrations ($P < 0.05$). The changes in the cGMP and HDL cholesterol concentrations positively correlated with FMD in the anthocyanin group ($P < 0.05$). In the presence of Nitric Oxide-cGMP inhibitors, the effects of anthocyanin on endothelial function were abolished in human participants and in a rat aortic ring model.

CONCLUSIONS: Anthocyanin supplementation improves endothelium-dependent vasodilation in individuals with high levels of blood cholesterol. This effect involves activation of the Nitric Oxide-cGMP signaling pathway, improvements in the serum lipid profile, and decreased inflammation.

In a further clinical trial the antioxidative effects of various beverages, *in vitro*, and also the effects *in vivo* on serum antiatherogenic macrophage cholesterol accumulation and foam cell formation were determined. These are the hallmark of early atherogenesis¹. Six healthy subjects consumed 100% blackcurrant juice, richest in polyphenols, for a week. This treatment modestly, but significantly, decreased

¹ Atherogenesis is the process of forming atheromas, plaques in the inner lining (the intima) of arteries.

serum-induced cholesterol accumulation in macrophages. The reduction in macrophage cholesterol mass, however, was not the result of increased cholesterol efflux from the cells. In fact, it is probably the result of inhibition of cholesterol-rich lipoprotein uptake by the cells, mediated by serum associated polyphenols and/or polyphenol metabolites.

Effects of blackcurrant juice and orange juice on markers of vascular inflammation and cardiovascular risk (6)

Vascular inflammation is an important contributing factor to cardiovascular disorder. This study looked at the effects of blackcurrant and orange juices on markers (indicators) of vascular inflammation in patients with peripheral arterial disease. The markers were C-reactive protein and fibrinogen. Lower levels of both markers are considered desirable and indicate lower risk.

This was a randomised, double-blind, placebo-controlled, cross-over study of four weeks duration. Study size was 48. Subjects drank 250 ml of blackcurrant juice and 250 ml of orange juice daily. A sugar drink placebo was used.

At the completion of the study, there were statistically highly significant decreases in the levels of each of C-reactive protein and fibrinogen. There was an 11% decrease in C-reactive protein, ($p < 0.008$); and a 3% decrease in fibrinogen ($p < 0.002$).

The study supports the view that increased intake of fruit products such as blackcurrant and orange juice decreases the risk of cardiovascular disorder.

Effect of blackcurrants on blood flow (7)

This was a randomised double-blind, placebo-controlled, cross-over study using nine female subjects (age 22 to 34). The subjects had daily subjective symptoms of chill, caused by peripheral circulation disorder, and used 50mg blackcurrant anthocyanin.

After soaking the right hand in cold water of 10 degrees centigrade for one minute, images were taken of the hand using thermography and blood flow volume measured every minute (up to 30 minutes) until the hand returned to resting level. Body temperature did not return to normal after 15 minutes without blackcurrant consumption. In contrast, however, body temperature began to return to normal 10 minutes after blackcurrant consumption.

Effects of blackcurrant intake on peripheral blood circulation during typing work (8)

This was a randomised double-blind, placebo-controlled, cross-over study. Study size was 10 people. Blackcurrant powder was prepared from liquid concentrate. The powder had an anthocyanin concentration of 10%.

There were two parts to the study - 1) the effect of blackcurrants on peripheral circulation during rest, and 2) during typing work.

1. Blackcurrant effects during rest

- Subjects ingested 17 mg powder capsule/kg subject weight for the resting study
- What was measured:
 - Anthocyanin content in plasma
 - Forearm blood flow

- Muscle oxygen consumption
 - Total hemoglobin and oxygenated hemoglobin
 - Electromyography of the right trapezius muscle.
- The results:
 - Anthocyanin content of plasma reached maximum after 1 hour, decreased to 50% by 4 hours.
 - Forearm blood flow increased significantly (about 40%) compared to placebo.
 - No effect on muscle oxygen consumption.

