(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 April 2007 (19.04.2007)

PCT

(10) International Publication Number
WO 2007/042271 A2

(51) International Patent Classification:
A61K 31/05 (2006.01) *A61P 21/00* (2006.01)
A61K 31/353 (2006.01)

(21) International Application Number:
PCT/EP2006/009814

(22) International Filing Date: 11 October 2006 (11.10.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
05022414.6 14 October 2005 (14.10.2005) EP
06009943.9 15 May 2006 (15.05.2006) EP

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 2007/042271 A2

(54) Title: NOVEL USE OF NUTRACEUTICAL COMPOSITIONS

(57) Abstract: The use of at least one component selected from the group consisting of EGCG, hydroxytyrosol, resveratrol and derivatives, metabolites or analogues thereof in the manufacture of a nutraceutical composition for the prevention and treatment of muscle wasting leading to muscle loss, atrophy and other associated muscle disorders in animals, in particular mammals including humans.

Novel Use of Nutraceutical Compositions

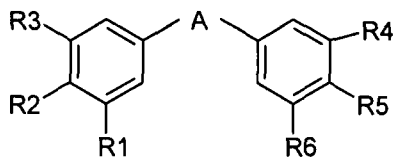
The present invention relates to a novel use of nutraceutical compositions comprising as active ingredient at least one component selected from the group consisting of EGCG, hydroxytyrosol, resveratrol and derivatives, metabolites or analogues thereof.

The compositions of the present invention are particularly intended for prevention and treatment of muscle wasting leading to muscle loss, atrophy and other associated muscle disorders in animals, in particular in mammals including humans.

The term "nutraceutical" as used herein denotes usefulness in both the nutritional and pharmaceutical field of application. Thus, the novel nutraceutical compositions can find use as supplements to food and beverages, dietary supplements and as pharmaceutical formulations for enteral or parenteral application which may be solid formulations such as capsules or tablets, or liquid formulations, such as solutions or suspensions. As will be evident from the foregoing, the term nutraceutical composition also comprises food and beverages containing the above-specified active ingredients.

The term "resveratrol and derivatives, metabolites or analogues thereof" as used herein comprises

compounds encompassed by the general formula



I

wherein A denotes a carbon-carbon single or double bond which latter may be trans or cis, and R1, R2, R3, R4, R5 and R6, independently from each other denote hydrogen, hydroxy, etherified hydroxy or esterified hydroxy groups. Preferred are compounds I wherein A is a double bond (-CH=CH-).

Etherified or esterified hydroxy groups may be derived from unsubstituted or substituted, straight or branched chain alkyl groups having 1 to 26 carbon atoms or from unsubstituted or substituted, straight or branched chain aliphatic, araliphatic or aromatic carboxylic acids having 1 to 26 carbon atoms. Etherified hydroxy groups may further be glycoside groups and esterified hydroxy groups may further be glucuronide or sulfate groups. Examples of compounds of formula I wherein A is -CH = CH- are resveratrol (R1, R3 and R5 = hydrogen, R2, R4 and R6 = hydroxy); piceatannol (R3 and R5 = hydrogen, R1, R2, R4 and R6 = hydroxy), and rhapontigenin (R5 = hydrogen, R1, R3, R4 and R6 = hydroxy, and R2 = methoxy). Examples of compounds of formula I wherein A is $-CH_2-CH_2-$ are dihydroresveratrol (R1, R3 and R5 = hydrogen; R2, R4 and R6 = hydroxy), dihydropiceatannol (R3 and R5 = hydrogen; R1, R2, R4 and R6 = hydroxy) and tristin (R3 and R5 = hydrogen; R2, R4 and R6 = hydroxy and R1 = methoxy). These compounds are all wellknown and commercially available or can be obtained in accordance with methods well-known in the art.

The term "EGCG" as used herein comprises (-)-epigallocatechin gallate (EGCG) and/or one or more derivatives (esterified forms, glycosides, sulphates) thereof. EGCG is the major catechin found in green tea. The beneficial health effects of green tea have been mainly attributed to the catechins. In mice, tea catechins reduced diet-induced weight gain, visceral fat mass, as well as plasma leptin, triglyceride and glucose levels. Tea catechins are also known to increase energy expenditure in rats. In humans, tea catechins have been shown to reduce body weight, visceral fat mass and plasma cholesterol, insulin and glucose levels. Green tea extract was shown to significantly increase energy expenditure and fat oxidation in healthy men. Furthermore, it was shown in brown adipose tissue of rats that EGCG stimulates metabolic activity and oxygen consumption. Additionally, several animal studies demonstrated that catechins inhibited cholesterol absorption and lowered plasma cholesterol levels. In turn, epicatechins increase the fecal excretion of cholesterol and total lipids. Therefore, EGCG has an antiobesity effect, through a stimulation of thermogenesis and/or an altered fat absorption.

