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(54) Title: USE OF FEATHERS AS A PLANT GROWING MEDIA COMPONENT OR SOIL AMENDMENT

(57) Abstract: A plant growing media component or soil amendment wherein reduced feathers are blended with one or more soil components or an existing soil material such that the reduced poultry feathers are present in the resulting blend in an amount of at least 10% by volume based upon the total volume of the blended composition.

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## USE OF FEATHERS AS A PLANT GROWING MEDIA COMPONENT OR SOIL AMENDMENT

### BACKGROUND OF THE INVENTION

1. Field of the Invention:

[0001] The present invention relates to methods and compositions involving the use of feathers as a plant growing media component or as a soil amendment.

5 2. Background:

[0002] A need exists for cost effective materials having suitable or improved chemical characteristics and physical properties for use as growing media components or as soil amendments. Growing media (e.g., potting soils) are typically designed for placement in containers and operate to provide water holding capacity, nutrient retention, physical support for the plant, and sufficient perviousness to allow air to reach the roots and to allow necessary gas/air exchanges to occur. Soil amendments, on the other hand, are components or compositions that are blended into naturally occurring or manufactured soils to improve drainage, water holding capacity, pH, or other physical properties or chemical characteristics. Examples of major users of growing media and soil amendments include, but are not limited to, commercial greenhouses and nurseries, golf courses, organic crop producers, and home plant growers and gardeners.

[0003] A need particularly exists for cost-effective growing media components and soil amendments capable of replacing or at least reducing the present demand for peat moss. As used herein, the terms "peat" and "peat moss" include all types of peat materials, including, but not limited to, reed peat, *Hypnum* peat, *Sphagnum* peat, sedge peat, reed-sedge peat, *Carex* peat, peat humus, Fibric peat, hemic peat, Sapric peat, etc. The ever-growing worldwide demand for peat materials is rapidly outpacing available

supplies. In addition, the mining of peat moss typically requires the draining of wetlands and/or creates other undesirable environmental effects or concerns.

[0004] In the United States alone, approximately four billion tons of feathers are produced in poultry processing operations each year. At present, almost all of these  
5 feathers are processed in rendering plants to produce a powdery, complex protein commonly used as a livestock feed additive. Unfortunately, the costs of such rendering processes typically equal or exceed the economic value of the rendered product.

[0005] It has been suggested that decomposed poultry feathers could be used as a fertilizer material. For example, United Kingdom patent applications GB2113517 and  
10 GB2170795 suggest that a solid organic fertilizer can be formed from rotted, crushed feathers, bones, heads, or feet of poultry by drying the rotted waste material and then milling the rotted, dried material to a powder.

[0006] Although it has been suggested that rotted, milled poultry feathers could potentially be used as a nitrogen nutrient source, poultry feather materials have not been  
15 recognized or known heretofore as a viable plant growing media component or soil amendment. Specifically, it has not been known or recognized that appropriately processed and prepared feather materials could provide physical support for plants, provide appropriate water retaining capacity and nutrient retention, air-filled pore space, gas exchange, and drainage, or provide favorable pH and other chemical characteristics.  
20 Rather, because of their inconsistent, nonhomogeneous physical structure, their moisture content, their contamination, decomposition and odor problems, and their difficulty in handling, feather materials have generally been viewed as not being acceptable or adaptable for such uses.

## SUMMARY OF THE INVENTION

[0007] The present invention satisfies the needs and alleviates the problems mentioned above. In accordance with the invention, an appropriately processed feather material which unexpectedly and surprisingly provides desirable physical support, water and nutrient retention, drainage, air-filled pore space and gas exchange, pH adjustment, and other physical properties and chemical characteristics is used as a growing media component and/or a soil amendment. The present invention also overcomes the feather odor, contamination, handling, storage, and other problems associated with waste feather materials.

10 [0008] In one aspect, the present invention provides a plant growing media comprising reduced feathers and a soil material. The soil material preferably comprises at least one component selected from the group consisting of peat, perlite, vermiculite, composted bark, coir, rice hulls, and composted waste. The reduced feathers are preferably present in the plant growing media in an amount of at least 10% by volume based upon the total volume of the media.

[0009] In another aspect, the present invention provides a method of plant production comprising the step of growing a plant in a plant-growing media comprising reduced feathers and a soil material. The soil material preferably comprises at least one component selected from the group consisting of peat, perlite, vermiculite, composted bark, coir, rice hulls, and composted waste. The reduced feathers are preferably present in the plant growing media in an amount of at least 10% by volume based upon the total volume of the media.

[0010] In yet another aspect, the present invention involves an improvement to a method of growing a plant in a soil material. The improvement comprises adding

reduced feathers to the soil material in an amount of at least 10% by volume based upon the total volume of the soil material and reduced feathers.

[0011] In each case, the feathers used in accordance with the present invention are preferably reduced using a refiner, a pulper, and/or similar reducing apparatus, preferably of the type used for processing recycled paper. In addition, the feathers will preferably be treated with an antimicrobial agent.

