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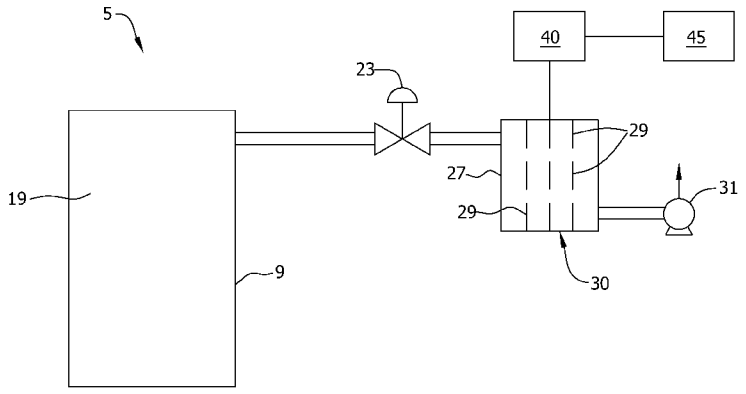
FIG. 1



(57) Abstract: Methods for identifying desirable traits such as flavor or aroma. Methods include screening plant varieties by sensing volatile compounds released from edible plant products produced by the plant.

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METHODS OF IDENTIFYING DESIRABLE TRAITS IN EDIBLE PLANT PRODUCTS

BACKGROUND

[0001] The field of this disclosure relates to methods for identifying desirable traits in the plants and, particularly, to methods that include screening plant varieties by sensing volatile compounds released from edible plant products produced by the plant.

[0002] Large-scale commercial production of fruits and vegetables has resulted in plant varieties that produce fruits and vegetables that are resistant to spoilage which facilitates long-distance shipping of the fruits or vegetables. However, this spoilage resistance has come at the cost of reducing freshness and desirable aroma and flavor in the fruits and vegetables. It has been found that consumer buying decisions in selecting a fruit or vegetable are driven by the consumer's perception of freshness and/or desirable aroma in the fruit or vegetable.

[0003] Current efforts to improve the aroma and taste in fruits and vegetables involve production of new plant varieties followed by consumer tests to determine whether the fruit or vegetable is characterized by improved aroma and/or taste. Consumer testing typically requires a panel of consumers who provide sensory evaluation by sampling the fruit or vegetable by smelling or tasting it. Such consumer testing panels are difficult for producers to conduct due to the level of expertise required to develop a testing protocol that produces desirable results. Further, such panels are expensive to assemble, do not provide instant results and are not well-suited to screen large numbers of fruits or vegetables.

[0004] Further, it has been found that different cultures prefer different traits in fruits and vegetables. For instance, a consumer from Latin America may desire peppers that are characterized by relatively high pungency; whereas, a consumer in the United States or Europe may prefer peppers that are less pungent and sweeter. This increases the complexity of consumer panel evaluations and increases the cost of screening fruits and vegetables for consumer production.

[0005] A continuing need exists for methods for testing and screening fruits and vegetables to determine whether the fruit or vegetable is characterized by desirable aroma and/or taste such that the variety may be used commercially or used as breeding stock for new fruit and vegetable varieties. There is a need for such methods that provide reliable and instant feedback, are inexpensive to perform. can screen many samples and can screen for different cultural preferences.

SUMMARY

[0006] In accordance with the present disclosure, methods for identifying desirable traits such as desirable aroma or taste are described. The methods generally involve screening a new variety of plant by sensing volatile compounds released from an edible portion of the plant (synonymously "edible plant product") to produce one or more electronic signals. The electronic signals may then be analyzed to determine whether the edible portion of the plant is characterized by improved flavor and/or taste. In this manner, numerous edible plant products may be screened quickly and reliably; however, it should be understood that the methods of the disclosure may be applied to screen as few as one or more edible plant products.

[0007] In one aspect of the present disclosure, a method of identifying desirable traits includes providing a variety of a plant, the plant containing an edible portion. The variety of plant is screened by sensing volatile compounds released from the edible portion of the plant to generate one or more electronic signals. The electronic signals are analyzed to determine whether the edible portion of the plants of the variety are desirable.

[0008] Another aspect of the present disclosure is directed to a method for selecting a plant as breeding stock in the development of commercially desirable edible plant products. The method includes identifying a desirable trait of the edible plant product. The desirable trait is associated with a distinctive feature of electronic signals generated by sensing volatile compounds released from the edible plant product. One or more volatile compounds released from an edible plant product of interest is sensed to

generate one or more electronic signals. The electronic signals are analyzed to determine whether they are characterized by the distinctive feature.

[0009] Various refinements exist of the features noted in relation to the above-mentioned aspects of the present disclosure. Further features may also be incorporated in the above-mentioned aspects of the present disclosure as well. These refinements and additional features may exist individually or in any combination. For instance, various features discussed below in relation to any of the illustrated embodiments of the present disclosure may be incorporated into any of the above-described aspects of the present disclosure, alone or in any combination.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Figure 1 is a schematic of a system for screening edible plant products according to one embodiment of the present disclosure with a processor and memory unit shown in schematic;

[0011] Figure 2 is a graph of the principal component analysis (PCA) score plot of volatiles released from three pepper varieties according to Example 1;

[0012] Figures 3-6 are graphs of the sensor interaction of volatiles released from four different melon varieties according to Example 2; and

[0013] Figure 7 is a graph of the principal component analysis (PCA) score plot of volatiles released from melon varieties according to Example 2.

[0014] Corresponding reference characters indicate corresponding parts throughout the drawings.

DETAILED DESCRIPTION

[0015] The methods of the present disclosure may generally be used to screen plants that contain edible portions and particularly portions that are edible by humans (e.g., grains, fruits, vegetables, nuts, etc.); however, it should be understood that they may be used to screen other types of plants without limitation (e.g., rose bushes, livestock forage grasses and the like). Suitably, the edible portion of the plant may be a fruit or vegetable including both the botanical and the culinary definitions of fruits or vegetables. "Botanical fruits" are characterized as a ripened plant ovary of a flowering plant that contains seeds while "botanical vegetables" are characterized as edible parts of plants other than the plant ovary. "Culinary fruits" and "culinary vegetables" refer to the common colloquial definitions of "fruits" and "vegetables" wherein fruits are typically sweet tasting edible plant products and are often associated with seeds and vegetables are less sweet edible products that may or may non contain seeds (e.g., both pumpkins and potatoes are considered in the culinary sense as "vegetables"). Edible portions of plants that may be screened according to embodiments of the present disclosure include the leafy portions of plants and also grains and/or nuts; however, these types of edible portions are less likely to produce aroma and volatile compounds without heating (as described below). In various embodiments, the edible portion of the plant may be selected from the group consisting of apples, oranges, pears, strawberries, lemons, limes, nectarines, avocados, grapefruits, clementines, cantaloupes, grapes, watermelons, papayas, plums, prunes, kumquats, pomegranates, apricots, tangerines, berries, peaches, pineapples, coconuts, melons, kiwis, cherries, tomatoes, nectarines, pumpkins, peppers, potatoes, beans, peas, asparagus, brussel sprouts, lettuce, radishes, turnips, rutabagas, mushrooms, olives, artichokes, carrots, herbs, corn, pickles, cabbage, broccoli, wheat, rice and soybeans.

[0016] The above listed fruits and vegetables may be screened for one or more of a number of desirable traits and/or qualities including, for example, pungency, flavor, aroma, freshness, tartness, sweetness, color, texture and bitterness. Further, the fruit or vegetable may be screened for a desirable rating in a system for rating a trait such as, for example, a scoville rating which relates to the pungency of fruits or vegetables and, particularly, relates to the pungency of peppers. In this regard, these examples should not be considered limiting as traits other than those listed may be screened without limitation.

In one or more embodiments, the variety of plant may be screened to select a plant product that is preferred by one or more cultural populations (e.g., as pungency is generally desirable in Latin American culture) and/or by persons that inhabit a distinct geographical region.