The term "hydroxytyrosol" as used herein comprises hydroxytyrosol and/or one or more derivatives (esterified forms, glycosides, sulphates) thereof such as for example oleuropein. Hydroxytyrosol or one of its derivatives or analogues are in the form of a

single compound or of a purified plant extract, especially an olive extract. Hydroxytyrosol is the main polyphenol found in olives. Hydroxytyrosol is believed to be the antioxidant with the highest free radical scavenging capacity: double that of quercetin and more than 3 times that of epicatechin. The wastewaters generated during olive processing contain high levels of hydroxytyrosol, from which hydroxytyrosol can be recovered to produce hydroxytyrosol extracts. Hydroxytyrosol has the same health promoting properties than other polyphenols: prevention of atherosclerosis, promotion of intestinal and respiratory health and prevention of cancer. Hydroxytyrosol also reduces the oxidative stress caused by smoking.

The term "derivatives, metabolites and analogues thereof" used in the present case covers compounds which are derived from resveratrol, EGCG and hydroxytyrosol by chemical reactions or which have a very similar structure and exhibit same or similar pharmacologic activities in the animal.

Muscle wasting is characterized by a progressive loss of muscle mass, weakening and degeneration of muscles especially the skeletal or voluntary muscles and the cardiac muscles.

The processes by which atrophy and hypertrophy occur are conserved across mammalian species. Multiple studies have demonstrated that the same basic molecular, cellular, and physiological processes occur during atrophy in both rodents and humans. Thus, rodent models of skeletal muscle atrophy have been successfully utilized to understand and predict human atrophy responses.

Muscle wasting is due to a variety of causes and is associated with various pathologies, diseases and illnesses. These includes but are not limited to muscular dystrophies caused by genetic disorders such as Duchenne's muscular dystrophy, progressive muscular dystrophy, Becker's type muscular dystrophy, Dejerine-Landouzy muscular dystrophy, Erb's muscular dystrophy, and infantile neuroaxonal muscular dystrophy. Muscles wasting also arise from chronic diseases and age. As the body ages, an increasing proportion of skeletal muscle is replaced by fibrous tissue. Therefore, normal aging in humans is associated with progressive decrease in skeletal muscle mass and strength, a condition called sarcopenia, which contributes to frailty and falls.

Moreover, age related disorders such as hypertension, glucose intolerance and diabetes, obesity, dyslipidemia, atherosclerotic and cardiovascular disease are also associated with loss of muscle mass.

In addition other conditions such as cancer, autoimmune diseases, infectious diseases, HIV infection, AIDS, chronic inflammation, arthritis, malnutrition, renal diseases, chronic obstructive pulmonary disease (COPD), emphysema, osteomalacia, chronic lower back pain, peripheral nerve damage, spinal cord damage, chemical damage, central nervous system (CNS) damage are linked to or can cause muscle wasting. Finally, conditions resulting in muscle wasting may arise from disuse conditions such as long term immobilization due to illness or disability such as confinement in a wheelchair, prolonged bed rest, bone fracture or trauma. It is estimated that bed-rest after surgery causes loss of skeletal muscle mass of approximately 10% per week.

Untreated muscle wasting disorders can have serious health consequences.

The changes that occur during muscle wasting can lead to a weakened physical state resulting in poor performance of the body and detrimental health effects.

Thus, muscle atrophy can seriously limit the rehabilitation of patients from immobilizations. Muscle wasting due to chronic diseases can lead to premature loss of mobility and increase the risk of disease-related morbidity. Muscle wasting due to disuse is especially a serious problem in elderly, who may already suffer from age-related deficits in muscle function and mass such leading to permanent disability and premature death, as well as increased bone fracture rate. Despite the clinical importance of the condition few treatments exist to prevent or reverse the condition.