2. Blackcurrant effects during typing

- Subjects ingested 7.7 mg powder capsule/kg subject weight
- What was measured:
 - Total hemoglobin and oxygenated hemoglobin
 - Electromyography of the right trapezius muscle.
- The results:
 - Total hemoglobin was significantly higher (about 40%) in the blackcurrant intake group.
 - Oxygenated hemoglobin was significantly higher in the blackcurrant intake group.
 - Significant stiffening of the trapezius muscle during typing in the placebo but not the blackcurrant intake group. However, final stiffness not significantly different between the two.
 - No effect on blood pressure, heart rate, subjective pain and typing performance.

When the circulation is disturbed by compression of the blood vessels resulting from continuous muscle contraction removal of metabolites such as lactic acid becomes insufficient and leads to development of muscle stiffness. The study shows a vasodilatory² effect of blackcurrants.

Blackcurrants may reduce muscle stiffness by increasing peripheral blood flow and reducing muscle fatigue. Additional laboratory studies with animal models have shown direct effects of anthocyanins on improving blood peripheral circulation (not referenced below).

2.2 Diet and Exercise

Effects of blackcurrant powder on exercise-induced oxidative stress (9)

Exercise induces oxidative stress in the body. Dietary antioxidant supplements and foods are commonly used to limit such stress after exercise. This study looked at the effectiveness of blackcurrant powders containing high levels of anthocyanins to mitigate exercise induced stress.

This was a double blind placebo controlled cross over study of three weeks duration. Study size was 10 healthy subjects who exercised regularly about three times a week. Subjects consumed four capsules containing 240mg anthocyanin (two pre and two post exercise) equivalent in total to about 48 g whole blackcurrants (this corresponds to about 1/3 cup berries). A sugar placebo was used.

² Vasodilation refers to the widening of blood vessels resulting from relaxation of smooth muscle cells within the vessel walls. When vessels dilate, the flow of blood is increased due to a decrease in vascular resistance. Therefore, dilation of arterial blood vessels (mainly arterioles) leads to a decrease in blood pressure.

- What was measured:
 - Three plasma oxidative stress parameters
 - Effects on cytokines and other immune system regulatory factors, as measured in a laboratory assay of inflammatory response generated by bacterial endotoxins.
- The results:
 - Blackcurrant powder reduced exercise induced oxidative stress as shown by significantly lower levels of protein carbonyls, oxidative capability, and creatine kinase activity ($p < 0.05$)
 - After exercise blood samples, from the subjects fed blackcurrant powder, showed a significant ($p < 0.05$) ability to suppress inflammatory responses as measured by cytokines and other regulatory factors in the above laboratory assay.

The researchers concluded that blackcurrant extracts taken at the appropriate time and amount, can augment the ability of regular exercise to enhance the immune responsiveness of the body.

Inflammatory response and diet (10)

This study showed, for the first time, direct evidence on the role of diet in modulating inflammatory response in healthy overweight subjects. In a double blind, randomized, placebo controlled, crossover study of fourteen healthy overweight humans, the study showed that when a fruit juice drink composed of pineapple, blackcurrant and plum was taken with a high fat meal, there was a highly significant effect on inhibition of IL-17 (a biomarker of inflammatory response).

Glycaemic control and clinical trials (11, 12)

Two recent clinical trials have shown berries rich in polyphenols decrease the postprandial glucose response of sucrose in healthy subjects. The delayed and attenuated glycaemic response indicates reduced digestion and/or absorption of sucrose from the berry meal. Diets with a high glycaemic response may be associated with increased risk of obesity, type 2 diabetes and CVD (cardiovascular disease). Previous studies have suggested that polyphenols may influence postprandial glycaemia (presence of glucose in the blood following a meal).

The trial investigated the glycaemic effect of a berry puree made of bilberries, blackcurrants, cranberries and strawberries, and sweetened with sucrose. A total of twelve healthy subjects (eleven women and one man, aged 25–69 years) with normal fasting plasma glucose ingested 150 g of the berry puree with 35 g sucrose or a control sucrose load in a randomised, controlled cross-over design. After consumption of the berry meal, the plasma glucose concentrations were significantly lower at 15 and 30 min and significantly higher at 150 min compared with the control meal. The peak glucose concentration was reached at 45 min after the berry meal and at 30 min after the control meal.