[0017] In accordance with the screening methods of embodiments of the present disclosure, an edible portion of a plant variety of interest may be placed into a container having a headspace into which volatile compounds collect. It should be understood that the entire edible portion of a plant may be placed into the container (e.g., as removed from the plant of interest such as in an entire pepper) or a portion (e.g., a slice, ground portion or liquid processed portion). Further, in some embodiments, a juice extracted from the plant (e.g., a fruit or vegetable juice) or a homogenate of an edible plant portion may be placed in the container for screening. In some embodiments, a portion of the edible product may be contacted with a solvent in which some of the edible product may dissolve. Volatile compounds dissolved in the solvent may vaporize into the headspace of the container to be sensed as described below. Suitable solvents include various buffer solutions and water. The pH of the buffer solutions may be from about 4.5 to about 9 or from about 5 to about 8. The buffer solutions may be aqueous and/or may contain salts such as NaCl or $CaCl_2$ and may contain EDTA and/or trichloroacetic acid. The edible plant product or portion thereof may be placed in a vial (optionally with solvent) that contains a headspace for analysis.

[0018] Upon placing the edible plant product in the container, the product may be allowed to sit in the container for a period of time to generate a sufficient amount of compounds to be sensed by the sensors. Such periods of time may range from about 30 seconds to about 30 minutes. In this regard, it should be understood that, in some embodiments, the volatile compounds may be sensed shortly after placing the edible portion of the plant in the container and that, optionally, analysis may occur without the edible plant portion sitting in the container for a pre-determined period of time.

[0019] In various embodiments, the edible plant product placed in the container (or portion thereof) is heated to vaporize volatile compounds. In some embodiments, the edible plant product is heated to a temperature of at least about 30°C, of at least about 40°C, at least about 50°C, at least about 60°C at least about 70°C, at least

about 80°C, at least about 90°C, at least about 100°C or from about 30°C to about 150°C, from about 30°C to about 110°C, from about 45°C to about 110°C or from about 50°C to about 100°C. The plant portion may be heated for at least about 30 seconds to vaporize volatile compounds and, in other embodiments is heated at least about 1 minute, at least about 5 minutes, at least about 15 minutes or from about 30 seconds to 1 hour, from about 30 seconds to about 30 minutes or from about 5 minutes to about 30 minutes. While the above-referenced temperatures and periods of heating are typical for the methods of analysis descried herein, other temperatures and/or periods of heating may be used without departing from the scope of the present disclosure.

[0020] Volatile compounds released from the edible plant portion collect in the headspace of the container. The headspace into which the volatile compounds enter may be air including purified air. However, it should be understood that other gases may be used without departing from the scope of the present disclosure. Air may be purified by removing volatile compounds therefrom and according to methods known in the art such as by, for example, membrane filtration. After volatiles have collected in the headspace, a volume of gas in the headspace containing the volatile compounds may be injected into a sensor for analysis. The volume of gas injected into the sensor for analysis may vary and in some embodiments is at least about 0.1 ml, at least about 0.5 ml, at least about 1 ml, at least about 2 ml or from about 0.1 ml to about 5 ml. A pump or blower may be used to pull or push the volatile compounds from the headspace of the container to the sensor to allow the volatile compounds to contact the sensing elements. Optionally, a valve may be used to hold the components in the headspace of the container during generation of vaporized compounds (i.e., the valve is closed during this step). The valve may then be opened to release the volatile components and to allow them to contact the sensing elements of the sensor with or without use of a pump. In some embodiments, the sensing elements themselves are located in the headspace of the container and/or the sensing system is configured to allow volatile compounds to travel to the sensing elements by diffusion. Purified air may be used to establish baseline measurements and to desorb volatiles that contact the sensing elements.

[0021] Sensors for detecting volatile compounds and for determining whether edible plant products are characterized by desirable odors and/or flavors may contain one or more sensing elements. A number of different types of sensing elements may be used, including, for example, polymers, metal oxides, quartz crystals, surface acoustic wave sensors and optical fibers. In one or more embodiments, a plurality of sensing elements may be arranged as an array to detect volatile components. Each sensing element produces an electronic signal in response to contact with a volatile component so as to produce a "fingerprint" of signals which can be compared to stored data to determine whether the plant product contains desirable aroma or flavor. The amount of sensors in the array may range from about 2 to about 50 or more (e.g., from about 10 to about 20).

[0022] When polymers are used as sensing elements, the polymer material may be conducting and/or may swell or contract upon contact with certain compounds. Typically each element of the array of polymers is distinct from other members of the array. For instance, the polymers may differ in their type of monomer subunits, concentration of electrically conductive dopant or the like. When metal oxides are used, the metal oxides may be part of a metal oxide semiconductor ("MOS") or even a field-effect transistor ("MOS-FET").

[0023] It should be noted that the electronic signals generated by the sensors may simply be a digital value or a measurement such as voltage or the conductance signal. Generally, contact of the sensing elements with volatile components elicits a change in the electrical resistance resulting in a change in voltage. The change in resistance depends on the characteristics of the sensors (coatings, dopants and the like) and the volatile component or components that contact the sensor. In this regard, the term "electronic signal" should not be viewed in a limiting sense.

[0024] Upon generation of the electronic signals, the signals are analyzed to determine whether the plant variety of interest produced an edible plant product with a desirable trait such as, for example, a desirable flavor or aroma. In some embodiments, the sensor may be previously calibrated such that the electronic signals are correlated to the amount of a desirable flavor or aroma. In various embodiments, the signals are analyzed by comparing the signals to signals generated by sensing volatile components released from an edible product that is known to be characterized by the desirable trait (e.g., a

"gold-standard" edible product). Edible products may be independently tested for expression of the desirable trait by use of a consumer study or by other methods such as gas chromatography-mass spectrometry ("GC-MS") or by high-performance liquid chromatograph ("HPLC").

[0025] In addition or alternatively, the electronic signal fingerprint may be analyzed by known statistical techniques. For instance, the electronic signals may be analyzed by principal component analysis ("PCA") or by a statistical quality control model ("SQC"). The desirable trait of the edible product may be associated with a feature of the principle component analysis or of the statistical quality control model. For example, the desirable trait may be associated with the coordinates of the PCA score plot (Example 1 below).

[0026] Generally, the methods of the present disclosure allow edible plant products of a plant variety of interest to be screened to determine whether the variety is suitable for commercial production of the edible product or to determine whether the variety should be used as breeding stock to produce new plant varieties. These new varieties in turn may also be screened by the methods of the present disclosure.

[0027] The methods of the present disclosure may be performed by operation of a system for screening edible plant portions. An exemplary system is shown in Figure 1 with the system being generally designated as numeral 5. The system 5 generally includes a container 9 in which the edible plant product (either the whole product or a sliced or ground portion thereof) is placed. The container 9 has a headspace 19 in which volatile compounds released from the edible plant product may collect. The system 5 may also include a heating element (not shown) for heating the edible plant product. Suitable methods for heating include, without limitation, capacitive heating, induction coils (RF) and electrical resistance elements.

[0028] The system 5 also includes a sensor 30 to generate one or more electronic signals in response to receiving, contacting or sensing a gaseous compound. The system 5 also includes a processor 40 configured to analyze the electronic signals and provide information concerning the desirable trait such as, for example, the pungency of a pepper. The sensor 30 may include a housing 27 and one or more sensing elements 29

within the housing. The sensing elements 29 (and optionally an array of elements as shown in Figure 1) of the sensor 30 may be selected from polymers, metal oxides, quartz crystal, surface acoustic wave sensors, optical fiber sensors and combinations thereof as described above. A pump 31 may convey the volatile compounds from the headspace 19 of the container 9 into the housing 27.

[0029] The system 5 may also include a memory unit 45 in which a library of data is stored. The library of data may relate to patterns of electronic signals produced from analyzing plant varieties that are known to be characterized by the desirable trait.

[0030] While the system 5 shown in Fig. 1 includes a container 9 for analyzing one sample, it should be understood that several samples may be processed and/or analyzed simultaneously without departing from the scope of the present disclosure. For instance, a plurality of samples may be included within a plurality of processing wells of a sample system and processed in parallel. Other methods and systems for screening plants for desirable traits other than as described and shown may be used and the illustrations and descriptions of the present disclosure should not be viewed in a limiting sense.