[0012] Further objects, features and advantages of the present invention will be apparent to those skilled in the art upon examining the accompanying drawings and upon reading the following description of the preferred embodiments.

10

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] The inventive growing media and soil amendment can employ generally any type of feathers. Poultry feathers are particularly well suited for use in the present invention. Although generally any type of chopped or otherwise reduced feathers can be used, the feathers will preferably be processed in accordance with the various procedures and steps set forth below. In addition, the reduced feathers employed in the present invention will preferably be reduced whole feathers but could alternatively be reduced feathers having all or a portion of the fiber and/or quill components separated therefrom. The degree to which the feathers are reduced can be adjusted as necessary or desired for the needs of the particular application in question.

20

[0014] Feathers from a poultry processing operation or other source will typically be delivered to an infeed system. The infeed system can be, for example, an infeed system of the type used for feeding raw feather materials to rendering plants. As

will be understood by those skilled in the art, such systems are capable of continuously delivering feathers to the processing system at a controlled or semi-controlled rate.

[0015] If necessary, the infeed system can deliver the raw, dirty feathers to an area where any other parts (e.g., heads and feet) and any foreign objects (e.g., metal  
5 objects, gloves, etc.) are removed. As will be understood by those skilled in the art, generally any method of removing such parts and foreign objects can be used. As one example, a water-filled, dissolved air flotation (DAF) tank could be used wherein dissolved air operates to physically separate meat parts and foreign objects from the raw feathers. Due to inherent buoyancy differences, any heads, feet, or other meat objects can  
10 be removed by adjusting the rate of air addition to the tank such that the meat objects travel through the tank at a rate of speed which is substantially slower than that of the feathers, thus causing the meat objects to be separated from the feathers by a divider plate or other separator appropriately positioned within the tank. Metal objects, on the other hand, separate from the raw feathers by simply dropping into a trap provided in the  
15 bottom of the tank.

[0016] Alternatively, or in addition, foreign material can be removed using metal detectors, centrifugal (e.g., cyclone) cleaners, and/or other devices or systems known in the art.

[0017] If desired or necessary, the raw feather material can be pressed to remove  
20 water therefrom. Such pressing can be beneficial for significantly reducing processing costs. Examples of mechanical, hydraulic, and other pressing apparatuses suitable for pressing the feather material include, but are not limited to, decanter centrifuges, centrifugal presses, belt presses, screw presses, pressing-type feed conveyors, or

combinations thereof. Any such pressing operation will preferably be conducted using a screw press and can involve multiple pressing steps.

[0018] The feathers are preferably reduced using an apparatus capable of producing a refined and/or pulped feather material. The apparatus will preferably  
5 comprise one or a plurality of refining and/or pulping machines of the type commonly employed in the paper industry for producing pulp from recycled paper. As will be understood by those skilled in the art, the pulping/refining step can be conducted in either a continuous or batch manner. As used herein, the terms "refiners" or "refining machines" also include disc mill apparatuses.

10 [0019] If a pulper is used, it will preferably be of the type used for processing recycled paper. The pulper will most preferably be a high shear pulper of the type having a rotor and stator assembly with a close tolerance in the defibering zone. An example of a commercially available pulper well suited for use in the present invention is the TORNADO pulper available from Bolton Emerson. Other suitable, but typically slower,  
15 units are available from Thermo Black Clawson and other manufacturers.

[0020] The feather reduction step will preferably be performed using one or more refining machines of the type used for processing recycled paper. The refining apparatus will most preferably be a disc mill type refiner of either single or double disc design. As will be understood by those skilled in the art, various alternative types of  
20 discs can be used in such apparatus to obtain generally any type and degree of grinding, shearing, shredding, pulverizing, rubbing, fluffing, or other refining desired.

[0021] Refiners and pulpers of the type mentioned above are unexpectedly and surprisingly effective for processing feather materials. These devices are well suited for handling the inherent structural strength of the feather materials and for overcoming the

tendency of such materials to clump together. The devices thus efficiently and economically produce a consistent, uniform product of higher quality. The devices can also handle large volumes of feathers even with some foreign materials contained therein.

[0022] Although not essential, the feathers are preferably processed in the refining or pulping apparatus in the presence of an aqueous liquid carrier. The amount of aqueous carrier used in the refining/pulping apparatus will preferably be in the range of from about 0% to about 50% by volume based on the total volume of feathers and carrier liquid.

[0023] The residence time of the feathers within the refining or pulping apparatus, and/or the degree to which the feather material is recycled through refining or pulping apparatus, can be varied as necessary to obtain the particular end product desired. Relevant factors include, for example, the size and structure of the raw feather feed material and the desired size of the resulting reduced product.

[0024] For most applications, the feathers will preferably have a total residence time within refining or pulping apparatus in the range of from about one second to about 15 minutes. As will be understood by those skilled in the art, multiple passes through the apparatus can be employed if desired. Some typical refining machines require from about one to about 60 seconds per pass.