Now it has been surprisingly found that compositions containing as active ingredient at least one component selected from the group consisting of EGCG, hydroxytyrosol, resveratrol and derivatives, metabolites or analogues thereof may be useful for the prevention and treatment of muscle wasting leading to muscle loss and atrophy and the associated muscle disorders in animals, in particular mammals including humans.

In a specific embodiment of the present invention the nutraceutical compositions in addition to the active ingredient(s) defined above contain at least one carotenoid from the group consisting of β-carotene, lutein, zeaxanthin, lycopene and β-cryptoxanthin.

Groups of animals of particular interest apart from mammals and humans in connection with the present invention are, e.g., domestic animals or pets, such as horses, camels dromedaries, dogs, cats and birds, and animals kept in zoological gardens. Domestic animals, pets and zoo animals will receive the active ingredients preferably via their food, e.g., via pet food, including their drinking water

Moreover, it has been found that the present compositions act on different critical pathways involved in the process of muscle loss. The compositions of the present invention increase lean muscle mass and muscular strength in animal models.

Therefore, the present invention provides compositions for treating muscle wasting disorders including for example muscular dystrophy, muscle wasting due to cancer, AIDS, rheumatoid arthritis, renal failure, uremia, chronic heart failure, age-related sarcopenia, prolonged bed-rest, spinal cord injury, stroke, bone fracture. The present invention also provides methods of treating metabolic disorders including obesity, diabetes, hyperglycemia, and bone loss.

In preferred embodiments of the invention the compositions comprise a combination of EGCG and resveratrol, of hydroxytyrosol and resveratrol, of EGCG and lycopene, of EGCG and β-cryptoxanthin or of hydroxytyrosol and lycopene. Moreover, a multi-vitamin and mineral supplement may be added to the nutraceutical compositions of the present invention to obtain an adequate amount of an essential nutrients, which is missing in some diets. The multi-vitamin and mineral supplement may also be useful for disease prevention and protection against nutritional losses and deficiencies due to lifestyle patterns.

In other embodiments, the nutraceutical compositions of the present invention comprise resveratrol, a derivative, metabolite or analogue thereof with at least one additional component selected from EGCG, hydroxytyrosol and derivatives, metabolites or analogues thereof, particularly resveratrol and EGCG. They contain such a resveratrol compound, particularly resveratrol, in an amount sufficient to provide to a human adult (weighing

about 70 kg) a dosage from about 0.5 mg/day to about 2000 mg/day, preferably from about 5 mg/day to about 500 mg/day. Thus, if the nutraceutical composition is a food or beverage the amount of a resveratrol compound, particularly resveratrol, contained therein is suitably in the range from about 0.2 mg to about 500 mg per serving. If the nutraceutical composition is a pharmaceutical formulation such formulation may contain from about 0.5 mg to about 500 mg per solid dosage unit, e.g., per capsule or tablet, or from about 0.5 mg per daily dose to about 2000 mg per daily dose of a liquid formulation. EGCG is preferably used in a concentration so that the daily consumption by a human adult (weighing about 70 kg) is in the range of from 10 mg/day to 2000 mg/day. A food or beverage suitably contains about 2 mg to about 500 mg of EGCG per serving. If the nutraceutical composition is a pharmaceutical formulation such formulation may contain EGCG in an amount from about 5 mg to about 500 mg per dosage unit, e.g., per capsule or tablet, or from about 10 mg per daily dose to about 2000 mg per daily dose of a liquid formulation.

Instead of EGCG or in addition to EGCG the compositions can contain hydroxyrosol. The amount of hydroxytyrosol in this composition may be such to provide a daily dosage from about 0.01 mg per kg body weight to about 60 mg per kg body weight of the subject to which it is to be administered. A food or beverage suitably contains about 0.3 mg per serving to about 1250 mg per serving of hydroxytyrosol. If the nutraceutical composition is a pharmaceutical formulation such formulation may contain hydroxytyrosol in an amount from about 1 mg to about 4000 mg per dosage unit, e.g., per capsule or tablet, or from about 1 mg per daily dose to about 4000 mg per daily dose of a liquid formulation.