EXAMPLES

Example 1: Grouping of Pepper Varieties and Screening for Unique Aroma Samples

[0031] Nineteen pepper varieties shown in Table 1 below were analyzed by the system shown in Figure 1. Homogenates of each pepper sample (100 g) were prepared by cutting the pepper and removing the seeds and placing the material in to a vial in which the material was ground using a ball mill at a speed of 800 rpm for 200 sec. A $CaCl_2$ and EDTA solution at a pH of 7.5 was added to the vial. Replicate samples (6 g each) were each placed in a vial having a headspace and septum and heated to 40°C for 20 min to generate volatiles. The volatiles were then injected into a sensor (as in the system of Fig. 1) for analysis. The sensor was a Fox 4000 electronic nose system (Alpha MOS; Toulouse, France) using 18 MOS sensing elements. The signals were subjected to principal component analysis. The PCA score plot is shown in Figure 2.

Group	Variety	Plot Label	Plot Label
1	A	4459	4471
1	B	4483	4521
1	C	4503	4456
1	D	4510	4478
1	E	4504	4454
1	F	4511	4452
2	G	4477	4487
2	H	4470	4474
2	I	4467	4500
2	J	4760	4761
2	K	4497	4501
2	L	4473	4525
2	M	4487	4519
3	N	4450	4462
3	O	4455	4490
3	P	4469	4493
3	Q	4460	4520
3	R	4499	4526
3	S	4458	4494

[0032] Groups 1 and 2 shown in Figure 2 are mostly the *C. chinense* genus and Group 3 is mostly the *C. annuum* genus. Floral varieties are found in Group 1. As can be seen in Figure 2, the *C. annuum* genus of peppers seems to vary along the PC2 axis and the *C. chinense* genus seems to vary along the PC1 axis. Groups 2 and 3 share an area of common aroma in several varieties.

[0033] Pepper varieties A, C, D, F and K were also subjected to human sensory analysis. The sensory analysis indicated that the varieties that exhibited a floral aroma were grouped together in Group 1. In view that varieties with distinctive aroma were grouped together, the screening method can properly identify pepper varieties that may be desirable commercially and/or that may be used to produce new varieties of peppers.

Example 2: Screening Melons for Breeding Stock

[0034] Ninety-five fresh melon fruits (De Ruiter Seeds, Bergschenhoek, Netherlands) were analyzed in a system similar to the system of Fig. 1. A portion of the headspace was injected into the device and a portion was also injected into a GC-MS instrument. The melons were prepared by slicing them and removing the skin and seeds. Each sliced melon was cut and 100 g of the melon was placed into a vial. The material was ground by use of a ball mill at a speed of 800 rpm for 240 minutes. A $CaCl_2$ and EDTA solution at a pH of 7.5 was added to the vial. Triplicate samples (1.5 ml each) were weighed into a vial (10 ml) having a headspace that was capped with a screw septum. Each sample was heated to 40°C for 20 minutes and the volatiles in the headspace were sensed and the signals subjected to PCA analysis. The sensor was a Fox 4000 electronic nose system (Alpha MOS; Toulouse, France) using 18 MOS sensing elements. The electrical signals generated by the system showed differences in volatile composition for melon samples. Graphs of the interaction between sensors and volatiles for four varieties of melons are shown in Figs. 3-6, respectively. Fig. 3 shows the intensity of response for a Galia variety melon and Figures 4-6 show the response for three different Charentais varieties. The different responses indicate that these varieties may be distinguished by use of the sensor. PCA analysis for the melons is shown in Fig. 7. The PCA analysis showed that two principal components mainly explain the difference in melon volatiles.

[0035] Two varieties of melons, Charentais and Galia-type melons, were identified as having the most intense content of sensed volatiles as shown in Fig. 7. GC-MS chromatographs showed the presence of several volatile components with a total of 28 typical chemical compounds identified, quantified and grouped as acetates, esters, aldehydes, alcohol and ketones. Acetates, a known product reported to increase during fruit development and maturity and to impart their unique and characteristic aroma and flavor to fruits, were the dominant compounds in Charentais and Galia-type melons. The data was correlated by taking all sensor responses from the Alpha MOS sensor and all GC-MS volatiles identified and employing PCA analysis. The results (Fig. 7) show a grouping of Charentais and Galia Melons from other low aroma varieties. The data suggests the presence of fatty acids and amino acids as main precursors to these volatile compounds as well as the possible presence of specific volatiles-producing enzymes

(lipoxygenase/hydroperoxide lyase), amino acids (such as isoleucine, valine and methionine) and active amino acid transferases involved in aroma/flavor formation. In addition, esters, aldehydes and alcohols compounds were also detected although not in an amount as high as acetates. A higher content of esters, aldehydes and alcohols were present in Charentais- and Galia-type melons. Further interpretation with additional metabolomic/biochemical data may indicate whether volatiles compounds are correlated with desirable sensory and quality melon parameters.

[0036] When introducing elements of the present disclosure or the preferred embodiments(s) thereof, the articles "a", "an", "the" and "said" are intended to mean that there are one or more of the elements. The terms "comprising", "including" and "having" are intended to be inclusive and mean that there may be additional elements other than the listed elements.

[0037] As various changes could be made in the above apparatus and methods without departing from the scope of the disclosure, it is intended that all matter contained in the above description and shown in the accompanying figures shall be interpreted as illustrative and not in a limiting sense.

WHAT IS CLAIMED IS:

1. A method of identifying desirable traits in edible plant products, the method comprising:

providing a variety of a plant, the plant containing an edible portion;

screening the variety of plant by (1) sensing volatile compounds released from the edible portion of the plant to generate one or more electronic signals and (2) analyzing the one or more electronic signals to determine whether the edible portion of the plants of the variety are desirable.

2. A method as set forth in claim 1 further comprising using the plant variety that produced the edible portion to produce a new variety of plant when the edible portion of the plant is determined to be desirable.

3. A method as set forth in claim 2 further comprising screening the new variety of plant by (1) sensing volatile compounds released from the edible portion of the plant to generate one or more electronic signals and (2) analyzing the one or more electronic signals to determine whether the edible portion of the plants of the new variety are desirable.

4. A method as set forth in any one of claims 1 to 3 wherein the trait is selected from the group consisting of pungency, flavor, aroma, freshness, tartness, sweetness, color, texture and bitterness.

5. A method as set forth in any one of claims 1 to 4 wherein the edible portion of the plant is selected from botanical fruits, botanical vegetables and grains.

6. A method as set forth in any one of claims 1 to 5 wherein the edible portion of the plant is selected from the group consisting of apples, oranges, pears, strawberries, lemons, limes, nectarines, avocados, grapefruits, clementines, cantaloupes, grapes, watermelons, papayas, plums, prunes, kumquats, pomegranates, apricots, tangerines, berries, peaches, pineapples, coconuts, melons, kiwis, cherries, tomatoes, nectarines, pumpkins, peppers, potatoes, beans, peas, asparagus, brussel sprouts, lettuce,

radishes, turnips, rutabagas, mushrooms, olives, artichokes, carrots, herbs, corn, pickles, cabbage, broccoli, wheat, rice, and soybeans.

7. A method as set forth in any one of claims 1 to 6 wherein the edible portion of the plant is placed into a container having a headspace into which the volatile compounds collect.

8. A method as set forth in claim 7 wherein the edible plant product as removed from the plant is placed into the container.

9. A method as set forth in claim 7 wherein the edible plant product is sliced, ground or processed before being placed into the container.

10. A method as set forth in claim 9 comprising contacting the edible plant product with a solvent and dissolving the volatile compound into the solvent and vaporizing the volatile compound from the solvent.

11. A method as set forth in any one of claims 7 to 10 wherein the edible plant product is heated to vaporize volatile compounds.

12. A method as set forth in any one of claims 1 to 11 wherein the desirable trait is associated with a feature of the principle component analysis.

13. A method as set forth in any one of claims 1 to 12 wherein the desirable trait is associated with a feature of the statistical quality control model.