[0025] Following the reducing step and depending upon the amount of particle reduction and/or other characteristics necessary for the final product, the inventive process can also optionally include one or more additional reduction and/or refining steps. Examples of devices and system which could be used for further reducing and/or otherwise refining the feathers pulp include, but are not limited to: linters; blenders; mills; choppers; centrifugal grinders; cleaners; and/or additional pulpers or refiners.

[0026] To address odor and premature decomposition problems, to provide desirable shelf life, and to provide inventive growing media compositions having sufficiently stable chemical characteristics and stable structural and physical properties for packaging, storage, and/or retail sale, the feather material will preferably be sanitized  
5 by treatment with one or more antimicrobial agents. Such treatment can occur before, during, and/or after the reduction procedure. Examples of preferred antimicrobial agents include, but are not limited to: hydrogen peroxide; chlorine bleaches such as sodium hypochlorite; calcium hypochlorite; cetylpyridinium chloride; 1-bromo-3-chloro-5,5 dimethylhydantoin; hydrogen dioxide; ozone; ethanol; Agribrom; and combinations  
10 thereof. The feather material can also be sanitized using ultraviolet light. The feather material will preferably be sanitized using hydrogen peroxide or chlorine bleach. Hydrogen peroxide leaves no harmful residual chemicals if over applied and is therefore the most preferred sanitizing agent.

[0027] The feather material can also optionally be washed before, during, or  
15 after the reduction procedure to remove fats, proteins, and other contaminants. Examples of suitable cleaning agents include, but are not limited to: inorganic solvents such as hydrogen peroxide; organic solvents such as ethanol; detergents; bleaches (preferably a chlorine bleach); and surface acting surfactants. Detergents employed for washing the feather material will most preferably be de-inking compounds or wetting agents of the  
20 type providing emulsification of fats, oils, and greases, as well as general soil detergency. An example of a commercially available wetting agent particularly well suited for use in the present invention is FIBERWET DI, available from Steen Research, Inc. FIBERWET DI comprises a mixture of silicates, ethylene diamine, tetra acetic acid, sodium xylene

sulfonate, sodium octane sulfonate, sodium laureth modified with 3 mol of ethylene oxide, and alkaryl ether phosphates.

[0028] If desired or necessary, the feather material can also be treated with other agents and additives such as deodorizers, pesticides, mold inhibitors, and agents for providing any appropriate pH adjustment. Examples of suitable agents for pH adjustment include, but are not limited to, phosphoric acid, sulfuric acid, nitric acid, aluminum sulfate, iron sulfate, and combinations thereof.

[0029] If the antimicrobial agent and/or cleaning agent employed in the present invention is hydrogen peroxide, bleach, a surface acting surfactant, or a combination thereof, the agent will preferably be used in an aqueous treatment solution (e.g., in the pulper carrier solution or in some other aqueous treatment solution) at a concentration in the range from about 5 ppm to about 15% by volume. The concentration of hydrogen peroxide and/or surfactant in the aqueous treatment solution will more preferably be in the range of from about 500 ppm to about 15% by volume and the concentration of bleach, if used, will more preferably be in the range of from about 5 ppm to about 3,500 ppm by volume. The concentration will most preferably be about 3% by volume for hydrogen peroxide or about 500 ppm by volume for surface acting surfactants or bleach.

[0030] Following the reduction procedure, the feather material is preferably at least partially dewatered by first delivering the material to a dewatering screen. As will be understood by those skilled in the art, the dewatering screen system will typically be an auger device having a perforated trough, a rotary screen, a vertical slit screen, a hydraulic press or similar dewatering device.

[0031] After the dewatering screen, the feather material will preferably be further dewatered to achieve an acceptable water content. As will be understood by those

skilled in the art, appropriate dewatering systems can be employed to achieve any desired final moisture level. For most applications, it will be preferable that the final moisture content of the reduced feather material be no more than 60% by weight. As indicated hereinabove, examples of suitable dewatering apparatuses and systems include but are not limited to centrifugal presses, belt presses, screw presses, sheeting apparatuses of the type used in the paper industry, and combinations thereof. Screw presses of the type commonly used in the paper industry for dewatering pulp and sludge fiber are particularly well suited for dewatering the reduced feather material.

[0032] If necessary or desired to remove additional moisture, the reduced feather material can be delivered through one or more drying units. Examples of suitable drying systems include, but are not limited to, forced air ovens, radio frequency ovens or dryers, tube dryers (e.g., jet tube dryers), vortex dryers, or other comparable drying systems.

[0033] As a further or alternative option, the wet reduced feather material can be conducted through one or more centrifugal cleaners. Centrifugal cleaners of the type commonly used in the paper industry are particularly well suited for use in the present invention. The centrifugal cleaners will most preferably be forward centrifugal cleaners. Cleaners of this type are commercially available, for example, from Posiflow or Uniflow. The cleaner will preferably employ a small nozzle producing a relatively high pressure drop (most preferably a pressure drop in the range of from about 5% to about 30% from inlet to outlet). Centrifugal cleaners of this type will readily remove any contaminants such as leg skin, parts of the head, eyes, etc. and will also remove most of the solution remaining in the reduced feather material.