Effect of anthocyanins on fibromyalgia (13)

Fibromyalgia is a condition of chronic widespread musculo-skeletal pain, particularly in the neck and shoulders, knees and elbows, and lower back.

This was a randomised double-blind, placebo-controlled, cross-over study of four treatment periods of 12 weeks each. Study size was 10. Subjects ingested 40, 80 or 120 mg anthocyanin per day, from a proprietary product based on extracts of grape seeds, and berries.

- What was measured:
 - Severity of pain symptoms
 - Fatigue and sleep disturbance
 - Patients assessment of treatment
 - General health questionnaire.
- The results:
 - There was a very significant effect (at 1% level) on reduction in sleep disturbance, as assessed by subject's diary record.
 - There was a significant improvement in the general health questionnaire.
 - There was a significant improvement in the severity of fatigue (at 1% level) as assessed by the investigator.
 - The best treatment was 80 mg/day.

The authors concluded that anthocyanins were beneficial for people suffering from this difficult chronic condition.

2.3 Organ Health

Effect of blackcurrants on dark adaptation and visual fatigue (14)

This was a randomised double-blind, placebo-controlled, cross-over study. Study size was 12. Subjects ingested up to 135, 270 and 540 mg blackcurrant powder for the dark adaptation test and 50 mg equivalent blackcurrant powder for the transient refractive alteration test.

- What was measured:
 - Dark adaptation threshold
 - Video display terminal (VDT) transient refractive alteration
 - Visual fatigue (asthenopia)
- The results
 - Dark adaptation was significantly improved at the highest level of 540 mg blackcurrant powder (50 mg anthocyanin);
 - There were no significant effects on VDT transient refractive alteration;
 - Visual fatigue was significantly reduced with blackcurrant treatment;
 - Lower back fatigue was significantly reduced with blackcurrant treatment.

The effects are considered to be mediated by increased blood flow in the peripheral circulation.

Effects of blackcurrant on kidney function (15, 16)

Two clinical trials showed a positive effect on kidney function.

In the first study the consumption of 330 ml blackcurrant juice daily for five days increased the

- urinary pH
- excretion of citric acid
- excretion of oxalic acid.

It is suggested that regular blackcurrant consumption could reduce the likelihood of kidney stone development as persistently low urinary pH is a significant factor for uric acid kidney stone formation.

In another study residents of a nursing home were given a daily glass of blackcurrant juice for 3 months. Residents reported reduced symptoms of urinary scalding, urgency and odour. Staff noted improvements in white cell count on urinalysis and reduced likelihood of recurrent urinary tract infection over a three month period.

3.0 Summary of laboratory studies

3.1 Laboratory study on allergen-induced asthma

Effect of blackcurrant extract epigallocatechin on markers of airway inflammation, (17)

A 2010 New Zealand *in vitro* laboratory study looked at the effectiveness of blackcurrant extract, enhanced for proanthocyanidins, and a purified component of blackcurrant extract, epigallocatechin, to reduce the high levels of eosinophils that result in airway inflammation and tissue damage in asthma. The *in vitro* study with human alveolar epithelial cells showed significant suppression of two of the responses in the immune response cascade:

- eotaxin-3 (CCL26) and
- phosphorylation of STAT-6.

In addition, the blackcurrant proanthocyanidin extract was able to act synergistically with IFN- γ to enhance the suppression CCL26 secretion in alveolar epithelial cells.

This study shows that it is feasible that components of blackcurrants may be taken up by the digestive tract into the bloodstream, and reduce eosinophils and airway inflammation.

3.2 Laboratory studies on antiviral activity

Summary of laboratory studies on antiviral activity (18, 19)

Blackcurrants have been shown to have properties that restrict the infection rate of viruses such as the common cold and flu viruses, including influenza A and B.