In case of carotenoids from the group consisting of β-carotene, lutein, zeaxanthin, lycopene and β-cryptoxanthin such carotenoid is preferably used in a concentration so that the daily consumption by an animal including humans (e.g. weighing about 70 kg) is in the range of from 0.05 mg/day to 50 mg/day (corresponding to a daily dosage of about 0.0007 to about 0.7 mg/kg body weight), more preferably from 0.5 mg/day to 30 mg/day. A nutraceutical composition preferably comprises 0.05 mg to 50 mg of the carotenoid per serving. If the composition is a pharmaceutical composition such composition may preferably comprise the carotenoid in an amount from 0.5 mg to 50 mg per dosage unit, e.g., per capsule or tablet, or a liquid formulation unit.

The term "serving" as used herein denotes an amount of food or beverage normally ingested by a human adult with a meal at a time and may range, e.g., from about 100 g to about 500 g.

The active ingredients of the composition defined above have different mechanisms of action thus providing synergistic effects in preventing muscle loss and atrophy and the associated muscle disorders in mammals, in particular humans.

The following Examples illustrate the invention further.

Example 1

The efficacy of resveratrol, EGCG as well as the combination of both compounds on muscle mass was tested in a 3 months feeding study in C57BLKS/J db/db mice (n=20/group). C57BLKS/J db/db mice suffer from severe metabolic disorder due to a defect in the leptin receptor and loss muscle mass as they age. Muscle wasting has been associated with chronic metabolic derangements. Moreover, muscle wasting induced by a variety of means in both rodents and humans results in similar changes in muscle anatomy, cross-sectional area, function, fiber type switching, contractile protein expression, and histology. In addition, several agents have been demonstrated to regulate skeletal muscle atrophy in both rodents and in humans. These agents include anabolic steroids, growth hormone, insulin-like growth factor 1, and beta adrenergic agonists. The data showed that skeletal muscle atrophy results from common mechanisms in both rodents and humans. Therefore, the rodent model can be used to evaluate the efficacy of compounds inhibiting muscle wasting.

Male db/db mice were obtained from Jackson Laboratory (Bar Harbor, ME, USA). Adult mice at the age of 8 weeks were used in the experiment. Mice were housed individually in plastic cages with bedding and allowed free access to standard rodent food and tap water. The animal rooms were controlled for temperature (24°C), humidity (55%), and light (12-h light-dark cycle). The animals were randomized into four groups. Resveratrol and EGCG were administered as feed-ad-mix. Corn cellulose (1% of diet) served as a carrier substance for resveratrol and EGCG as well as a placebo when used alone. Group 1 received placebo, group 2 received a diet containing 0.08% of resveratrol; group 3 received a diet containing 0.08% of EGCG; and group 4 received a diet containing 0.08% of

resveratrol and 0.08 % of EGCG. Body weight and food intake were determined over the course of the study. Total muscle mass was determined by nuclear magnetic resonance (NMR) measurement after 3 months of treatment. There was no difference in food intake between the groups over the study period.

Body weight and muscle tissue weight for each treatment group is shown in Table 1.

Table 1: Body weight (BW), muscle mass and change from baseline in db/db mice after 3 months of treatment.

	2 months old mice		**5 months old mice**		**Change from baseline**	
	BW (g)	Muscle (g)	BW (g)	Muscle (g)	BW (g)	Muscle (g)
Control	30.2	16.0	30.7	15.7	0.5	-0.3
Resveratrol 0.08%	30.3	16.0	34.2	17.0	3.9	1.0
EGCG 0.08%	30.4	15.7	31.4	16.2	1.0	0.5
Resveratrol 0.08% + EGCG 0.08%	30.4	16.0	35.7	17.4	5.3	1.4

In untreated animals (control), muscle mass is reduced by 2%. In the contrary in the resveratrol, EGCG and the resvertarol + EGCG group muscle mass is increased by 6, 3 and 9% respectively. Thus, adminstration of resveratrol, EGCG and the combination of the two prevents muscle loss in the mice. The combination of resveratrol and EGCG significantly increased muscle mass and was more potent than any of the single compound alone.

Example 2: Pharmaceutical compositions (may be prepared by conventional formulation procedures using the ingredients specified below)

Soft gelatin capsule

Soft gelatin capsules are prepared by conventional procedures using ingredients specified below:

Active ingredients: Resveratrol 10 mg and vitamin E 50 mg

Other ingredients: glycerol, water, gelatine, vegetable oil.