[0034] For use in accordance with the present invention as a plant growing media component or as a soil amendment, the feather material will preferably be reduced to an average length of not more than 3/4 inch. The reduced feather material will more preferably have an average length of not more than 1/2 inch. The feathers will most preferably be either coarsely reduced to an average length of more than 1/4 inch or finely reduced to an average length of not more than 1/4 inch.

[0035] When used as a growing media component, the reduced feather material will be blended with at least one other soil component. Examples of suitable soil components include, but are not limited to, peat, perlite, vermiculite, composted bark, coir, rice hulls, and composted waste material (e.g., manure, paper, and/or municipal waste). Depending upon the particular use in question, the amount of reduced feather material in the resulting plant growing media composition will preferably be at least 10% by volume, more preferably from about 10% to about 65%, and most preferably from about 20% to about 65% of the total volume of the growing media composition.

[0036] If a finely reduced feather material is employed, the feather material will preferably be present in an amount in the range of from about 10% to about 60%, more preferably from about 20% to about 60%, by volume based upon the total volume of the growing media composition. If a coarsely reduced feather material is used, the feather material will preferably be present in an amount in the range of from about 10% to about 65%, more preferably from about 20% to about 65%, by volume based upon the total volume of the growing media composition.

[0037] The plant growing media composition will also preferably include peat in an amount in the range of from about 35% to about 90% by volume based upon the total volume of the plant growing media composition. Additionally, if present, the

inventive media composition will preferably include perlite and/or one or more of the other soil materials listed above in an amount of not more than 80% (more preferably from about 10% to about 30% by volume) based upon the total volume of the growing media composition.

5           **[0038]** As will be understood by those skilled in the art, the inventive blended growing media composition can be used directly for growing plants or can be packaged in the same manner as other growing media compositions for storage and/or sale.

**[0039]** When used as an amendment for existing natural or manufactured soil materials, the reduced feather material will preferably be added to the soil material in an amount of at least 10% by volume and will more preferably be added in an amount in the  
10           range of from about 10% to about 65%, most preferably from about 20% to about 65%, by volume based upon the resulting total blended volume of the soil material and the reduced feather material. If a coarsely reduced feather material is used, the reduced feather material will preferably be added to the soil material in an amount in the range of  
15           from about 10% to about 65%, more preferably from about 20% to about 65%, by volume based upon the total blended volume of the soil material and the feather material.  
          If a finely reduced feather material is used, the feather material will preferably be added to the soil material in an amount in the range of from about 10% to about 60%, more preferably from about 20% to about 60%, by volume based upon the total blended  
20           volume of the soil material and the feather material.

**[0040]** Coarsely reduced feather materials are typically preferred for use in the present invention, for example, for growing larger plants such as nursery crops (e.g., trees and shrubs) and larger greenhouse crops. Finely reduced feather materials, on the other

hand, are typically preferred for use in the present invention, for example, for growing seedlings, plugs, and small greenhouse plants.

### **EXAMPLE 1**

[0041] Process reduced chicken feathers were continuously stirred in an aqueous  
5 hydrogen peroxide solution having a hydrogen peroxide concentration of 2500 ppm by volume. It was observed that such mixing for a period of from two to three minutes was adequate to remove substantially all fat and residual proteins from the feathers and to kill bacteria on the surfaces of the feathers and in the hollow areas of the fibers and quills. It was also observed that, the more violent the agitation, the less mixing time was required.  
10 Comparative tests revealed that essentially the same amount of agitation was required for processing the feathers with ethanol.

### **EXAMPLE 2**

#### **Growth of Geranium and Vinca in Processed-Poultry-Feather-Containing Substrates** 15

##### Materials and Methods

[0042] Four substrates were formulated by blending processed reduced poultry (chicken) feathers (Tyson Foods, Springdale, AR), coarse horticultural perlite and  
20 *Sphagnum* peat (SunGro Horticulture, Bellevue, WA) at varying proportions. All substrates contained 20% (v/v) perlite. Substrates also contained 0%, 10%, 15% or 20% (v/v) processed coarse feather with the remainder being *Sphagnum* peat.

[0043] Four-leaf plugs (seedlings in size 288 plug trays with 5 ml volume per plug cell) of *Pelargonium x hortorum* 'Orbit Cardinal' (geranium) and *Catharanthus*

*roseus* 'Cooler Blush' (vinca) were transplanted into 8-cm plastic containers filled with each of the test substrates described.

[0044] Plants were placed into a glass-glazed greenhouse. Greenhouse air temperatures were maintained between 20 and 25° C (68 and 77°F). Plants were grown  
5 under ambient light levels (250 - 300  $\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ ). Immediately after being placed into the greenhouse, all containers were drenched with the fungicide Banrot® at the recommended label rate. Plants were fertilized at each irrigation with a 200  $\text{mg}\cdot\text{L}^{-1}$  N solution using Excel 15-5-15 Cal Mag water-soluble fertilizer (Scotts, Co, Marysville, OH).