14. A method as set forth in any one of claims 1 to 13 wherein the volatile compounds are detected by contacting the compounds with a sensor comprising a sensing element, the sensing element being selected from the group consisting of polymers, metal oxides, quartz crystal, surface acoustic wave elements and optical fiber elements.

15. A method as set forth in claim 14 wherein the metal oxide is part of a metal oxide semiconductor.

16. A method as set forth in claim 15 wherein the metal oxide semiconductor is a field-effect transistor.

17. A method as set forth in any one of claims 1 to 13 wherein the volatile compounds are contacted with an array of sensing elements.

18. A method as set forth in claim 17 wherein the sensing elements in the array are selected from the group consisting of polymers, metal oxides, quartz crystals, surface acoustic waver sensors or optical fiber sensors.

19. A method as set forth in any one of claims 1 to 18 wherein the variety of plant is screened to select edible plant products that are preferred by persons of a distinct geographical region.

20. A method as set forth in any one of claims 1 to 19 wherein the edible portion of the plant is heated to at least about 30°C, at least about 40°C, at least about 50°C, at least about 60°C at least about 70°C, at least about 80°C, at least about 90°C, at least about 100°C or from about 30°C to about 150°C, from about 30°C to about 110°C, from about 45°C to about 110°C or from about 50°C to about 100°C.

21. A method for selecting a plant as breeding stock in the development of commercially desirable edible plant products, the method comprising:

identifying a desirable trait of the edible plant product;

associating that desirable trait with a distinctive feature of one or more electronic signals generated by sensing volatile compounds released from the edible plant product;

sensing one or more volatile compounds released from an edible plant product of interest to generate one or more electronic signals; and

analyzing the one or more electronic signals to determine whether they are characterized by the distinctive feature.

22. A method as set forth in claim 21 further comprising using a plant variety that produced the edible plant product of interest when the edible plant product of interest is characterized by the distinctive feature to produce a new variety of plant.

23. A method as set forth in claim 22 further comprising sensing volatile compounds released from edible plant products of the new plant variety to generate one or more electronic signals and analyzing the one or more electronic signals to determine whether they are characterized by the distinctive feature.

24. A method as set forth in any one of claims 21 to 23 wherein the feature is selected from the intensity of one or more electronic signals generated by one or more sensors, a feature associated with a principal component analysis or a feature associated with the statistical quality control model.

25. A method as set forth in any one of claims 21 to 24 wherein the trait is selected from the group consisting of pungency, flavor, aroma, freshness, tartness, sweetness, color, texture and bitterness.

26. A method as set forth in any one of claims 21 to 25 wherein the edible plant product is selected from botanical fruits, botanical vegetables and grains.

27. A method as set forth in any one of claims 21 to 26 wherein the edible plant product is selected from the group consisting of apples, oranges, pears, strawberries, lemons, limes, nectarines, avocados, grapefruits, clementines, cantaloupes, grapes, watermelons, papayas, plums, prunes, kumquats, pomegranates, apricots, tangerines, berries, peaches, pineapples, coconuts, melons, kiwis, cherries, tomatoes, nectarines, pumpkins, peppers, potatoes, beans, peas, asparagus, brussel sprouts, lettuce, radishes, turnips, rutabagas, mushrooms, olives, artichokes, carrots, herbs, corn, pickles, cabbage, broccoli, wheat, rice and soybeans.

28. A method as set forth in any one of claims 21 to 27 wherein the edible plant product is placed into a container having a headspace into which the volatile compounds collect.

29. A method as set forth in claim 28 wherein the edible plant product as removed from the plant is placed into the container.

30. A method as set forth in claim 28 wherein the edible plant product is sliced, ground or processed before being placed into the container.

31. A method as set forth in claim 29 or claim 30 comprising contacting the edible plant product with a solvent and dissolving the volatile compound into the solvent and vaporizing the volatile compound from the solvent.

32. A method as set forth in any one of claims 28 to 31 wherein the edible plant product is heated to vaporize volatile compounds.

33. A method as set forth in any one of claims 21 to 32 wherein the desirable trait is associated with a feature of the principle component analysis.

34. A method as set forth in any one of claims 21 to 32 wherein the desirable trait is associated with a feature of the statistical quality control model.

35. A method as set forth in any one of claims 21 to 34 wherein the volatile compounds are detected by contacting the compounds with a sensor comprising a sensing element, the sensing element being selected from the group consisting of polymers, metal oxides, quartz crystal, surface acoustic wave elements and optical fiber elements.

36. A method as set forth in claim 35 wherein the metal oxide is part of a metal oxide semiconductor.

37. A method as set forth in claim 36 wherein the metal oxide semiconductor is a field-effect transistor.

38. A method as set forth in any one of claims 21 to 34 wherein the volatile compounds are contacted with an array of sensing elements.

39. A method as set forth in claim 38 wherein the sensing elements in the array are selected from the group consisting of polymers, metal oxides, quartz crystals, surface acoustic waver sensors or optical fiber sensors.

40. A method as set forth in any one of claims 21 to 39 wherein the desirable trait is preferred by persons of a distinct geographical region.

41. A method of as set forth in any one of claims 21 to 40 wherein the edible plant product is heated to at least about 30°C, of at least about 40°C, at least about 50°C, at least about 60°C at least about 70°C, at least about 80°C, at least about 90°C, at least about 100°C or from about 30°C to about 150°C, from about 30°C to about 110°C, from about 45°C to about 110°C or from about 50°C to about 100°C.

AMENDED CLAIMS

received by the International Bureau on 17 May 2011 (17.05.2011)

1. A method of identifying desirable traits in edible plant products, the method comprising:

providing a variety of a plant, the plant containing an edible portion;

screening the variety of plant by (1) sensing volatile compounds released from the edible portion of the plant to generate one or more electronic signals and (2) analyzing the one or more electronic signals to determine whether the edible portion of the plants of the variety have the desirable trait, the desirable trait being selected from the group consisting of pungency, tartness, sweetness, color, texture and bitterness.

2. A method as set forth in claim 1 further comprising using the plant variety that produced the edible portion to produce a new variety of plant when the edible portion of the plant is determined to be desirable.

3. A method as set forth in claim 2 further comprising screening the new variety of plant by (1) sensing volatile compounds released from the edible portion of the plant to generate one or more electronic signals and (2) analyzing the one or more electronic signals to determine whether the edible portion of the plants of the new variety are desirable.

4. A method as set forth in any one of claims 1 to 3 wherein the trait is selected from the group consisting of pungency, tartness, sweetness, and bitterness.

5. A method as set forth in any one of claims 1 to 3 wherein the trait is pungency.

6. A method as set forth in any one of claims 1 to 6 wherein the edible portion of the plant is selected from botanical fruits, botanical vegetables and grains.

7. A method as set forth in any one of claims 1 to 6 wherein the edible portion of the plant is selected from the group consisting of apples, oranges, pears, strawberries, lemons, limes, nectarines, avocados, grapefruits, clementines, cantaloupes, grapes, watermelons, papayas, plums, prunes, kumquats, pomegranates, apricots,

tangerines, berries, peaches, pineapples, coconuts, melons, kiwis, cherries, tomatoes, nectarines, pumpkins, peppers, potatoes, beans, peas, asparagus, brussel sprouts, lettuce, radishes, turnips, rutabagas, mushrooms, olives, artichokes, carrots, herbs, corn, pickles, cabbage, broccoli, wheat, rice, and soybeans.

8. A method as set forth in any one of claims 1 to 7 wherein the edible portion of the plant is placed into a container having a headspace into which the volatile compounds collect.

9. A method as set forth in claim 8 wherein the edible plant product as removed from the plant is placed into the container.

10. A method as set forth in claim 8 wherein the edible plant product is sliced, ground or processed before being placed into the container.

11. A method as set forth in claim 10 comprising contacting the edible plant product with a solvent and dissolving the volatile compound into the solvent and vaporizing the volatile compound from the solvent.

12. A method as set forth in any one of claims 8 to 11 wherein the edible plant product is heated to vaporize volatile compounds.

13. A method as set forth in any one of claims 1 to 12 wherein the desirable trait is associated with a feature of the principle component analysis.

