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(54) **Medium chain dicarboxylic acids and their derivates and metabolic disorders**

Dicarboxylsäuren von mittlerer Kettenlänge und ihre Derivate und Stoffwechselstörungen

Acides dicarboxyliques à chaîne moyenne et leurs dérivés, et troubles du métabolisme

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- **SALINARI SERENELLA ET AL: "Dodecanedioic acid overcomes metabolic inflexibility in type 2 diabetic subjects." November 2006 (2006-11), AMERICAN JOURNAL OF PHYSIOLOGY. ENDOCRINOLOGY AND METABOLISM NOV 2006, VOL. 291, NR. 5, PAGE(S) E1051 - E1058 , XP002493030 ISSN: 0193-1849 * abstract ** page E1052, column 1, paragraph 4 * * page E1056, column 1, paragraph 3 ***
- **GRECO A V ET AL: "The metabolic effect of dodecanedioic acid infusion in non-insulin-dependent diabetic patients." NUTRITION (BURBANK, LOS ANGELES COUNTY, CALIF.) APR 1998, vol. 14, no. 4, April 1998 (1998-04), pages 351-357, XP002493029 ISSN: 0899-9007**

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Description

[0001] The present invention relates in general to medium chain dicarboxylic acids, their derivatives and their uses. In particular, the present invention relates to a composition comprising medium chain dicarboxylic acids and to the use of medium chain dicarboxylic acids and their derivatives for the preparation of products to treat or prevent metabolic disorders.

[0002] Diabetes mellitus is a metabolic condition characterized primarily by high blood glucose levels that result from the body's inability to make or use insulin. Hyperglycemia can lead to numerous clinical complications including blindness, limb amputations, heart attack or stroke. In 2007, it was estimated that 246 million of adults have diabetes, and if nothing is done to slow down the epidemic, within 25 years the number will reach more than 380 million.

[0003] The most common types of diabetes are insulin-dependent diabetes (Type-1 diabetes, T1D) and type-2 diabetes (T2D), which is by far the most abundant type. The increase in type-2 diabetes is mainly driven by increasing obesity rates. Today, more than 1.1 billion people are estimated to be overweight, of which around 320 million are obese.

[0004] The pathophysiology of the development of T2D is complex and multifactorial. Obesity, sedentary life style and/or increased age may lead to insulin resistance and to increased circulating insulin concentrations over time. At some point a loss of control of blood glucose begins to emerge, resulting in impaired glucose tolerance (IGT) or impaired fasting glucose (IFG) and may ultimately result in T2D. Therefore IGT and IFG refer to metabolic states intermediate between normal glucose homeostasis and diabetes.

[0005] A further test, the oral glucose tolerance test (OGTT), may be performed to assess whether the patient is diabetic or has IGT. The OGTT consists of a glucose drink containing 75g of glucose. The patient's blood sugar level is measured at one and two hours following administration of the drink.

[0006] As glucose is an essential nutrient for the human body, its circulating levels must be carefully maintained constant, in order to supply adequate amounts to peripheral tissues. The liver plays a central role in glucose homeostasis by balancing its uptake and storage via glycogenesis and its release via glycogenolysis and gluconeogenesis. An impairment of glucose homeostasis is a typical feature of T2D. Patients with T2D exhibit increased hepatic glucose production (HGP), which is identified as the main cause of fasting hyperglycaemia and is associated with a reduced plasma glucose clearance (Gastaldelli A, et al., Diabetes 2000; 49:1367-1373), and a 25-45% reduced synthesis of glycogen compared with non-diabetic subjects (Roden M, et al., Best Pract Res Clin Endocrinol Metab. 2003;17:365-83).

[0007] Limiting blood glucose peaks after a meal in diabetic subjects also constitutes an important target of the overall glycemic control strategy.

[0008] Actual treatments for T2D comprise several classes of drugs, which can be used alone or in combination with insulin.

[0009] Biguanides work by reducing the amount of glucose produced by the liver. Obese patients with T2D are usually started on biguanides. Common side effects include abdominal discomfort, diarrhea, nausea or vomiting, loss of appetite, and metallic taste.

[0010] Alpha-glucosidase inhibitors slow the digestion of carbohydrates, delay glucose absorption, and reduce the increase in blood glucose after a meal. Common side effects include abdominal pain, diarrhea, and flatulence.

[0011] In animals and humans, medium-chain dicarboxylic acids (DA), which include adipic (C6), suberic (C8), sebacic (C10), and dodecanedioic (C12) acids, derive from ω -oxidation of the corresponding fatty acids or from the β -oxidation of longer-chain dicarboxylic acids. In plants, DA are components of the natural protective polymers cutin and suberin (Mingrone G, et al., Nutr Rev. 2006; 64:449-56). DA energy density is intermediate between glucose and fatty acids.

[0012] US 5,272,177 describes the use of sebacic acid and derivatives as a suitable fuel substrate in enteral and parenteral nutrition during severe catabolic stages such as sepsis, shock, multiple trauma and burns.

[0013] JP 61171417 describes an antidiabetic containing an aliphatic saturated dicarboxylic acid or salt thereof, which shows a promoting action on insulin secretion when blood sugar levels are high.

[0014] Sallinari et al, in Am. J. Physiol. Endocrinol. Metab. 291, E1051-1058, 2006, describe the use of dodecanoic acid (C12) in overcoming metabolic inflexibility in type 2 diabetic subjects, and that C12 can be a suitable energy substrate during exercise by reducing muscle fatigue in such subjects.

[0015] Grecco et al, in Nutrition, 14(4), 1998, 351-357, describe that C12 infusion decreases plasma glucose levels to a normal range in patients with non-insulin-dependent diabetes mellitus without influencing plasma insulin levels, and suggest that C12 may represent a fuel substrate immediately available for tissue energy requirements.

[0016] Raguso et al, in Journal of Parenteral and Enteral Nutrition, 1, 1994, p-13, describe a reduction in glucose uptake in humans that have had sodium sebacate (C10) administered by continuous intravenous infusion.

[0017] Starting out from the prior art it was the object of the present invention to provide the art with a composition and a use that allows it to manage glucose levels in the blood of human or animal patients that is safe to use and does not exhibit the side effects that are common to the medications known in the art. This composition should be suitable for enteral or oral application.

[0018] The present inventors were surprised to see that this object could be solved by the use in accordance with

claim 1 and a composition in accordance with claim 19.

[0019] It was found that a composition comprising at least one medium chain dicarboxylic acid, specifically sebacic (C10) acid, or a derivative thereof solves the object of the present invention and can successfully be used for the preparation of a product to treat or prevent metabolic disorders.

[0020] Consequently, one embodiment of the present invention relates to a composition comprising sebacic (C10) acid or a derivative thereof for use in the treatment or prevention, by oral or enteral administration, of metabolic disorders.

[0021] It also relates to the use of a composition comprising sebacic (C10) acid or a derivative thereof for the preparation of a product for use in the treatment or prevention, by oral or enteral administration, of metabolic disorders.