[0045] After 6 weeks, the experiment was terminated. Shoot and root fresh and  
10 dry weights were determined. The experimental design was a complete randomized block with 8 blocks and each treatment combination appearing once in each block. An analysis of variance was conducted to determine if significant differences in plant growth occurred among the different substrates. Where significant differences occurred, a LSD ( $\alpha = 0.05$ ) mean separation test was conducted to determine which means were significantly  
15 different from one another.

### Results and Discussion

[0046] Geranium (Table 1) and vinca (Table 2) shoot fresh weight, shoot dry weight, root fresh weight and root dry weight were not significantly different among the substrates. Based upon growth variables measured in this study, geranium and vinca  
20 plants grown in substrates amended with up to 20% processed feather performed similarly to those grown in 80% *Sphagnum* peat and 20% perlite. Additionally, geranium plants grown in substrates containing coarse processed feather had visually darker green foliage than those grown in 80% *Sphagnum* peat and 20% perlite (Figures 1 and 2). No visual difference in foliage color was observed for vinca grown in the different substrates.

Table 1. Growth of geranium in *Sphagnum* peat-based media amended with coarse processed poultry feathers.

Substrate component (%v/v)			Fresh shoot weight (g)	Dry shoot weight (g)	Fresh root weight (g)	Dry root weight (g)
<i>Sphagnum</i> peat <sup>z</sup>						
	Feather	Perlite				
80	0	20	50.6	6.1	5.9	0.8
70	10	20	50.5	5.7	6.4	0.9
65	15	20	49.7	5.7	6.1	0.8
60	20	20	48.9	5.7	5.9	0.8
Significance						
Treatment			NS	NS	NS	NS
Block			NS	NS	NS	NS

<sup>z</sup> *Sphagnum* peat was amended with calcitic lime to adjust the pH to 5.4 prior to use.

NS Nonsignificant

Table 2. Growth of vinca in *Sphagnum* peat-based media amended with coarse processed poultry feathers.

Substrate components (%v/v)			Fresh shoot weight (g)	Dry Shoot weight (g)	Fresh root weight (g)	Dry root weight (g)
<i>Sphagnum</i> peat <sup>z</sup>						
	Feather	Perlite				
80	0	20	12.3	1.8	3.7	0.4
70	10	20	9.2	1.4	3.0	0.3
65	15	20	11.9	1.8	3.5	0.3
60	20	20	7.6	1.1	1.9	0.2
Significance						
Treatment			NS	NS	NS	NS
Block			NS	NS	NS	NS

<sup>z</sup> *Sphagnum* peat was amended with calcitic lime to adjust the pH to 5.4 prior to use.

NS Nonsignificant

Conclusion:

- 5            [0047] Geranium and vinca plants of similar or higher qualities can be grown in a *Sphagnum* peat-based substrate amended with up to at least 20% coarse processed poultry feathers as in a 80% *Sphagnum* peat and 20% perlite control.

### **EXAMPLE 3**

#### **Growth of Tomato and Cucumber in Processed-Poultry-Feather-Containing Substrates**

##### 5 **Materials and Methods**

[0048] Five substrates were formulated by blending fine and coarse processed reduced poultry (chicken) feathers (Tyson Foods, Springdale, AR), coarse horticultural perlite and *Sphagnum* peat (SunGro Horticulture, Bellevue, WA) at varying proportions. All substrates contained 20% (v/v) perlite. Substrates also contained 0%, 30%, or 40%  
10 (v/v) fine or coarse processed poultry feather with the remainder being *Sphagnum* peat.

[0049] Four-leaf plugs (seedlings in size 288 plug trays with 5 ml volume per plug cell) of *Lycopersicon esculentum* (tomato) 'Better Boy' were transplanted into 8-cm black plastic containers filled with each of the test substrates previously described. *Cucumis sativus* (cucumber) seed were sown directly into the containers filled with each  
15 substrate.

[0050] Plants were placed into a glass-glazed greenhouse. Greenhouse air temperatures were maintained between 20 and 25° C (68 and 77°F). Plants were grown under ambient light levels (250 - 300  $\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ ). Immediately after being placed into the greenhouse, all containers were drenched with the fungicide Banrot® at the recommended  
20 label rate. Plants were fertilized at each irrigation with a 200  $\text{mg}\cdot\text{L}^{-1}$  N solution using Excel 15-5-15 Cal Mag water-soluble fertilizer (Scotts, Co, Marysville, OH).

[0051] After 4 weeks, the experiment was terminated. Shoot and root fresh and dry weights were determined. The experimental design was a complete randomized block with 6 blocks and each treatment combination appearing once in each block. An analysis

of variance was conducted to determine if significant differences in plant growth occurred among the different substrates. Where significant differences occurred, a LSD ( $\alpha = 0.05$ ) mean separation test was conducted to determine which means were significantly different from one another.