14. A method as set forth in any one of claims 1 to 13 wherein the desirable trait is associated with a feature of the statistical quality control model.

15. A method as set forth in any one of claims 1 to 14 wherein the volatile compounds are detected by contacting the compounds with a sensor comprising a sensing element, the sensing element being selected from the group consisting of polymers, metal oxides, quartz crystal, surface acoustic wave elements and optical fiber elements.

16. A method as set forth in claim 15 wherein the metal oxide is part of a metal oxide semiconductor.

17. A method as set forth in claim 16 wherein the metal oxide semiconductor is a field-effect transistor.

18. A method as set forth in any one of claims 1 to 14 wherein the volatile compounds are contacted with an array of sensing elements.

19. A method as set forth in claim 18 wherein the sensing elements in the array are selected from the group consisting of polymers, metal oxides, quartz crystals, surface acoustic waver sensors or optical fiber sensors.

20. A method as set forth in any one of claims 1 to 19 wherein the variety of plant is screened to select edible plant products that are preferred by persons of a distinct geographical region.

21. A method as set forth in any one of claims 1 to 20 wherein the edible portion of the plant is heated to at least about 30°C, at least about 40°C, at least about 50°C, at least about 60°C at least about 70°C, at least about 80°C, at least about 90°C, at least about 100°C or from about 30°C to about 150°C, from about 30°C to about 110°C, from about 45°C to about 110°C or from about 50°C to about 100°C.

22. A method for selecting a plant as breeding stock in the development of commercially desirable edible plant products, the method comprising:

identifying a desirable trait of the edible plant product;

associating that desirable trait with a distinctive feature of one or more electronic signals generated by sensing volatile compounds released from the edible plant product;

sensing one or more volatile compounds released from an edible plant product of interest to generate one or more electronic signals;

analyzing the one or more electronic signals to determine whether they are characterized by the distinctive feature; and

using a plant variety that produced the edible plant product of interest when the edible plant product of interest is characterized by the distinctive feature to produce a new variety of plant.

23. A method as set forth in claim 22 further comprising sensing volatile compounds released from edible plant products of the new plant variety to generate one or more electronic signals and analyzing the one or more electronic signals to determine whether they are characterized by the distinctive feature.

24. A method as set forth in claim 22 or claim 23 wherein the feature is selected from the intensity of one or more electronic signals generated by one or more sensors, a feature associated with a principal component analysis or a feature associated with the statistical quality control model.

25. A method as set forth in any one of claims 22 to 24 wherein the trait is selected from the group consisting of pungency, flavor, aroma, freshness, tartness, sweetness, color, texture and bitterness.

26. A method as set forth in any one of claims 22 to 24 wherein the trait is selected from the group consisting of pungency, tartness, sweetness and bitterness.

27. A method as set forth in any one of claims 22 to 24 wherein the trait is pungency.

28. A method as set forth in any one of claims 22 to 27 wherein the edible plant product is selected from botanical fruits, botanical vegetables and grains.

29. A method as set forth in any one of claims 22 to 28 wherein the edible plant product is selected from the group consisting of apples, oranges, pears, strawberries, lemons, limes, nectarines, avocados, grapefruits, clementines, cantaloupes, grapes, watermelons, papayas, plums, prunes, kumquats, pomegranates, apricots, tangerines, berries, peaches, pineapples, coconuts, melons, kiwis, cherries, tomatoes, nectarines, pumpkins, peppers, potatoes, beans, peas, asparagus, brussel sprouts, lettuce, radishes, turnips, rutabagas, mushrooms, olives, artichokes, carrots, herbs, corn, pickles, cabbage, broccoli, wheat, rice and soybeans.

30. A method as set forth in any one of claims 22 to 29 wherein the edible plant product is placed into a container having a headspace into which the volatile compounds collect.

31. A method as set forth in claim 30 wherein the edible plant product as removed from the plant is placed into the container.

32. A method as set forth in claim 30 wherein the edible plant product is sliced, ground or processed before being placed into the container.

33. A method as set forth in claim 31 or claim 32 comprising contacting the edible plant product with a solvent and dissolving the volatile compound into the solvent and vaporizing the volatile compound from the solvent.

34. A method as set forth in any one of claims 30 to 33 wherein the edible plant product is heated to vaporize volatile compounds.

35. A method as set forth in any one of claims 22 to 34 wherein the desirable trait is associated with a feature of the principle component analysis.

36. A method as set forth in any one of claims 22 to 34 wherein the desirable trait is associated with a feature of the statistical quality control model.

37. A method as set forth in any one of claims 22 to 36 wherein the volatile compounds are detected by contacting the compounds with a sensor comprising a sensing element, the sensing element being selected from the group consisting of polymers, metal oxides, quartz crystal, surface acoustic wave elements and optical fiber elements.

38. A method as set forth in claim 37 wherein the metal oxide is part of a metal oxide semiconductor.

39. A method as set forth in claim 38 wherein the metal oxide semiconductor is a field-effect transistor.

40. A method as set forth in any one of claims 22 to 36 wherein the volatile compounds are contacted with an array of sensing elements.

41. A method as set forth in claim 40 wherein the sensing elements in the array are selected from the group consisting of polymers, metal oxides, quartz crystals, surface acoustic waver sensors or optical fiber sensors.

42. A method as set forth in any one of claims 22 to 41 wherein the desirable trait is preferred by persons of a distinct geographical region.

43. A method of as set forth in any one of claims 22 to 42 wherein the edible plant product is heated to at least about 30°C, of at least about 40°C, at least about 50°C, at least about 60°C at least about 70°C, at least about 80°C, at least about 90°C, at least about 100°C or from about 30°C to about 150°C, from about 30°C to about 110°C, from about 45°C to about 110°C or from about 50°C to about 100°C.