[0022] Metabolic disorders include for example peripheral insulin resistance, impaired glucose tolerance and diabetes.

[0023] The composition or product may further comprise a medium chain dicarboxylic acid or a derivative thereof. Medium chain dicarboxylic acids are preferably selected from the group consisting of C4-C14 dicarboxylic acids. More preferably the medium chain dicarboxylic acids are selected from the group consisting of C6-C12 dicarboxylic acids and comprise C6, C7, C8, C9, C10, C11 and C12 dicarboxylic acids. Examples are succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, phthalic acid, isophthalic acid, terephthalic acid.

[0024] Most preferred are the naturally occurring medium chain dicarboxylic acids selected from the group consisting of adipic (C6) acid, suberic (C8) acid, sebacic (C10) acid, dodecanedioic (C12) acid. The medium chain dicarboxylic acids may be used alone or in mixtures of two or more dicarboxylic acids.

[0025] The derivatives of medium chain dicarboxylic acids, specifically sebacic acid, comprise compounds which after hydration, de-esterification or acidification yield the medium chain dicarboxylic acids. The derivatives of medium chain dicarboxylic acids are selected from the group consisting of salt forms of the dicarboxylic acids, preferably sodium, potassium, calcium or magnesium salts, and esters of dicarboxylic acids, preferably glycerol esters, in particular triglycerides, or ethanol esters.

[0026] Naturally occurring medium chain dicarboxylic acids, specifically sebacic acid, and their derivatives are in particular preferred for the purpose of the present invention. They may be isolated from naturally occurring foodstuff and are, hence, usually very well tolerated by the body. Furthermore, they may be provided in the form of extracts from foodstuff, so that no extensive purification procedure is required.

[0027] The product prepared by the use of the present invention is preferably a food product, a food supplement, a nutraceutical, a pet food product or a medicament. It may also be a beverage or a cosmetic product.

[0028] The product, in particular if it is a food product or a beverage may also comprise a protein source, a carbohydrate source and/or a lipid source. The present inventors have found that this composition can very well be applied orally or enterally. In contrast to a parental application this has the advantage that unnecessary puncturing of the skin of the patients and corresponding risks for, e.g., infections are avoided. Furthermore, while parenteral compositions cannot comprise a protein source, a carbohydrate source and a lipid source simultaneously, since this would lead to clotting during storage, resulting in severe health risks for the patient after injection, this is in contrast very well possible for oral and enteral application forms.

[0029] The product of the present invention may be a nutritionally complete formula.

[0030] As protein source any suitable dietary protein may be used, for example animal proteins (such as milk proteins, meat proteins and egg proteins); vegetable proteins (such as soy protein, wheat protein, rice protein, and pea protein); mixtures of free amino acids; or combinations thereof. Milk proteins such as casein and whey, and soy proteins are particularly preferred. The proteins may be intact or hydrolysed or a mixture of intact and hydrolysed proteins. It may be desirable to supply partially hydrolysed proteins (degree of hydrolysis between 2 and 20%), for example for animals believed to be at risk of developing cows' milk allergy. If hydrolysed proteins are required, the hydrolysis process may be carried out as desired and as is known in the art. For example, a whey protein hydrolysate may be prepared by enzymatically hydrolysing the whey fraction in one or more steps. If the whey fraction used as the starting material is substantially lactose free, it is found that the protein suffers much less lysine blockage during the hydrolysis process. This enables the extent of lysine blockage to be reduced from about 15% by weight of total lysine to less than about 10% by weight of lysine; for example about 7% by weight of lysine which greatly improves the nutritional quality of the protein source.

[0031] If the product includes a fat source, the fat source preferably provides 5% to 40% of the energy of the composition; for example 20% to 30% of the energy. A suitable fat profile may be obtained using a blend of canola oil, corn oil and high-oleic acid sunflower oil. Fat source may also include coconut oil or palm oil, rich in medium chain triglycerides.

[0032] A carbohydrate source may preferably provide 40% to 80% of the energy of the composition. Any suitable carbohydrate may be used, for example sucrose, lactose, glucose, fructose, corn syrup solids, maltodextrins, and mixtures thereof.

[0033] Dietary fibre may also be added if desired. Dietary fibre passes through the small intestine undigested by enzymes and functions as a natural bulking agent and laxative. Dietary fibre may be soluble or insoluble and in general a blend of the two types is preferred. Suitable sources of dietary fibre include soy, pea, oat, pectin, guar gum, gum Arabic, fructooligosaccharides, galacto-oligosaccharides, sialyl-lactose and oligosaccharides derived from animal milks.

A preferred fibre blend is a mixture of inulin with shorter chain fructo-oligosaccharides. Preferably, if fibre is present, the fibre content is between 2 and 40 g/l of the composition as consumed, more preferably between 4 and 10 g/l.

[0034] The composition may also contain minerals and micronutrients such as trace elements and vitamins in accordance with the recommendations of Government bodies such as the USRDA. For example, the composition may contain per daily dose one or more of the following micronutrients in the ranges given:- 300 to 500 mg calcium, 50 to 100 mg magnesium, 150 to 250 mg phosphorus, 5 to 20 mg iron, 1 to 7 mg zinc, 0.1 to 0.3 mg copper, 50 to 200 µg iodine, 5 to 15 µg selenium, 1000 to 3000 µg beta carotene, 10 to 80 mg Vitamin C, 1 to 2 mg Vitamin B1, 0.5 to 1.5 mg Vitamin B6, 0.5 to 2 mg Vitamin B2, 5 to 18 mg niacin, 0.5 to 2.0 µg Vitamin B12, 100 to 800 µg folic acid, 30 to 70 µg biotin, 1 to 5 µg Vitamin D, 3 to 10 µg Vitamin E.

[0035] One or more food grade emulsifiers may be incorporated into the composition if desired; for example diacetyl tartaric acid esters of mono- and di-glycerides, lecithin.

[0036] The amount of sebacic acid or derivative thereof to be administered in accordance with the present invention is not particularly limited and will depend, e.g., on the weight and age of the patient to be treated, its condition, in particular health condition and the amount and kind of food consumed.

[0037] However, in general it is preferred that the at least one medium chain dicarboxylic acid or derivative thereof is present in the product in amount of 1g-40g per daily dose.

[0038] The product of the present invention may further contain protective hydrocolloids (such as gums, proteins, modified starches), binders, film forming agents, encapsulating agents/materials, wall/shell materials, matrix compounds, coatings, emulsifiers, surface active agents, solubilizing agents (oils, fats, waxes, lecithins etc.), adsorbents, carriers, fillers, co-compounds, dispersing agents, wetting agents, processing aids (solvents), flowing agents, taste masking agents, weighting agents, jellifying agents, gel forming agents, antioxidants and antimicrobials. The composition may also contain conventional pharmaceutical additives and adjuvants, excipients and diluents, including, but not limited to, water, gelatine of any origin, vegetable gums, ligninsulfonate, talc, sugars, starch, gum arabic, vegetable oils, polyalkylene glycols, flavouring agents, preservatives, stabilizers, emulsifying agents, buffers, lubricants, colorants, wetting agents, fillers, and the like. In all cases, such further components will be selected having regard to their suitability for the intended recipient.