5

### Results and Discussion

[0052] Tomato grown in substrates composed of up to 40% coarse processed reduced poultry feathers had similar shoot fresh weights, shoot dry weights, root fresh weights and root dry weights as tomato grown in 80% *Sphagnum* peat and 20% perlite substrate (Table 3). Shoot fresh and dry weights of tomato grown in 30% fine feather-amended substrates were similar to shoot fresh and dry weights of tomato grown in 80% *Sphagnum* peat and 20% perlite. Root fresh and dry weights of tomato grown in 30% fine feather-amended substrates were significantly lower than root fresh and dry weights of tomato grown in 80% *Sphagnum* peat and 20% perlite. Shoot fresh weights, shoots dry weights, root fresh weights and root dry weights of tomato grown in 40% fine feather-amended substrates were significantly lower than shoot fresh weights, shoots dry weights, root fresh weights and root dry weights of tomato grown in 80% *Sphagnum* peat and 20% perlite.

Table 3. Tomato grown in *Sphagnum* peat-based substrates amended with coarse or fine processed poultry feathers.

Substrate components (%v/v)				Fresh shoot weight (g)	Dry shoot weight (g)	Fresh root weight (g)	Dry root weight (g)
<i>Sphagnum</i> peat <sup>z</sup>	Coarse feather	Fine feather	Perlite				
80	0	0	20	52.2	8.2	15.8	1.7
50	30	0	20	49.1	7.8	15.4	1.7
40	40	0	20	50.8	7.7	17.2	2.1
50	0	30	20	49.2	7.8	12.6	0.2
40	0	40	20	40.9	5.5	14.5	0.2
Significance							
Treatment				**	***	*	**
LSD ( $\alpha=0.05$ )				4.8	0.7	2.4	0.3

<sup>z</sup> *Sphagnum* peat was amended with calcitic lime to adjust the pH to 5.4 prior to use.

\*, \*\*, \*\*\* Significant at P= 0.05, 0.01 or 0.001, respectively.

- 5            [0053] Cucumber grown in substrates composed of up to 40% coarse and 30% fine processed reduced poultry feathers had similar shoot fresh weights, shoot dry weights, root fresh weights and root dry weights as cucumber grown in 80% *Sphagnum* peat and 20% perlite (Table 4, Figures 7 and 8). Cucumber grown in 30% coarse processed poultry feather had similar fresh shoot weights and dry root weights as
- 10 cucumber grown in 80% *Sphagnum* peat and 20% perlite. Cucumber grown in 40% fine processed poultry feather had significantly lower dry shoot weight and fresh root weight than those grown in 80% *Sphagnum* peat and 20% perlite.

Table 4. Cucumber grown in *Sphagnum* peat-based substrates amended with coarse or fine processed poultry feathers.

Substrate components (%v/v)				Fresh shoot weight (g)	Dry shoot weight (g)	Fresh root weight (g)	Dry root weight (g)
<i>Sphagnum</i> peat <sup>z</sup>	Coarse feather	Fine feather	Perlite				
80	0	0	20	31.2	3.7	14.9	1.2
50	30	0	20	24.2	3.0	13.1	1.0
40	40	0	20	32.6	4.1	14.7	1.4
50	0	30	20	39.7	4.9	17.5	1.6
40	0	40	20	27.9	2.6	9.0	0.9
Significance							
Treatment				NS	**	*	NS
LSD ( $\alpha=0.05$ )				10.3	0.9	4.7	0.5

<sup>z</sup> *Sphagnum* peat was amended with calcitic lime to adjust the pH to 5.4 prior to use.  
 NS, \*, \*\* Nonsignificant or significant at P= 0.05 or 0.01, respectively.

## 5 Conclusion:

[0054] Tomato and cucumber plants of similar qualities can be grown in *Sphagnum* peat-based substrates amended with up to 40% coarse processed poultry feathers or 30% fine processed poultry feathers as in a 80% *Sphagnum* peat and 20% perlite control.

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## EXAMPLE 4

### **Growth of Tomato in SB-300 Commercial Substrate Amended with Processed-Poultry Feathers**

## 15 Materials and Methods

[0055] Two substrates were formulated by blending coarse processed reduced poultry (chicken) feathers (Tyson Foods, Springdale, AR) at 0% or 40% (v/v) with the commercially available SB-300 substrate (SunGro Horticulture, Bellevue, WA). Four-leaf

plugs (seedlings in size 288 plug trays with 5 ml volume per plug cell) of *Lycopersicon esculentum* (tomato) 'Better Boy' were transplanted into 6-pack containers filled with the substrates.