Hard gelatin capsule

Hard gelatin capsules are prepared by conventional procedures using ingredients specified below:

Active ingredients: resveratrol 5 mg, EGCG 100 mg, genistein, 5 mg, vitamin E 50 mg, vitamin K 1 mg

Other ingredients: Fillers: lactose or cellulose or cellulose derivatives, Lubricant: magnesium stearate if necessary (0.5%)

Tablet

Tablets are prepared by conventional procedures using ingredients specified below:

Active ingredients: resveratrol 5 mg, EGCG 50 mg, vitamin E 20 mg

Other ingredients: microcrystalline cellulose, silicone dioxide (SiO2), magnesium stearate, crosscarmellose sodium.

Example 3: Food items may be prepared by conventional procedures using ingredients specified below:

A Soft Drink containing resveratrol, EGCG and hydroxytyrsol may be prepared as follows:

1.1 Juice concentrates and water soluble flavours	[g]
Orange concentrate	
60.3 °Brix, 5.15% acidity	657.99
Lemon concentrate	
43.5 °Brix, 32.7% acidity	95.96
Orange flavour, water soluble	3.43
Apricot flavour, water soluble	6.71
Water	26.46

1.2 Color	
β-Carotene 10% CWS	0.89
Water	67.65

1.3 Acid and Antioxidant

Ascorbic acid	4.11
Citric acid anhydrous	0.69
Water	43.18

1.4 Stabilizers

Pectin	0.20
Sodium benzoate	2.74
Water	65.60

1.5 Oil soluble flavours

Orange flavour, oil soluble	0.34
Orange oil distilled	0.34

1.6 Active ingredient

Resveratrol, EGCG and Hydroxytyrosol in amounts providing 5 mg resveratrol / per serving, 10 mg EGCG / per serving and 5 mg hydroxytyrosol / per serving.

Fruit juice concentrates and water soluble flavours are mixed without incorporation of air. The color is dissolved in deionized water. Ascorbic acid and citric acid is dissolved in water. Sodium benzoate is dissolved in water. The pectin is added unter stirring and dissolved while boiling. The solution is cooled down. Orange oil and oil soluble flavours are premixed. The active ingredient as mentioned under 1.6 is stirred into the fruit juice concentrate mixture (1.1).

In order to prepare the soft drink compound all parts .1.1 to 1.6 are mixed together before homogenising using a Turrax and then a high-pressure homogenizer (p_1 = 200 bar, p_2 = 50 bar).

Claims

1. The use of at least one component selected from the group consisting of EGCG, hydroxytyrosol, resveratrol and derivatives, metabolites or analogues thereof in the manufacture of nutraceutical compositions for the prevention and treatment of muscle wasting leading to muscle loss, atrophy and other associated muscle disorders in animals, in particular mammals including humans.

2. The use of resveratrol, a derivative, metabolite or analogue thereof according to claim 1, in combination with at least one additional component selected from the group consisting of EGCG, hydroxytyrosol and derivatives, metabolites or analogues thereof.

3. The use according to claim 1 or claim 2 wherein the nutraceutical compositions in addition contain at least one carotenoid from the group consisting of β-carotene, lutein, zeaxanthin, lycopene and β-cryptoxanthin.

4. The use of resveratrol, a derivative, metabolite or analogue thereof according to claim 1, in combination with at least one additional component selected from EGCG and hydroxytyrosol.

5. The use of resveratrol according to claim 1 in combination with EGCG.

6. The use as in any one of claims 1 to 5, wherein said resveratrol is used in an amount sufficient to provide a daily dosage of 0.03 mg per kg body weight to about 10 mg per kg body weight of the subject to which it is to be administered; said EGCG is used in an amount sufficient to provide a daily dosage of 0.1 mg per kg body weight to about 20 mg per kg body weight of the subject to which it is to be administered; said hydroxytyrosol is used in an amount sufficient to provide a daily dosage of 0.03 mg per kg body weight to about 10 mg per kg body weight of the subject to which it is to be administered.

7. The use as in claim 3 wherein said carotenoid is used in an amount sufficient to provide a daily dosage of 0.0007 to 0.7 mg per kg body weight of the subject to which it is to be administered.

8. The use as in any one of claims 1 to 7 wherein the nutraceutical composition is a food or beverage, or a supplement composition for food or beverage.

9. The use as in any one of claims 1 to 7 wherein the nutraceutical composition is a pharmaceutical composition.

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