[0039] The product prepared by the use of the present invention may also comprise at least one kind of food grade bacteria, in particular probiotics. "Food grade bacteria" means bacteria that are used and generally regarded as safe for use in food. Probiotics are microorganisms which when administered in adequate amounts confer a health benefit on the host.

[0040] Modifications of the intestinal flora are thought to be associated with obesity. These changes were demonstrated in obese mice to affect the metabolic potential of gut microbiota resulting in an increased capacity to harvest energy from the diet (Turnbaugh PJ, et al., Microbial ecology: human gut microbes associated with obesity. Nature. 2006). Such modifications of the gut microbiota are proposed to contribute to the pathophysiology of obesity. Probiotics, the beneficial bacteria present in food or food supplements, are known to modify the intestinal microbiota (Fuller R & Gibson GR, Modification of the intestinal microflora using probiotics and prebiotics. Scand J. Gastroenterol. 1997).

[0041] Probiotics that are preferably used in the product of the present invention are selected from the group consisting of group consisting of Bifidobacterium, Lactobacillus, Streptococcus and Saccharomyces or mixtures thereof, in particular selected from the group consisting of Bifidobacterium longum, Bifidobacterium lactis, Lactobacillus acidophilus, Lactobacillus rhamnosus, Lactobacillus johnsonii, Lactobacillus plantarum, Lactobacillus salivarius, Streptococcus faecium, Saccharomyces boulardii and Lactobacillus reuteri or mixtures thereof, preferably selected from the group consisting of Lactobacillus johnsonii NCC 533 (CNCM I-1225), Bifidobacterium longum NCC 490 (CNCM I-2170), Bifidobacterium longum NCC 2705 (CNCM I-2618), Bifidobacterium lactis Bb12, Bifidobacterium lactis NCC2818 (CNCM I-3446), Lactobacillus paracasei NCC 2461 (CNCM I-2116), Lactobacillus rhamnosus GG, Lactobacillus rhamnosus NCC4007 (CG-MCC 1.3724) Enterococcus faecium SF 68 (NCIMB 10415), and mixtures thereof.

[0042] Prebiotics may also be added, for example to support the function of the probiotics or because they have a positive effect on digestion by themselves. Consequently, the product prepared by the use of the present invention may further contain at least one prebiotic. "Prebiotic" means food substances intended to promote the growth of probiotic bacteria in the intestines. Preferably the prebiotic may be selected from the group consisting of oligosaccharides and optionally contain galactose, mannose, soy and/or inulin; dietary fibers; or mixtures thereof.

[0043] Preferably, the product prepared by the use of the present invention is to be administered to pre-diabetic or diabetic subjects.

[0044] Insulin resistance represents an insensitivity of the peripheral tissues (e.g., muscle, liver, adipose tissue) to the effects of insulin on glucose uptake. To compensate for this, the pancreas releases much more insulin such that the cells are adequately triggered to absorb glucose. This leads to high plasma insulin levels (hyperinsulinemia). Insulin resistance in normoglycemic people is defined as a fasting plasma insulin level ≥ 16.7 mU/l (Ascaso JF, et al., Diabetes Care. 2003;33:20-5).

[0045] Pre-diabetes is characterized by an impaired fasting glucose and an impaired glucose tolerance. At some point

a loss of control of blood glucose begins to emerge, resulting in impaired glucose tolerance (IGT) or impaired fasting glucose (IFG) and may ultimately result in T2D. Therefore IGT and IFG refer to metabolic states intermediate between normal glucose homeostasis and diabetes. IFG is defined as fasting blood sugar levels of between 6.1 and 7.0 mmol/L. IGT is indicated if the blood sugar level is between 7.8 and 11.1 mmol/L two hours following administration of a glucose drink containing 75g of glucose

[0046] Diabetes is a metabolic condition characterized primarily by high blood glucose levels that result from the body's inability to make or use insulin. Fasting blood sugar levels of more than 7.8 mmol/L or blood sugar levels of more than 11.1 mmol/L indicate diabetes.

[0047] Reference is made in this respect to Figure 1.

[0048] Type-1 diabetes (T1D), also called insulin-dependent diabetes, is caused by an autoimmune disease reaction where the body's defence system attacks the insulin-producing cells. People with T1 D produce very little or no insulin.

[0049] Type-2 diabetes (T2D), which is the most common type (about 90% of all diabetes), is strongly associated to an excess of body fat, especially when concentrated within the abdomen.

[0050] The product prepared by the use of the present invention is considered to be in particularly effective, if it is administered during or after a meal. Of course the product prepared by the use of the present invention may be a part of the meal or may even represent a full meal. After the meal means within 1 hour, preferably within 30 minutes, even more preferred within 15 minutes after completion of the meal.

[0051] The present inventors were surprised to find that the product prepared by the use of the present invention have several beneficial effects on a body.

[0052] Subjects treated exhibited a significant decrease in postprandial glycemia. Their insulin secretion rate decreased markedly. Also the endogenous glucose production and the gluconeogenesis decreased. Simultaneously, a significant increase in postprandial glucose clearance was observed.

[0053] Consequently the product prepared by the use of the present invention may be used to treat or prevent hyperglycemia. Several disorders are linked to hyperglycemia. Consequently, these disorders may be treated or prevented by the use of the present invention as well. For example, nephropathy, retinopathy, heart and cardiovascular diseases may be prevented by the use of the present invention.

[0054] The product prepared according to the present invention may further be used to improve glucose clearance. Also, it may be used to at least partially inhibit hepatic glucose production and/or to decrease endogenous glucose production.

[0055] A further embodiment of the present invention relates to the use of the product to treat or prevent diabetes, in particular diabetes type 1 and diabetes type 2.

[0056] A further embodiment of the present invention relates to a composition, in particular a food composition, comprising sebacic acid or a derivative thereof. All features described above for the use of the present invention may be applied equally to this composition of the present invention. In particular, the composition of the present invention may optionally a probiotic. Further, it may contain a prebiotic.

[0057] It is clear to those skilled in the art that they can freely combine all features described herein without departing from the scope of the invention as disclosed. In particular, all features described for the use of the present invention apply also to the composition comprising at least one medium chain dicarboxylic acid or a derivative thereof to treat or prevent metabolic disorders.

[0058] Further embodiments and advantages of the present invention are apparent from the following examples and figures.

Figure 1 shows how hyperinsulinemia leads from insulin resistance to impaired glucose tolerance and how hyperglycemia leads from impaired glucose tolerance to diabetes.

Figure 2 shows the time course of plasma glucose and insulin in healthy people after ingestion of no C10, 50% CHO, 15% protein and 35% lipids plus water; 23 g C10, 50% CHO, 15% protein and 35% C10 DA (23 g) plus water or 10 g C10, 50% CHO, 15% protein and 35% lipids plus 10 g of C10 plus water. Ingestion of the different meals was performed at 100 min.