[0056] Plants were placed into a glass-glazed greenhouse. Greenhouse air temperatures were maintained between 20 and 25° C (68 and 77°F). Plants were grown under ambient light levels (250 - 300  $\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ ). Immediately after being placed into the greenhouse, all containers were drenched with the fungicide Banrot® at the recommended label rate. Plants were fertilized at each irrigation with a 200  $\text{mg}\cdot\text{L}^{-1}$  N solution using Excel 15-5-15 Cal Mag water-soluble fertilizer (Scotts, Co, Marysville, OH).

[0057] After 4 weeks, the experiment was terminated. Shoot and root fresh and dry weights were determined. The experimental design was a complete randomized design with 4 replications. A 6-pack container constituted a replication. An analysis of variance was conducted to determine if significant differences in plant growth occurred among the different substrates. Where significant differences occurred, a LSD ( $\alpha = 0.05$ ) mean separation test was conducted to determine which means were significantly different from one another.

#### Results and Discussion

[0058] Tomato grown in SB-300 amended with 40% coarse processed reduced poultry feathers had similar fresh shoot weight, dry shoot weight, and fresh root weight as tomato grown in SB-300 substrate (Table 5). Tomato grown in SB-300 substrate amended with 40% coarse processed poultry feather had a significantly higher root dry weight than tomato grown in SB-300.

Table 5. Tomato grown in cell packs with SB-300 and SB-300 with coarse processed poultry feathers.

Substrates	Fresh shoot weight (g)	Dry shoot weight (g)	Fresh root weight (g)	Dry root weight (g)
SB-300 <sup>z</sup>	17.3	2.4	5.3	0.6
SB-300 + 40% feather <sup>y</sup>	16.0	2.2	5.9	0.8
Significance Treatment	NS	NS	NS	*

<sup>z</sup> SunGro Horticulture, Bellevue, WA

<sup>y</sup> SunGro SB-300 with 40% processed poultry feather (%v/v)

NS, \* Nonsignificant or significant at P = 0.05, respectively.

### Conclusion:

[0059] Tomato plants of similar or higher quality can be grown in cell packs filled with SB-300 commercial substrate blended with up to 40% (v/v) processed coarse poultry feather as compared to tomatoes grown in 100% SB-300.

\* \* \* \*

[0060] Thus, the present invention is well adapted to carry out the objects and attain the ends and advantages mentioned above as well as those inherent therein. While presently preferred embodiments have been described for purposes of this disclosure, numerous changes and modifications will be apparent to those skilled in the art. Such changes and modifications are encompassed within the spirit of this invention as defined by the appended claims.

## WHAT IS CLAIMED IS:

1. A plant growing media comprising reduced feathers and a soil material, wherein:  
said soil material comprises at least one component selected from the group  
consisting of peat, perlite, vermiculite, composted bark, coir, rice hulls,  
and composted waste; and  
5 said reduced feathers are present in said plant growing media in an amount of at  
least 10% by volume based upon the total volume of said plant growing  
media.
2. The plant growing media of claim 1 wherein said reduced feathers have an  
10 average length of greater than 1/4 inch.
3. The plant growing media of claim 2 wherein said reduced feathers are present in  
an amount in the range of from about 10% to about 65% by volume based upon the total  
volume of said plant growing media.  
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4. The plant growing media of claim 1 wherein said reduced feathers have an  
average length of not more than 1/4 inch.
5. The plant growing media of claim 4 wherein said reduced feathers are present in  
20 an amount in the range of from about 10% to about 60% by volume based upon the total  
volume of said plant growing media.

6. The plant growing media of claim 1 wherein said reduced feathers have been reduced using at least one refiner, at least one pulper, or a combination thereof.
7. The plant growing media of claim 1 wherein said reduced feathers have been  
5 treated with at least one antimicrobial agent.
8. The plant growing media of claim 7 wherein said antimicrobial agent is hydrogen peroxide, bleach, or a combination thereof.
- 10 9. The plant growing media of claim 1 wherein said reduced feathers have an adjusted pH resulting from treatment with phosphoric acid, sulfuric acid, nitric acid, aluminum sulfate, iron sulfate, or a combination thereof.
10. The plant growing media of claim 1 wherein said reduced feathers have been  
15 cleaned using a cleaning agent.
11. The plant growing media of claim 10 wherein said cleaning agent is selected from the group consisting of hydrogen peroxide, detergent, de-inking compounds, surface acting surfactants, chlorine bleach, and combinations thereof.
- 20 12. The plant growing media of claim 1 comprising peat in an amount in the range of from about 35% to about 90% by volume based upon the total volume of said plant growing media.

13. A method of plant production comprising the step of growing a plant in a plant growing media comprising reduced feathers and a soil material, wherein:

said soil material comprises at least one component selected from the group consisting of peat, perlite, vermiculite, composted bark, coir, rice hulls, and composted waste; and

said reduced feathers are present in said plant growing media in an amount of at least 10% by volume based upon the total volume of said plant growing media.

14. The method of claim 13 wherein said reduced feathers have an average length of greater than 1/4 inch.

15. The method of claim 14 wherein said reduced feathers are present in an amount in the range of from about 10% to about 65% by volume based upon the total volume of said plant growing media.