Research on the antiviral activity of blackcurrants has been carried out on both cultured cells *in vitro* and *in vivo* mouse models.

- For studies on cells cultured in a laboratory, the following was measured:
 - viral plaque formation
 - infectivity of the virus
 - growth of the virus in cells
 - release of the virus from infected cells.
- In the study on mice, the following was measured
 - infectivity of the virus
 - mortality rates
 - mode of action

- The results
 - both studies showed blackcurrant extract to possess antiviral activity.
 - In one *in vitro* experiment it was found that cells infected by influenza virus type A (IVA) or influenza virus type B (IVB) had their rate of infection almost stopped when blackcurrant extract was applied.
 - In another experiment, addition of virus and extract simultaneously to cells resulted in infection rates 2 - 5% of that observed when only virus was added.
 - Mice fed extract exhibited reduced virus accumulation and improved mortality
 - Fractionation of extract demonstrated antiviral activity is possessed by the polyphenol containing fraction
 - Polyphenols act on haemagglutinin³, inhibiting a virus's ability to enter infect a cell and reproduce within it.

3.3 Laboratory studies on cholesterol and endothelia

Animal model trials (20-23)

Black currant fruit extracts were intravenously administered to hypercholesterolemic rabbits. The levels of triglyceride, total cholesterol and low-density lipoprotein cholesterol markedly decreased, whereas the level of high-density lipoprotein cholesterol normalized after treatment with the fruit extract. The results indicated that blackcurrant fruits can reduce the levels of blood lipids in experimental rabbits.

Blackcurrant fruit juice applied to isolated pig arteries, and rat aorta was a potent inducers of endothelium-dependent relaxation, in a concentration dependent manner. Similarly, a blackcurrant extract protected human umbilical vein endothelial cells from experimentally induced injury.

3.4 Laboratory study on probiotics

Probiotic bacteria enhanced (24)

In this animal study rats were fed blackcurrant powder three times weekly for a month. This treatment was very effective at promoting the growth of lactobacilli and bifidobacteria, which are beneficial probiotic bacteria, in the caecum (the first part of the large intestine) of these rats.

3.5 Laboratory study on chemoprevention

Chemopreventive effects in cell systems (25, 26)

A recent paper reviewed the studies of the effects of blackcurrants on tumour cells.

In vitro pharmacological effects were shown for whole fruit extract on the following cancer cell types:

- HT29 colon cancer
- MCF-7 breast cancer cells
- HeLa cervical cancer cells
- Prostate cancer cells
- HepG2 human liver cancer cells.

Mechanisms for the effects were dose dependent and included:

- inhibition of cancer cell growth
- decreased the proliferation of cancer calls

³ haemagglutinin is the molecule on the surface of viral particles that binds the virus to cells it is infecting

- reduced cell viability.

There are two *in vivo* studies of pharmacological effects of dietary blackcurrant fruit extract in transplanted tumour models in animals:

- Solid tumour growth was reduced in Ehrlich carcinoma bearing mice
- There was an inhibition incidence, multiplicity, size and volume of nodules in cells giving rise to liver cancer in rats as well as suppression of abnormal cellular proliferation.

Note: There are no clinical trials on the dietary effect of blackcurrant extracts on tumour cells.