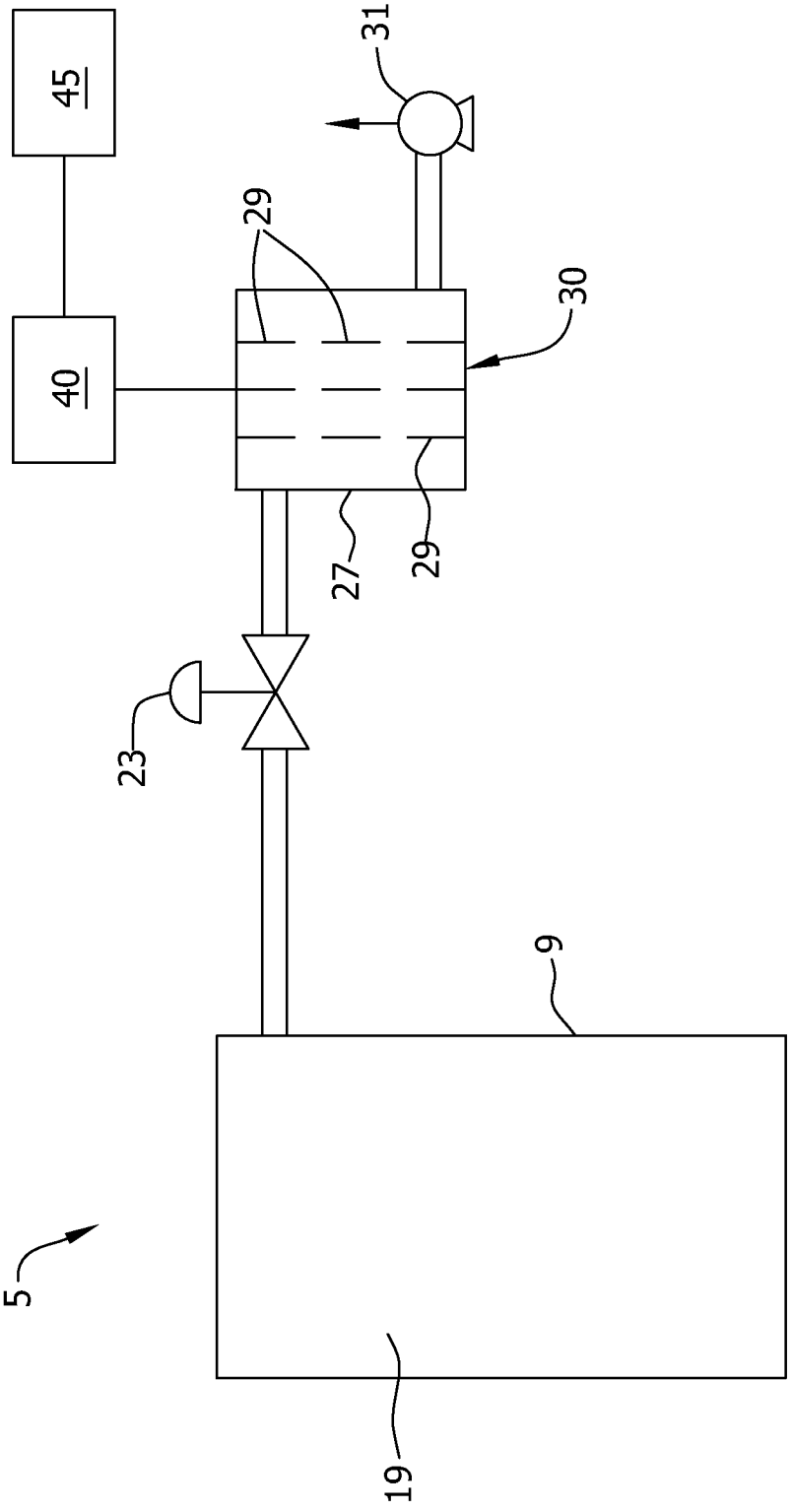
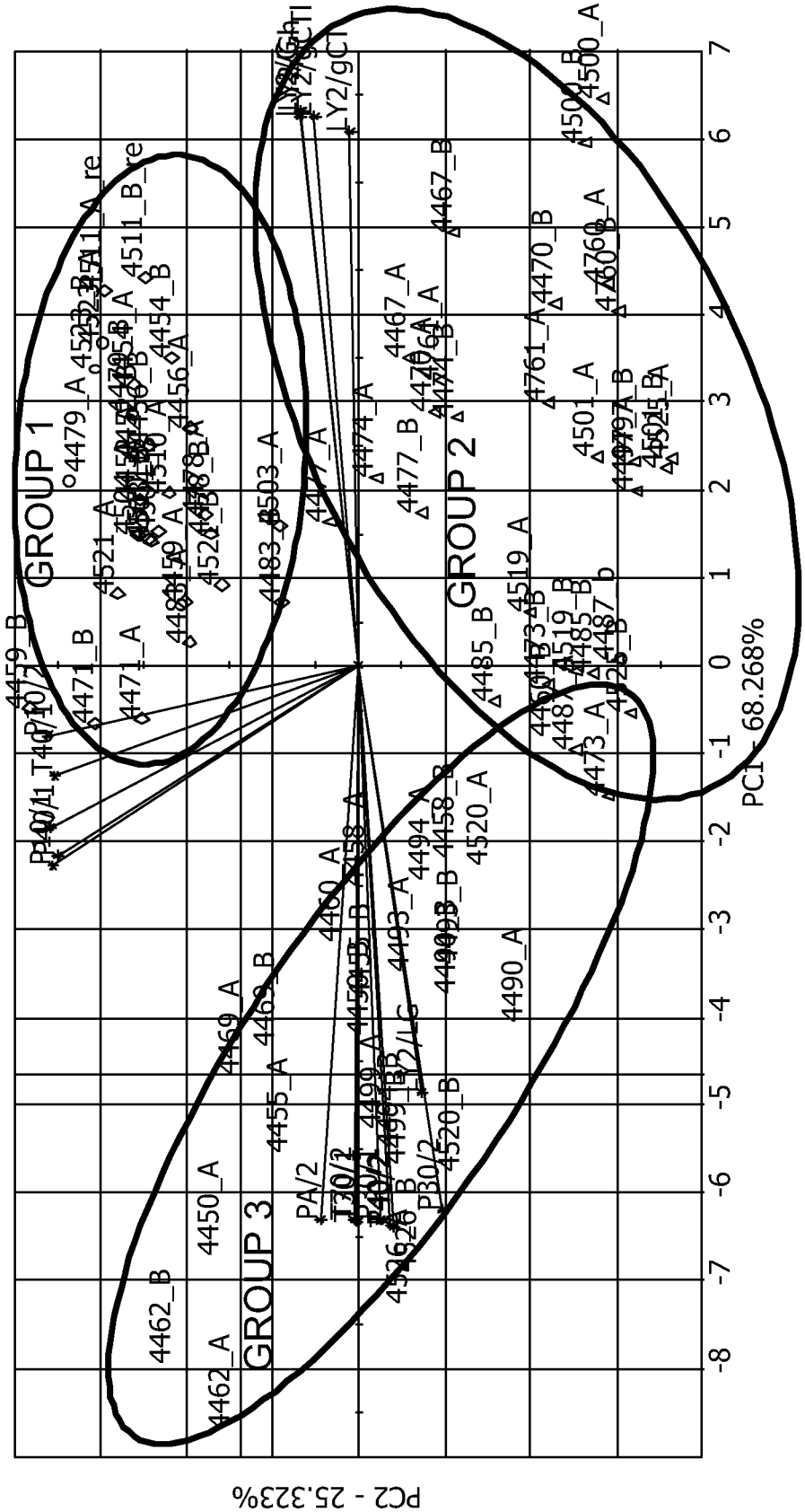
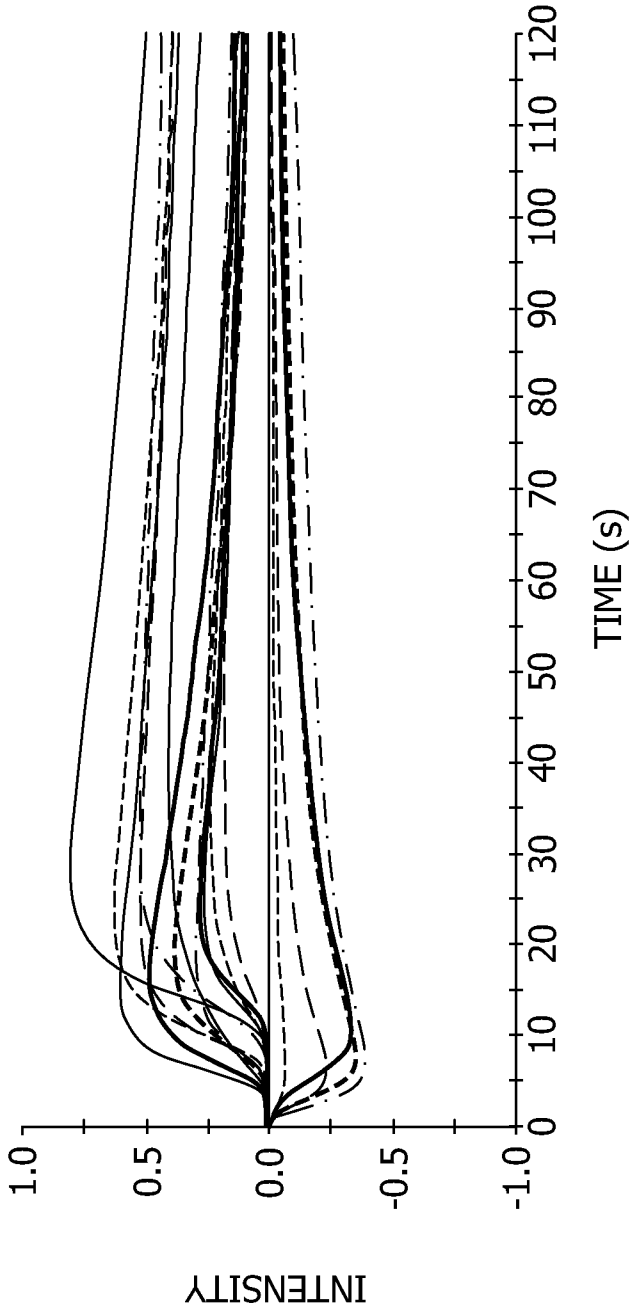