16. The method of claim 13 wherein said reduced feathers have an average length of not more than 1/4 inch.

17. The method of claim 16 wherein said reduced feathers are present in an amount in the range of from about 10% to about 60% by volume based upon the total volume of said plant growing media.

18. The method of claim 13 wherein said reduced feathers have been reduced using at least one refiner, at least one pulper, or a combination thereof.

19. The method of claim 13 wherein said reduced feathers have been treated with at least one antimicrobial agent.

20. The method of claim 19 wherein said antimicrobial agent is hydrogen peroxide, bleach, or a combination thereof.

21. The method of claim 13 wherein said reduced feathers have an adjusted pH resulting from treatment with phosphoric acid, sulfuric acid, nitric acid, aluminum sulfate, iron sulfate, or a combination thereof.

22. The method of claim 13 wherein said reduced feathers have been cleaned using a cleaning agent.

23. The method of claim 22 wherein said cleaning agent is selected from the group consisting of hydrogen peroxide, detergent, de-inking compounds, surface acting surfactants, chlorine bleach, and combinations thereof.

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24. The method of claim 13 wherein said plant growing media comprises peat in an amount in the range of from about 35% to about 90% by volume based upon the total volume of said plant growing media.

25. In a method of growing a plant in a soil material, the improvement comprising adding reduced feathers to said soil material in an amount of at least 10% by volume based upon the total volume of said soil material and said reduced feathers.

5 26. The method of claim 25 wherein said reduced feathers have an average length of greater than 1/4 inch.

27. The method of claim 26 wherein said reduced feathers are added in an amount in the range of from about 10% to about 65% by volume based upon the total volume of  
10 said soil material and said reduced feathers.

28. The method of claim 25 wherein said reduced feathers have an average length of not more than 1/4 inch.

15 29. The method of claim 28 wherein said reduced feathers are added in an amount in the range of from about 10% to about 60% by volume based upon the total volume of said soil material and said reduced feathers.

30. The method of claim 25 wherein said reduced feathers have been reduced using at  
20 least one refiner, at least one pulper, or a combination thereof.

31. The method of claim 25 wherein said reduced feathers have been treated with at least one antimicrobial agent.

32. The method of claim 31 wherein said antimicrobial agent is hydrogen peroxide, bleach, or a combination thereof.

33. The method of claim 25 wherein said reduced feathers have an adjusted pH  
5 resulting from treatment with phosphoric acid, sulfuric acid, nitric acid, aluminum sulfate, iron sulfate, or a combination thereof.

34. The method of claim 25 wherein said reduced feathers have been cleaned using a cleaning agent.

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35. The method of claim 34 wherein said cleaning agent is selected from the group consisting of hydrogen peroxide, detergent, de-inking compounds, surface acting surfactants, chlorine bleach, and combinations thereof.

15 36. A plant growing media comprising reduced feathers mixed with at least one soil component wherein:

said reduced feathers are present in an amount of at least 10% by volume based

upon the total volume of said plant growing media; and

said reduced feathers have an average length of not more than 3/4 inch.

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37. The plant growing media of claim 36 wherein said average length is not more than 1/2 inch.

38. The plant growing media of claim 37 wherein said reduced feathers are present in an amount in the range of from about 10% to about 65% by volume based upon the total volume of said plant growing media.
- 5 39. The plant growing media of claim 36 wherein said reduced feathers have been reduced using at least one refiner, at least one pulper, or a combination thereof.
40. A method of plant production comprising the step of growing a plant in a plant growing media comprising reduced feathers mixed with at least one soil component  
10 wherein:  
said reduced feathers are present in an amount of at least 10% by volume based upon the total volume of said plant growing media; and  
said reduced feathers have an average length of not more than 3/4 inch.
- 15 41. The method of claim 40 wherein said average length is not more than 1/2 inch.
42. The method of claim 41 wherein said reduced feathers are present in an amount in the range of from about 10% to about 65% by volume based upon the total volume of said plant growing media.
- 20 43. The method of claim 40 wherein said reduced feathers have been reduced using at least one refiner, at least one pulper, or a combination thereof.

## INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 03/32324

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C05F15/00 C05F1/00 C09K17/50 A23J1/10 A01N63/02  
C09K17/32

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C05F C09K A23J A01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

WPI Data, EPO-Internal, BIOSIS

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	EP 0 384 290 A (SCHNEIDER INGRID) 29 August 1990 (1990-08-29) column 1, line 24-32 column 2, line 13-35 column 3, line 24-27 ---	1-43
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Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

## ° Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
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# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 03/33234

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	<p>B. GAGNON &amp; S. BERROUARD: "Effects of several organic fertilizers on growth of greenhouse tomato transplants."  CAN. J. PLANT SCI.,  vol. 74, 1994, pages 167-168, XP009027263  page 167, column 1, line 9-25  page 168, column 1, paragraph 3; table 1</p>	1-43
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Information on patent family members

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PCT/US 03/33234

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