References

1. Wallace, T.C. Anthocyanins in Cardiovascular Disease. *ADVANCES IN NUTRITION* 2008, 2:1-7.
2. K. Iwasaki-Kurashige, R. Y. Loyage-Rendon, H. Matsumoto, T. Tokunaga and H. Azuma, Possible mediators involved in decreasing peripheral vascular resistance with blackcurrant concentrate (BC) in hind-limb perfusion model of the rat, *VASC. PHARMACOL.*, 2006, 44, 215–233.
3. I. Edirisinghe, K. Banaszewski, J. Cappozzo, D. McCarthy and B. M. Burton-Freeman, Effect of blackcurrant anthocyanins on the activation of endothelial nitric oxide synthase (eNOS) in vitro in human endothelial cells, *J. AGRIC. FOOD CHEM.*, 2011, 59, 8616–8624.
4. Zhu, Yanna Xia, Min Yang, Yan Liu, Fengqion gLi, Zhongxia Hao, Yuanta Mi, Mantia Jin, TianruLing, Wenhua. Purified Anthocyanin Supplementation Improves Endothelial Function via NO-cGMP Activation in Hypercholesterolemic Individuals. *CLINICAL CHEMISTRY* 2011, 57 1524-1533.
5. M. Rosenblat, N. Volkova, J. Attias, R. Mahamid and M. Aviram, Consumption of polyphenolic-rich beverages (mostly pomegranate and blackcurrant juices) by healthy subjects for a short term increased serum antioxidant status, and the serum's ability to attenuate macrophage cholesterol accumulation, *FOOD FUNCT.*, 2010, 1, 99–109.
6. Dalgard, C., Nielsen, F., Morrow, J.D., Enghusen-Poulsen, H., Jonung, T., Hørder, M., de Maat, M.P.M. Supplementation with orange and blackcurrant juice, but not vitamin E, improves inflammatory markers in patients with peripheral arterial disease. *BRITISH JOURNAL OF NUTRITION* 2009, 101:263-269.
7. Takenami, E. Kurashige, K.I. Matsumoto, H. Honma, T. Osada, T. Okubo, M. Hamaoka, T. Improvement of cold water immersion induced circulation impairment by blackcurrant extract intake-the investigation on cold constitutional women. *THE JOURNAL OF THE JAPANESE SOCIETY OF THERMOLOGY* 2004, 23: 194-201
8. Matsumoto, H., Takenami, E., Iwasaki-Kurashige, K., Osado, T., Katsumura, T., Hamaoka, T. Effects of blackcurrant anthocyanin intake on peripheral muscle circulation during typing work in humans. *EUROPEAN JOURNAL APPLIED PHYSIOLOGY* 2005, 94: 36-45