Figure 3 shows the time course of plasma glucose and insulin in T2D patients after ingestion of no C10, 50% CHO, 15% protein and 35% lipids plus water; 23 g C10, 50% CHO, 15% protein and 35% C10 DA (23 g) plus water or 10 g C10, 50% CHO, 15% protein and 35% lipids plus 10 g of C10 plus water. Ingestion of the different meals was performed at 100 min.

Figure 4 reports the time course of plasma sebacate in healthy subjects.

Figure 5 reports the time course of plasma sebacate in T2D subjects.

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Examples:

[0059] The acute effects of oral ingestion of sebatic acid on postprandial glycemia, hepatic gluconeogenesis and glycogenolysis were tested in T2D subjects and healthy volunteers during ingestion of a mixed meal at breakfast.

[0060] Type 2 diabetic patients and healthy subjects were matched for gender distribution, age, and body mass index as reported in the following table 1:

Table 1	Age	Height (cm)	Weight (kg)	BMI (kg/m ²)	FFM (kg)	FM (kg)
Healthy Subjects (4W/6M)	47.2±6.03	173.8±7.68	80.8±12.67	26.63±3.03	62.62±6.80	18.18±8.71
Type 2 Diabetic Subjects (5W/5M)	52.1±6.98	170.7±6.53	81.94±15.97	27.98±4.08	59.86±11.23	22.08±6.80

[0061] The subjects ingested the following formula meal

[0062] No C10 group (control group): 50% CHO, 15% protein and 35% lipids plus water

23 g C10 group: 50% CHO, 15% protein and 35% C10 DA (23 g) plus water

10 g C10 group: 50% CHO, 15% protein and 35% lipids plus 10 g of C10 plus water

[0063] The results of the cross-over single-blind pilot study showed in T2D subjects (n=10)

[0064] A significant decrease in postprandial:

- Glycemia area under the curve (AUC) with the 10 g (-17%) and 23g C10 DA (-16%) meal
- Insulin secretion rate with the 23 g C10 DA meal (-35%)
- Endogenous Glucose Production with the 10 g (-10%) and 23g C10 DA (-9%) meal
- Gluconeogenesis (%) with the 10 g (-2.1%) and 23g C10 DA (-2.3%) meal

[0065] A significant increase in postprandial:

- Glucose clearance with the 10 g (+12.6%) and 23g C10 DA (+8.2%) meal

[0066] In healthy subjects (n=10), only the postprandial insulinemia AUC was significantly decreased (-38%; 23 g sebatic acid)

[0067] In T2D patients the effect of C10 was more pronounced as shown in Figure 3 respectively for plasma glucose and plasma insulin time courses.

[0068] Figure 4 reports the time course of plasma sebatic acid in healthy subjects. The peak was reached after 320 minutes from the beginning of the experiment, i.e. 200 minutes after the ingestion of the meal enriched with C10. C10 peaked later (delay of 40 minutes) after 23 g C10 ingestion.

[0069] Figure 5 reports the time course of plasma sebatic acid in T2D subjects. The concentration of plasma C10 raised to values about 1.5 times higher than those reached in controls, however the peak times were maintained. Another difference was that in diabetics the two curves (10 g vs. 23 g) were overlapped up to 320 minutes, and then the concentration of C10 declined slower in the 23g C10 fed patients compared with 10 g of C10.

[0070] Table 2 summarizes the mean values and the standard error of the means (SEM) for insulin area under the curve (AUCs), glucose AUCs and Insulin secretion Rates (ISR) after the meals. Glucose AUC was significantly lower in diabetic patients after the meal containing 10g of C10.

[0071] The ISR was significantly reduced after the meal in which lipids were substituted with 23g C10 in both healthy subjects and diabetic patients.

Table 2	HEALTHY SUBJECTS			TYPE 2 DIABETIC SUBJECTS		
0-420 minutes	Mean	SEM	P	Mean	SEM	P
Insulin AUC No C10 (pM)	63609.30	9531.96		39343.20	7789.74	
Insulin AUC 10g C10 (pM)	51112.80	8521.08		33535.50	5527.50	
Insulin AUC 23g C10 (pM)	39234.00	6780.18	0.022	29463.00	4315.86	
Glucose AUC No C10 (mM)	38278.08	1493.35		52496.40	6474.09	
Glucose AUC 10g C10 (mM)	37445.93	1354.06		43655.70	4902.50	0.028

(continued)

Table 2	HEALTHY SUBJECTS			TYPE 2 DIABETIC SUBJECTS		
0-420 minutes	Mean	SEM	P	Mean	SEM	P
Glucose AUC 23g C10 (mM)	38119.95	1034.10		44185.28	5203.04	0.049
Total ISR No C10 (nmol)	105.82	12.62		219.99	34.33	
Total ISR 10g C10 (nmol)	101.15	16.49		213.69	46.30	
Total ISR 23g C10 (nmol)	93.60	14.00		142.27	26.48	0.036

[0072] Table 3 reports the Endogenous Glucose Production (EGP), the total Rate of Appearance of deuterated glucose (Ra), the GlucoNeoGenesis (GNG) and the glucose clearance for both healthy subjects and type 2 diabetic patients. In type 2 diabetics EGP was significantly reduced after C10 enriched meals compared with the standard meal. GNG was higher in the diabetic patients compared with healthy subjects after the standard test meal, but it was significantly reduced after both C10 enriched meals. C10 ingestion significantly improved the glucose clearance in both healthy subjects and in diabetic patients.

Table 3	HEALTHY SUBJECTS			TYPE 2 DIABETIC SUBJECTS		
	No C10	10g C10	33g C10	No C10	10g C10	23g C10
EGP ($\mu\text{mol}\cdot\text{min}^{-1}\cdot\text{kg}_{\text{ffm}}^{-1}$)	6.52 \pm 2.45	6.30 \pm 2.45	6.172 \pm 0.68	10.97 \pm 4.89	7.81 \pm 3.27*	7.00 \pm 2.47*
Total Ra ($\mu\text{mol}\cdot\text{min}^{-1}\cdot\text{kg}_{\text{ffm}}^{-1}$)	20.76 \pm 2.00	20.60 \pm 2.88	21.20 \pm 1.30	20.10 \pm 2.70	19.60 \pm 2.41	20.32 \pm 2.19
Gluconeogenesis (%)	32.40 \pm 5.26	31.28 \pm 5.07	31.20 \pm 3.63	42.98 \pm 3.40	40.86 \pm 3.62*	40.72 \pm 4.00§
Glucose clearance ($\text{ml}\cdot\text{min}^{-1}\cdot\text{kg}^{-1}$)	2.55 \pm 0.30	2.73 \pm 0.24#	2.74 \pm 0.36#	1.58 \pm 0.19	1.76 \pm 0.13#	1.7 \pm 0.21§
EGP, endogenous glucose production; Ra, rate of appearance; GNG, gluconeogenesis * = P<0.02; # = P<0.01; § = P<0.05						

[0073] In T2D subjects, a possible explanation of the effect of sebacic acid in reducing plasma glucose concentration after a energy balanced mixed meal is that C10 DA improves tissue glucose uptake - as shown by the higher glucose clearance - and likely increases the storage of glucose in the liver, as glycogen, and decreases hepatic glucose output. Of relevance is that this effect is also observed after administration of 10g of C10 DA, even in presence of lipids in the test meal.