FIG. 1

FIG. 2

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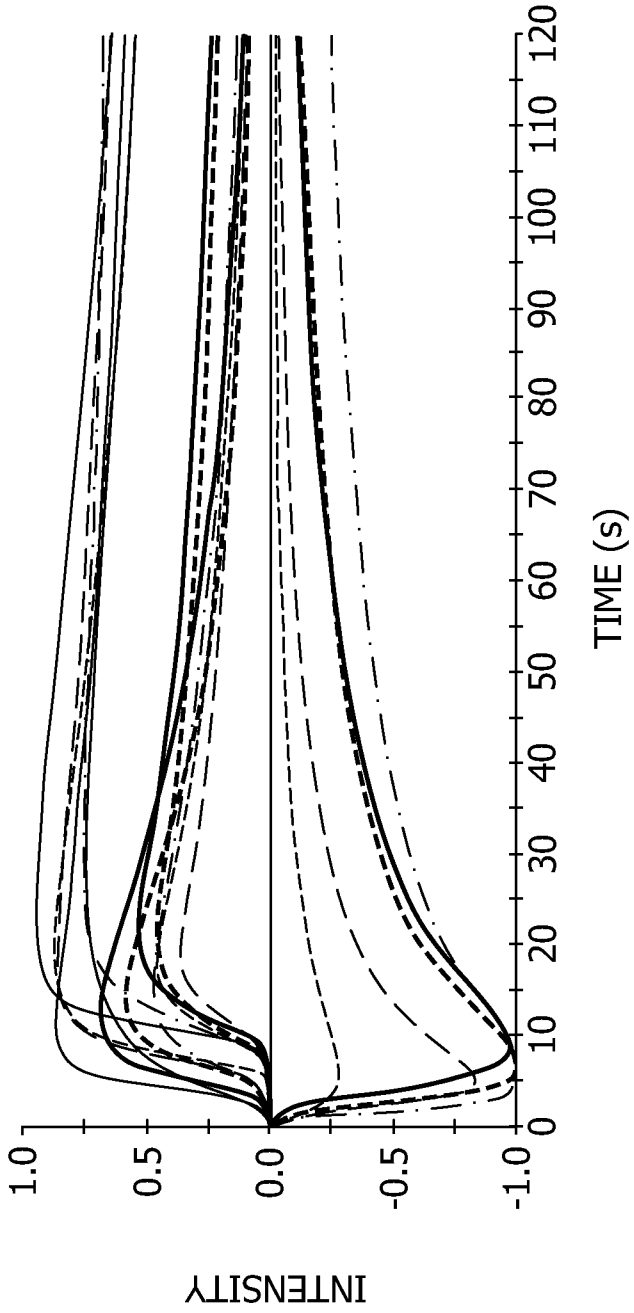
TIME (s)

FIG. 3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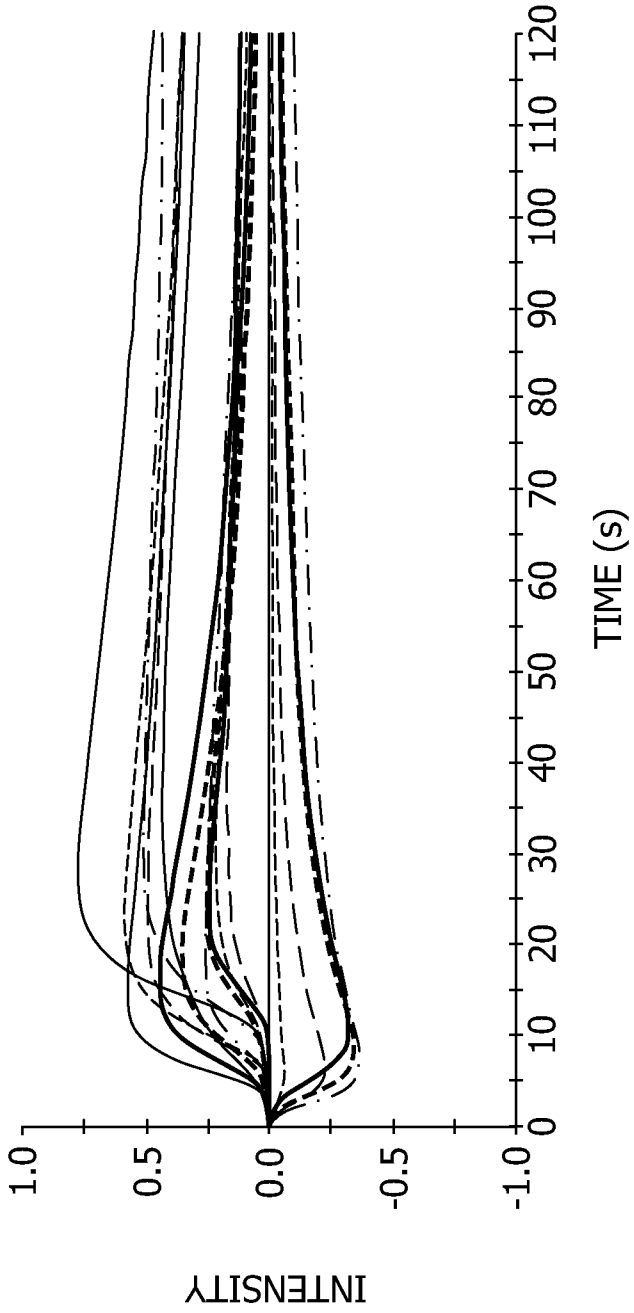
TIME (s)

FIG. 4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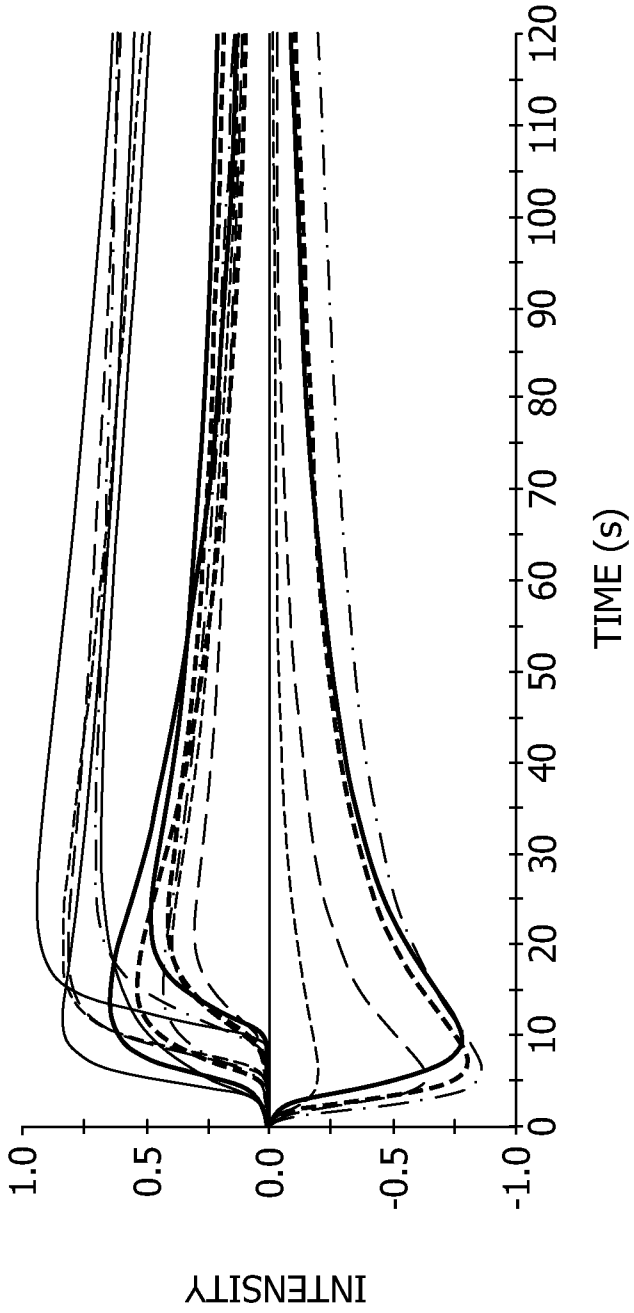
TIME (s)