9. Lyall, K. A., Hurst, S. M., Cooney, J., Jensen, D., Lo, K., Hurst, R. D., Stevenson L. M. Short-term blackcurrant extract consumption modulates exercise-induced oxidative stress and lipopolysaccharide-stimulated inflammatory responses. *AM J PHYSIOL REGUL INTEGR COMP PHYSIOL* 2009, 297: 70–81.
10. Peluso, Ilaria Raguzzini, Anna Villano, Debora V Cesqui, Eleonora Toti, Elisabetta Catasta, Giovina Serafini, Mauro. High Fat Meal Increase of IL-17 is Prevented by Ingestion of Fruit Juice Drink in Healthy Overweight Subjects. *CURRENT PHARMACEUTICAL DESIGN* 2012, 18: 85-90.
11. Torronen, Riitta Sarkkinen, Essi Tapola, Niin Hautaniemi, Elina Kilpi, Kyllikki Niskanen, Leo. Berries modify the postprandial plasma glucose response to sucrose in healthy subjects. *BRITISH JOURNAL OF NUTRITION* 2010, 103: 1094-1097.
12. Torronen, Riitta Sarkkinen, Essi Niskanen, Tarja Tapola, Niina Kilpi, KyllikkiNiskanen, Leo. Postprandial glucose, insulin and glucagon-like peptide 1 responses to sucrose ingested with berries in healthy subjects. *BRITISH JOURNAL OF NUTRITION* 2012, 107:1445-1451
13. Edwards, A.M., Blackburn, L., Townsend, S., David, J. Food supplements in the treatment of primary fibromyalgia: a double-blind, crossover trial of anthocyanidins and placebo. *JOURNAL OF NUTRITIONAL & ENVIRONMENTAL MEDICINE* 2000, 10: 189-199.
14. Nakaishi, H., Matsumoto, H., Tominaga,S., Hirayama, M. Effects of blackcurrant anthocyanoside intake on dark adaptation and VDT work induced transient refractive alteration in healthy humans. *ALTERNATIVE MEDICINE REVIEW* 2000, 5: 553-562
15. Kebler, T., Jansen, B., Hesse, A. Effect of blackcurrant, cranberry and plum juice consumption on risk factors associated with kidney stone formation. *EUROPEAN JOURNAL OF CLINICAL NUTRITION* 2002, 56: 1020-1023.
16. Boyle, L., Martin, J., Tilley A., Ager, C., Payne, B. Study of use of Blackcurrant Juice in Nursing Home Residents to Alleviate Urinary Infection and Associated Problems. Aged care Unit, Julia Farr Services, FLINDERS UNIVERSITY AUSTRALIA NOV 1996.
17. Hurst, S. M., McGhie, T.K., Cooney, J., Jensen, D., Gould, E.M., Lyall, K. A., Hurst, R. D. Blackcurrant proanthocyanidins augment IFN- γ -induced suppression of IL-4 stimulated CCL26 secretion in alveolar epithelial cells. *MOLECULAR NUTRITION & FOOD RESEARCH* 2010, 54: S159–S170
18. Knox, M.Y., Suzutani, T., Yosida, I., Azuma, M. Anti-influenza virus activity of crude extract of *Ribes nigrum* L. *PHYTOTHERAPY RESEARCH* 2003, 17: 120-122.
19. Noguchi, A., Takeda, T., Watanabe, T, Yasui, H. Inhibitory effect of Cassis extract against influenza virus infection. *JOURNAL OF THE FACULTY OF AGRICULTURE, SHINSHU UNIVERSITY* 2008, 44 No. 1.2.
20. Li GuoQing Wu SongLin Ababarri, S. Study on impact of blackcurrant and *Lonicera caerulea* fruit on rabbits with hyperlipemia. *ENDEMIC DISEASES BULLETIN / DI FANG BING TONG BAO* 2009, 2 14-19.
21. Auger, Cyril Kim, Jong-HunTrinh, Sandrine Chataigneau, Thierry Popken, Anne M. Schini-Kerth, Valerie B. Fruit juice-induced endothelium-dependent relaxations in isolated porcine coronary arteries: evaluation of different fruit juices and purees and optimization of a red fruit juice blend. *FOOD & FUNCTION* 2011, 2: 245-250.

22. Li Zhao, Xiaogu Ma, Long Re, Ziy Gu, YajingTu, Erxunjiang . Experiment study of blackcurrant on vascular endothelial cells injury induced by hydrogen peroxide. WEI SHENG YAN JIU = JOURNAL OF HYGIENE RESEARCH 2009,38 592-595.
23. Yuko Nakamura, Hitoshi Matsumoto¹ and Kazuo Todoki Endothelium-Dependent Vasorelaxation Induced by Blackcurrant Concentrate in Rat Thoracic Aorta .JPN. J. PHARMACOL.2002, 89, 29 – 35.
24. Abdul-Lateef Molan • Zhuojian Liu •Marlena Kruger The ability of blackcurrant extracts to positively modulate key markers of gastrointestinal function in rats WORLD J MICROBIOL BIOTECHNOL (2010) 26:1735–1743
25. Ashwin Gopalan, Sharon C. Reuben, Shamima Ahmed, Altaf S. Darvesh, Judit Hohmann, Anupam Bishayee The health benefits of blackcurrants. FOOD & FUNCTION 2012, 3, 795-809
26. Bishayee, A., Mbimba, T., Thoppil, R., Haznagy-Radnai, E., Sipos, P., Darvesh, A., Folkesson, H., Hohmann, J. Anthocyanin-rich blackcurrant (*Ribes nigrum* L.) extract affords chemoprevention against diethylnitrosamine-induced hepatocellular carcinogenesis in rats. Journal of Nutritional Biochemistry (2011) 22:1035 – 1046.

Disclaimer

Catalyst[®] Ltd has prepared this report based on information from published papers. While care has been used in analysing this information and preparing this report Catalyst[®] Ltd gives no warranty that the information accessed is free from error. Catalyst[®] Ltd shall not be liable for any loss suffered through the use, directly or indirectly, of any information, product or service based on the information in this report.