[0074] A typical nutritional formula containing medium chain DA may contain 1 to 30 g DA per serving for an adult person.

Claims

1. Use of a composition comprising sebacic (C10) acid, or a derivative thereof selected from salt forms of the acid and esters of the acid, for the preparation of a product for use in the treatment or prevention, by oral or enteral administration, of metabolic disorders.
2. A composition comprising sebacic (C10) acid, or a derivative thereof selected from salt forms of the acid and esters of the acid, for use in the treatment or prevention, by oral or enteral administration, of metabolic disorders.
3. Use in accordance with claim 1 or composition in accordance with claim 2, wherein the product or composition is a food product, a food supplement, a nutraceutical, a pet food product or a medicament.
4. Use or composition in accordance with one of the preceding claims wherein the product or composition further comprises a medium chain dicarboxylic acid or a derivative thereof selected from salt forms of the acid and esters

of the acid, a protein source, a carbohydrate source and/or a lipid source.

5. Use or composition in accordance with claim 4 wherein the medium chain dicarboxylic acid is selected from the group consisting of adipic (C6) acid, suberic (C8) acid, dodecanedioic (C12) acid, and mixtures thereof.
6. Use or composition in accordance with one of the preceding claims wherein derivatives of sebacic (C10) acid and/or the derivatives of medium chain dicarboxylic acids are selected from the sodium, potassium, calcium and magnesium salts, and the esters of the acid are selected from glycerol esters and ethanol esters.
7. Use or composition in accordance with claim 6, in which the glycerol esters are selected from triglycerides.
8. Use or composition in accordance with one of the preceding claims wherein the sebacic (C10) acid or derivative thereof is present in the product in amount of 1 g-50g per daily dose.
9. Use or composition in accordance with one of the preceding claims wherein the product comprises at least one kind of food grade bacteria, in particular probiotics.
10. Use or composition in accordance with claim 9, **characterized in that** the probiotics are selected from the group consisting of Bifidobacterium, Lactobacillus, Streptococcus and Saccharomyces or mixtures thereof, in particular selected from the group consisting of Bifidobacterium longum, Bifidobacterium lactis, Lactobacillus acidophilus, Lactobacillus rhamnosus, Lactobacillus johnsonii, Lactobacillus plantarum, Lactobacillus salivarius, Streptococcus faecium, Saccharomyces boulardii and Lactobacillus reuteri or mixtures thereof, preferably selected from the group consisting of Lactobacillus johnsonii NCC 533 (CNCM I-1225), Bifidobacterium longum NCC 490 (CNCM I-2170), Bifidobacterium longum NCC 2705 (CNCM I-2618), Bifidobacterium lactis Bb12, Bifidobacterium lactis NCC2818 (CNCM I-3446), Lactobacillus paracasei NCC 2461 (CNCM I-2116), Lactobacillus rhamnosus GG, Lactobacillus rhamnosus NCC4007 (CGMCC 1.3724) Enterococcus faecium SF 68 (NCIMB 10415), and mixtures thereof.
11. Use or composition in accordance with one of the preceding claims wherein the product or composition further contains at least one prebiotic.
12. Use or composition in accordance with claim 11 **characterized in that** the prebiotic is selected from the group consisting of oligosaccharides and optionally contain galactose, mannose, soy and/or inulin; dietary fibers; or mixtures thereof.
13. Use or composition in accordance with one of the preceding claims wherein the composition or product is to be administered to pre-diabetic or diabetic subjects.
14. Use or composition in accordance with one of the preceding claims wherein the composition or product is to be administered during or after a meal.
15. Use or composition in accordance with one of the preceding claims wherein the composition or product is for use in treating or preventing hyperglycemia.
16. Use in accordance with one of the preceding claims wherein the composition or product is for use in improving glucose clearance and/or insulin sensitivity.
17. Use or composition in accordance with one of the preceding claims wherein the composition or product is for use in inhibiting hepatic glucose production and/or endogenous glucose production.
18. Use or composition in accordance with one of the preceding claims wherein the composition or product is for use in treating or prevent diabetes, in particular diabetes type 1 and diabetes type 2.
19. Use or composition in accordance with one of the preceding claims wherein the composition or product is for use in treating or preventing hyperglycemia related disorders, such as nephropathy, retinopathy, heart and cardiovascular diseases.

Patentansprüche

1. Verwendung einer Zusammensetzung, die Sebacinsäure (C10) oder ein Derivat davon, das aus Salzformen der Säure und Estern der Säure ausgewählt ist, umfasst, zur Herstellung eines Produkts zur Verwendung bei der Behandlung oder Prävention, durch orale oder enterale Verabreichung, von Stoffwechselstörungen.
2. Zusammensetzung, die Sebacinsäure (C10) oder ein Derivat davon, das aus Salzformen der Säure und Estern der Säure ausgewählt ist, umfasst, zur Verwendung bei der Behandlung oder Prävention, durch orale oder enterale Verabreichung, von Stoffwechselstörungen.
3. Verwendung nach Anspruch 1 oder Zusammensetzung nach Anspruch 2, worin das Produkt oder die Zusammensetzung ein Nahrungsmittelprodukt, ein Nahrungsergänzungsmittel, ein Nutrazeutikum, ein Haustierfutterprodukt oder ein Medikament ist.
4. Verwendung oder Zusammensetzung nach einem der vorstehenden Ansprüche, worin das Produkt oder die Zusammensetzung weiter eine mittelkettige Dicarbonsäure oder ein Derivat davon, das aus Salzformen der Säure und Estern der Säure ausgewählt ist, eine Proteinquelle, eine Kohlenhydratquelle und/oder eine Lipidquelle umfasst.
5. Verwendung oder Zusammensetzung nach Anspruch 4, worin die mittelkettige Dicarbonsäure aus der Gruppe ausgewählt ist, die aus Adipinsäure (C6), Suberinsäure (C8), Dodecandisäure (C12) und Mischungen davon besteht.
6. Verwendung oder Zusammensetzung nach einem der vorstehenden Ansprüche, worin die Derivate von Sebacinsäure (C10) und/oder die Derivate von mittelkettigen Dicarbonsäuren aus den Natrium-, Kalium-, Calcium- und Magnesiumsalzen ausgewählt sind und die Ester der Säure aus Glycerolester und Ethanolester ausgewählt sind.
7. Verwendung oder Zusammensetzung nach Anspruch 6, in der die Glycerolester aus Triglyceriden ausgewählt sind.
8. Verwendung oder Zusammensetzung nach einem der vorstehenden Ansprüche, worin die Sebacinsäure (C10) oder das Derivat davon im Produkt in einer Menge von 1 g-50 g pro Tagesdosis vorliegt.
9. Verwendung oder Zusammensetzung nach einem der vorstehenden Ansprüche, worin das Produkt mindestens eine Art an nahrungsmitteltauglichen Bakterien, insbesondere Probiotika, umfasst.
10. Verwendung oder Zusammensetzung nach Anspruch 9, **dadurch gekennzeichnet, dass** die Probiotika aus der Gruppe ausgewählt sind, die aus Bifidobacterium, Lactobacillus, Streptococcus und Saccharomyces oder Mischungen davon besteht, insbesondere aus der Gruppe ausgewählt sind, die aus Folgenden besteht: Bifidobacterium longum, Bifidobacterium lactis, Lactobacillus acidophilus, Lactobacillus rhamnosus, Lactobacillus johnsonii, Lactobacillus plantarum, Lactobacillus salivarius, Streptococcus faecium, Saccharomyces boulardii und Lactobacillus reuteri oder Mischungen davon, bevorzugt aus der Gruppe ausgewählt sind, die aus Folgenden besteht:

Lactobacillus johnsonii NCC 533 (CNCM 1-1225),
Bifidobacterium longum NCC 490 (CNCM 1-2170),
Bifidobacterium longum NCC 2705 (CNCM 1-2618),
Bifidobacterium lactis Bb12, Bifidobacterium lactis NCC 2818 (CNCM 1-3446), Lactobacillus paracasei NCC 2461 (CNCM 1-2116), Lactobacillus rhamnosus GG, Lactobacillus rhamnosus NCC 4007 (CGMCC 1.3724),
Enterococcus faecium SF 68 (NCIMB 10415) und Mischungen davon.
11. Verwendung oder Zusammensetzung nach einem der vorstehenden Ansprüche, worin das Produkt oder die Zusammensetzung weiter mindestens ein Präbiotikum enthält.
12. Verwendung oder Zusammensetzung nach Anspruch 11, **dadurch gekennzeichnet, dass** das Präbiotikum aus der Gruppe ausgewählt ist, die aus Oligosacchariden besteht, und optional Galactose, Mannose, Soja und/oder Inulin; Ballaststoffe; oder Mischungen davon enthält.
13. Verwendung oder Zusammensetzung nach einem der vorstehenden Ansprüche, worin die Zusammensetzung oder das Produkt an prädiabetische oder diabetische Subjekte zu verabreichen ist.
14. Verwendung oder Zusammensetzung nach einem der vorstehenden Ansprüche, worin die Zusammensetzung oder

das Produkt während oder nach einer Mahlzeit zu verabreichen ist.

15. Verwendung oder Zusammensetzung nach einem der vorstehenden Ansprüche, worin die Zusammensetzung oder das Produkt zur Verwendung bei der Behandlung oder Prävention von Hyperglycämie vorgesehen ist.

16. Verwendung nach einem der vorstehenden Ansprüche, worin die Zusammensetzung oder das Produkt zur Verwendung bei der Verbesserung von Glucose-Clearance und/oder Insulinsensitivität vorgesehen ist.

17. Verwendung oder Zusammensetzung nach einem der vorstehenden Ansprüche, worin die Zusammensetzung oder das Produkt zur Verwendung bei der Hemmung der hepatischen Glucoseproduktion und/oder endogenen Glucoseproduktion vorgesehen ist.

18. Verwendung oder Zusammensetzung nach einem der vorstehenden Ansprüche, worin die Zusammensetzung oder das Produkt zur Verwendung bei der Behandlung oder Prävention von Diabetes, insbesondere Diabetes Typ 1 und Diabetes Typ 2, vorgesehen ist.

19. Verwendung oder Zusammensetzung nach einem der vorstehenden Ansprüche, worin die Zusammensetzung oder das Produkt zur Verwendung bei der Behandlung oder Prävention von mit Hyperglycämie verbundenen Störungen, wie zum Beispiel Nephropathie, Retinopathie, Herz- und Kreislauferkrankungen, vorgesehen ist.

Revendications

1. Utilisation d'une composition comprenant de l'acide sébacique (C10), ou un de ses dérivés sélectionné entre les formes sel de l'acide et les esters de l'acide, pour la préparation d'un produit devant être utilisé dans le traitement ou la prévention, par administration orale ou entérale, des troubles métaboliques.

2. Composition comprenant de l'acide sébacique (C10), ou un de ses dérivés sélectionné entre les formes sel de l'acide et les esters de l'acide, devant être utilisée dans le traitement ou la prévention, par administration orale ou entérale, des troubles métaboliques.

3. Utilisation selon la revendication 1 ou composition selon la revendication 2, le produit ou la composition étant un produit alimentaire, un supplément alimentaire, un produit nutraceutique, un produit alimentaire pour animaux ou un médicament.

4. Utilisation ou composition selon l'une des revendications précédentes, le produit ou la composition comprenant en outre un acide dicarboxylique à chaîne moyenne ou un de ses dérivés sélectionné entre les formes sel de l'acide et les esters de l'acide, une source protéique, une source glucidique et/ou une source lipidique.

5. Utilisation ou composition selon la revendication 4, dans laquelle l'acide dicarboxylique à chaîne moyenne est sélectionné dans le groupe comprenant l'acide adipique (C6), l'acide subérique (C8), l'acide dodécánedioïque (C12), et des mélanges de ces acides.

6. Utilisation ou composition selon l'une des revendications précédentes, dans laquelle des dérivés de l'acide sébacique (C10) et/ou les dérivés des acides dicarboxyliques à chaîne moyenne sont sélectionnés entre les sels de sodium, de potassium, de calcium et de magnésium, et les esters des acides sont sélectionnés entre les esters du glycérol et les esters de l'éthanol.

7. Utilisation ou composition selon la revendication 6, dans laquelle les esters du glycérol sont sélectionnés parmi les triglycérides.

8. Utilisation ou composition selon l'une quelconque des revendications précédentes, dans laquelle l'acide sébacique (C10) ou son dérivé est présent dans le produit à raison de 1 g à 50 g par dose journalière.

9. Utilisation ou composition selon l'une quelconque des revendications précédentes, dans laquelle le produit comprend au moins un type de bactéries de qualité alimentaire, en particulier des probiotiques.