FIG. 5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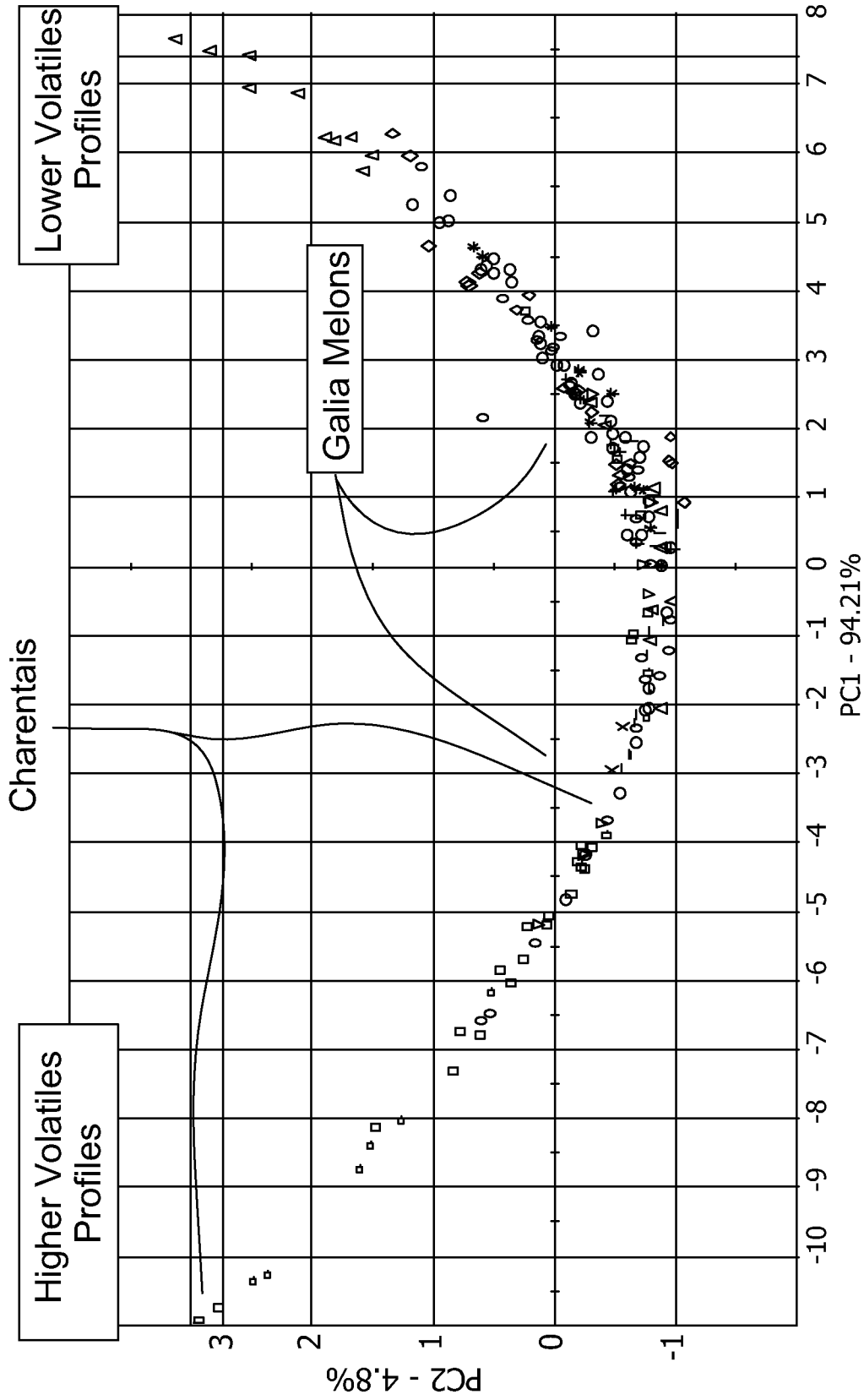
TIME (s)

FIG. 6

FIG. 7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Galia Melons
Charentais
Higher Volatiles Profiles
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PC1 - 94.21%
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0
-1
8
7
6
5
4
3
2
1
0
-1
-2
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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/062141

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01N33/00 G01N33/02 G01N33/497 G01N27/414
ADD.

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)
G01N

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)
EPO-Internal, WPI Data, FSTA, BIOSIS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	HIRSCHFELDER MONIKA ET AL: "Rapid discrimination of strawberry varieties using a gas sensor array", GARTENBAUWISSENSCHAFT, MUENCHEN, DE, vol. 63, no. 4, 1 July 1998 (1998-07-01), pages 185-190, XP009145368, ISSN: 0016-478X page 185, left-hand column, paragraph 1 - page 186, right-hand column, paragraph 4; figure 1; table 4 page 189, right-hand column, paragraph 2-3 ----- -/--	1-7,9, 13-18, 21-28, 30,34-39

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 March 2011	17/03/2011

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Lazar, Zala

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/062141

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	INFANTE R ET AL: "Quality oriented fruit breeding: peach (Prunus persica (L.) Batsch).", JOURNAL OF FOOD, AGRICULTURE & ENVIRONMENT, vol. 6, no. 2, 2008, pages 342-356, XP002626002, * abstract page 342, left-hand column, paragraph 1 - page 344, right-hand column, paragraph 2 page 346, left-hand column, paragraph 2 - page 348, left-hand column, paragraph 3 page 352, left-hand column, paragraph 3 -----	1-6,19, 21-23, 25-27,40
X	BERNATH J ET AL: "Evaluation of selected oregano (Origanum vulgare L. subsp. hirtum Ietswaart) lines with traditional methods and sensory analysis", JOURNAL OF HERBS, SPICES AND MEDICINAL PLANTS, vol. 11, no. 4, 1 January 2005 (2005-01-01), pages 19-26, XP009145261, ISSN: 1049-6475, DOI: DOI:10.1300/J044V11N04_03 * abstract page 20, paragraph 6 - page 22, paragraph 2 page 24, paragraph 2-3 -----	1-7,9-18
X	WILSON A.D. AND BAIETTO M.: "Applications and Advances in Electronic-Nose Technologies", SENSORS, vol. 9, 29 June 2009 (2009-06-29), pages 5099-5148, XP002626001, DOI: 10.3390/s90705099 page 5100, paragraph 1 - page 5101, paragraph 1 page 5102, paragraph 2 - page 5106, paragraph 1 page 5108, paragraph 4 - page 5109, paragraph 2; tables 3,5 page 5115, paragraph 3; table 6 page 5117, paragraph 2 page 5118, paragraph 1 - page 5119, paragraph 1; table 7 page 5122, paragraph 6 - page 5123, paragraph 5 ----- -/--	1-6,12, 14-18, 21-27, 33,35-39

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/062141

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	SUPRIYADI ET AL: "Maturity discrimination of snake fruit (Salacca edulis Reinw.) cv. Pondoh based on volatiles analysis using an electronic nose device equipped with a sensor array and fingerprint mass spectrometry", FLAVOUR AND FRAGRANCE JOURNAL, vol. 19, 2004, pages 44-50, XP018000252, page 44, left-hand column, paragraph 1 - page 45, right-hand column, paragraph 3 page 46, left-hand column, paragraph 1 - page 47, right-hand column, paragraph 1 page 50, left-hand column, paragraph 1 -----	1,5-7, 9-12, 14-21, 24,26, 27, 30-33, 35-41
X	JONSSON A ET AL: "Electronic nose for microbial quality classification of grains", INTERNATIONAL JOURNAL OF FOOD MICROBIOLOGY, vol. 35, no. 2, 1997, pages 187-193, XP002626003, ISSN: 0168-1605 * abstract page 187, left-hand column, paragraph 1 - page 188, right-hand column, paragraph 5 page 189, right-hand column, paragraph 2 - page 192, right-hand column, paragraph 3; table 2 -----	1,4-8, 11, 14-18, 20,21, 25-29, 32, 35-39,41