10. Utilisation ou composition selon la revendication 9, caractérisée en ce que les probiotiques sont sélectionnés dans

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le groupe comprenant : bifidobacterium, lactobacillus, streptocoques et saccharomyces ou des mélanges de ces organismes, sélectionnés en particulier dans le groupe comprenant : bifidobacterium longum, bifidobacterium lactis, lactobacillus acidophilus, lactobacillus rhamnosus, lactobacillus johnsonii, lactobacillus plantarum, lactobacillus salivarius, streptococcus faecium, saccharomyces boulardii et lactobacillus reuteri ou des mélanges de ces organismes, sélectionnés de préférence dans le groupe comprenant : lactobacillus johnsonii NCC 533 (CNCM 1-1225), bifidobacterium longum NCC 490 (CNCM I-2170), bifidobacterium longum NCC 2705 (CNCM 1-2618), bifidobacterium lactis Bb12, bifidobacterium lactis NCC2818 (CNCM 1-3446), lactobacillus paracasei NCC 2461 (CNCM I-2116), lactobacillus rhamnosus GG, lactobacillus rhamnosus NCC4007 (CGMCC 1.3724), enterococcus faecium SF 68 (NCIMB 10415), et des mélanges de ces organismes.

11. Utilisation ou composition selon l'une des revendications précédentes, le produit ou la composition contenant en outre au moins un prébiotique.
12. Utilisation ou composition selon la revendication 11, **caractérisée en ce que** le prébiotique est sélectionné dans le groupe comprenant des oligosaccharides et contient facultativement du galactose, du mannose, du soja et/ou de l'inuline; des fibres alimentaires; ou des mélanges de ces éléments.
13. Utilisation ou composition selon l'une des revendications précédentes, la composition ou le produit devant être administré à des sujets pré-diabétiques ou diabétiques.
14. Utilisation ou composition selon l'une des revendications précédentes, la composition ou le produit devant être administré pendant ou après un repas.
15. Utilisation ou composition selon l'une des revendications précédentes, la composition ou le produit devant être utilisé pour le traitement ou la prévention de l'hyperglycémie.
16. Utilisation selon l'une des revendications précédentes, la composition ou le produit devant être utilisé pour améliorer l'élimination du glucose et/ou la sensibilité à l'insuline.
17. Utilisation ou composition selon l'une des revendications précédentes, la composition ou le produit devant être utilisé pour inhiber la production de glucose hépatique et/ou la production de glucose endogène.
18. Utilisation ou composition selon l'une des revendications précédentes, la composition ou le produit devant être utilisé pour le traitement ou la prévention du diabète, en particulier du diabète de type 1 et du diabète de type 2.
19. Utilisation ou composition selon l'une des revendications précédentes, la composition ou le produit devant être utilisé pour le traitement ou la prévention des troubles liés à l'hyperglycémie, tels que la néphropathie, la rétinopathie et les maladies cardiaques et cardiovasculaires.

Figure 1:

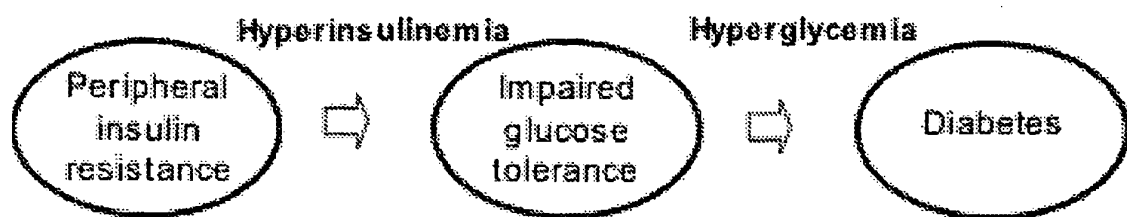


Figure 2 :

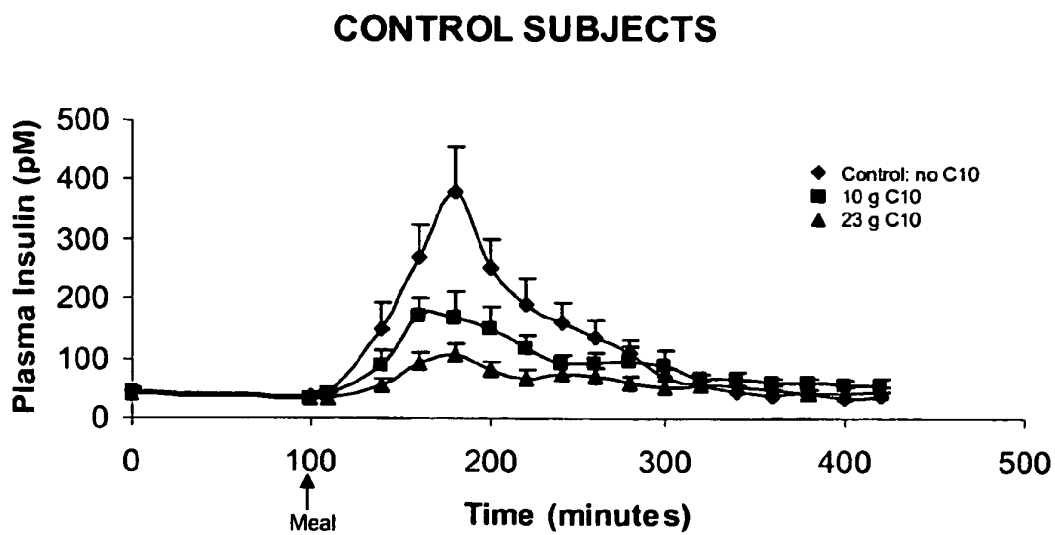
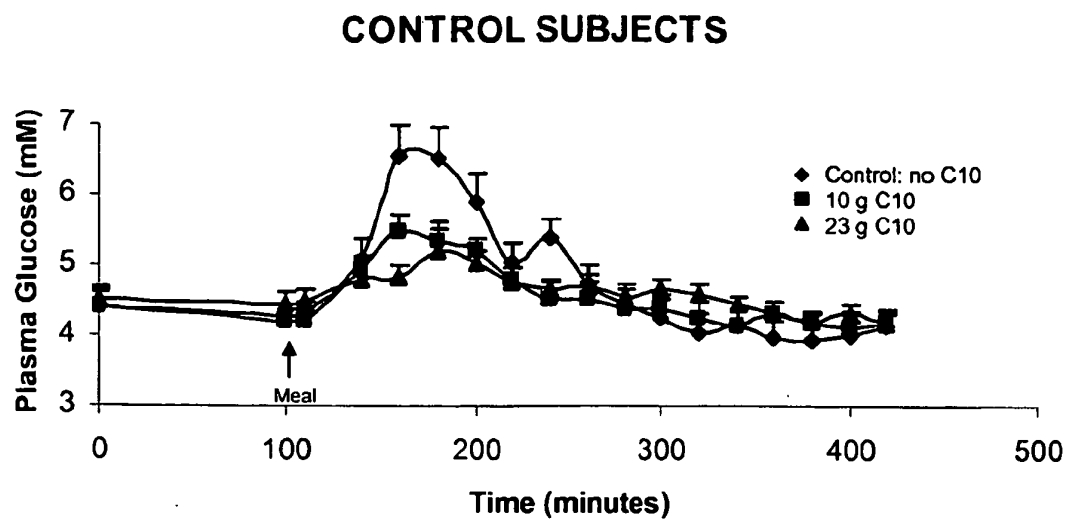


Figure 3:

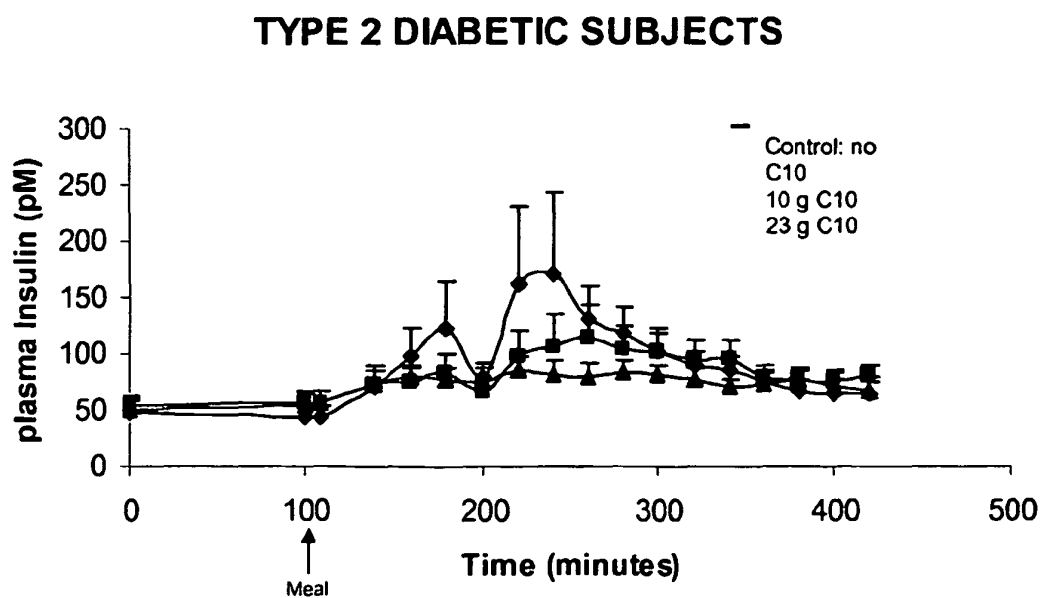
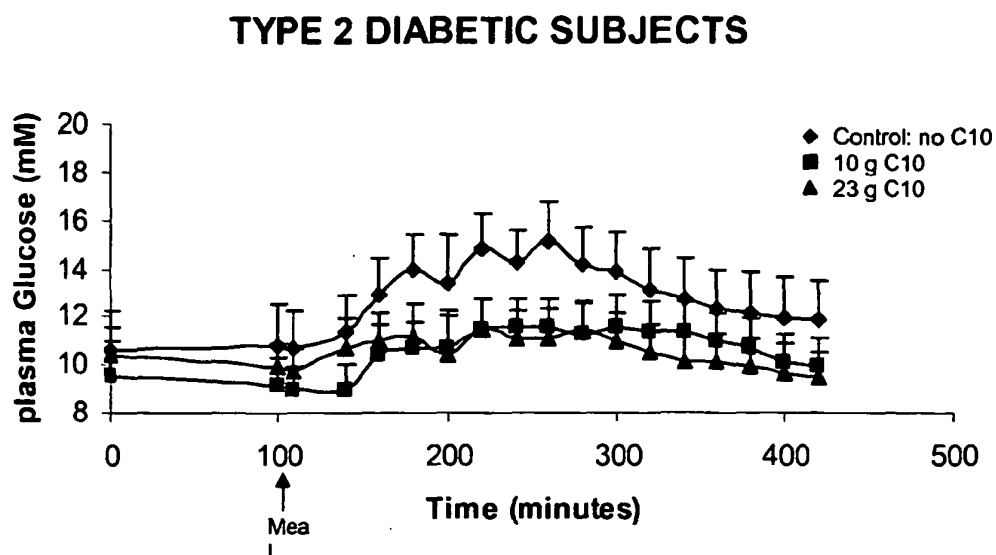


Figure 4:

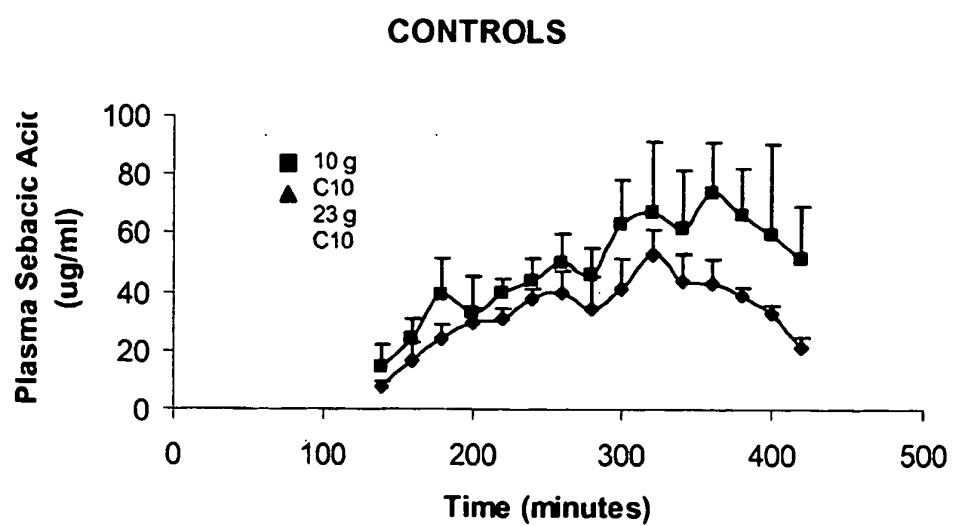
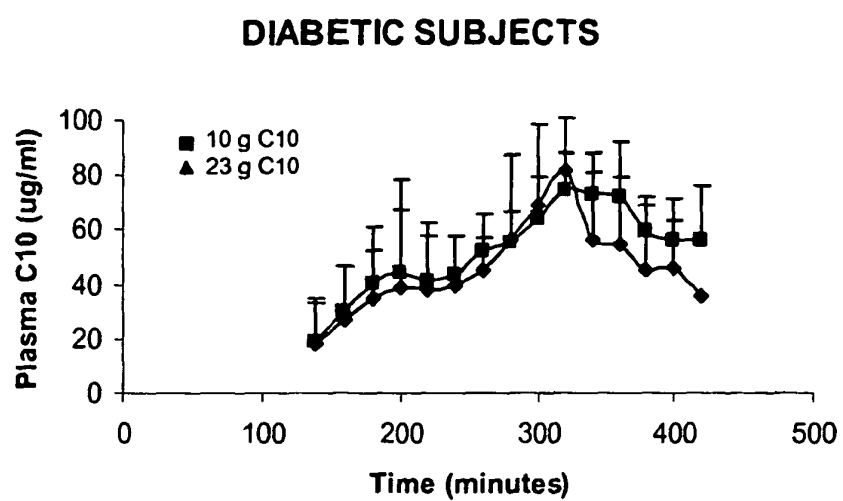


Figure 5



REFERENCES CITED IN THE DESCRIPTION

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