

DESCRIPTION

METHOD FOR HYDROPONICALLY CULTIVATING LOW-POTASSIUM VEGETABLE, AND LOW-POTASSIUM VEGETABLE

5

TECHNICAL FIELD

[0001] The present invention relates to a method for hydroponically cultivating low-potassium vegetables, and low-potassium vegetables.

10 BACKGROUND ART

[0002] Renal disease patients are poor in the ability of discharging potassium or sodium. Accordingly, at the time of intake of potassium or sodium in a large amount, it is accumulated in the body of each of the patients without being discharged in the form of urine. When such a situation is left as it is, this may
15 cause high blood pressure in which the blood pressure of each of the patients becomes high, a cerebrovascular disorder (cerebral stroke or the like), or heart disease (heart failure or the like) resulting from the high blood pressure.

[0003] Treatment methods using drugs such as diuretics are used for decreasing the concentration of potassium in blood of a renal disease patient.
20 As another method used to decrease the concentration of potassium in blood of a renal disease patient, a dietary therapy using low potassium foods has been attracting attention from the viewpoints of less side effects resulting from drugs and low cost.

[0004] As low potassium foods used for the treatment of renal disease patients,
25 various conventional foods have been examined. As an example, low-potassium vegetables hydroponically cultivated and a cultivation method thereof have been conventionally researched (for example, see PTL 1 or PTL 2).

[0005] In the hydroponic cultivation method disclosed in PTL 1 or PTL 2, a hydroponic cultivation period is divided into an early period and a late period. Vegetables are cultivated using a typical fertilizer for hydroponic cultivation, which contains KNO_3 , during the early period and the vegetables are cultivated using a fertilizer for hydroponic cultivation, which contains HNO_3 or NaNO_3 , in place of KNO_3 during the late period. Moreover, the pH of a fertilizer for hydroponic cultivation is adjusted using NaOH over the entire cultivation period.

[0006] Further, in order to prevent an increase in the content of sodium due to NaOH used to adjust the pH of the fertilizers in these hydroponic cultivation methods, a hydroponic cultivation method that uses a fertilizer for hydroponic cultivation containing a large amount of magnesium, which is easily absorbed by a vegetable at the same level as potassium and contributes to a growth of a vegetable has been developed (for example, see PTL 3).

[0007] In the hydroponic cultivation method disclosed in PTL 3, a cultivation period is divided into an early period and a late period. Vegetables are cultivated using a typical fertilizer for hydroponic cultivation, which contains potassium, calcium, magnesium, phosphorus, and nitrogen as main components, during the early period, and the vegetables are cultivated using a fertilizer for hydroponic cultivation, which contains calcium, magnesium, phosphorus, and nitrogen as main components, without potassium and sodium during the late period. When a vegetable such as lettuce is cultivated according to this hydroponic cultivation method, the vegetable can be cultivated such that the total content of potassium and sodium is small.

Citation List

Patent Literature

[0008] PTL 1: Japanese Patent Unexamined Publication No. 2008-61587

PTL 2: Japanese Patent Unexamined Publication No. 2011-36226

PTL 3: Japanese Patent Unexamined Publication No. 2012-183062

SUMMARY OF INVENTION

5 [0009] The present invention provides a low-potassium vegetable in which the total content of potassium and sodium therein is small and a difference in the content thereof among leaves is small; and a hydroponic cultivation method for cultivating the low-potassium vegetable.

[0010] In a method for hydroponically cultivating a low-potassium vegetable of
10 the present invention, a total cultivation period from sowing to harvest is divided into a first cultivation period, a second cultivation period following the first cultivation period, and a third cultivation period following the second cultivation period according to a kind of a vegetable to be cultivated. In the first cultivation period, the vegetable is cultivated using a hydroponic
15 cultivation fertilizer containing potassium. In the second cultivation period, the vegetable is cultivated using a hydroponic cultivation fertilizer that does not substantially contain potassium and contains magnesium. In the third cultivation period, the vegetable is cultivated using water that does not contain a fertilizer.

20 [0011] Further, a low-potassium vegetable of the present invention includes an inner leaf positioned in a central portion; an outer leaf positioned in an outermost portion; and a middle leaf located in an intermediate position between the inner leaf and the outer leaf. In addition, a difference in content of potassium between the inner leaf and the middle leaf is smaller than a
25 difference in content of potassium between the middle leaf and the outer leaf.

[0012] According to the present invention as mentioned above, it is possible to provide a low-potassium vegetable in which the total content of potassium and

sodium in the entire vegetable is small and a difference in content among leaves is small; and a hydroponic cultivation method which realizes such a vegetable.

5 **BRIEF DESCRIPTION OF DRAWINGS**

[0013] FIG. 1 is a diagram showing respective cultivation periods in a hydroponic cultivation method according to an embodiment of the present invention.

FIG. 2 is a view showing a relationship among an inner leaf, a middle
10 leaf, and an outer leaf of a lettuce.

FIG. 3A is a diagram showing the content of potassium at each of measurement positions of an example and Reference Example 1 according to the embodiment of the present invention.

FIG. 3B is a diagram showing the content of sodium at each of the
15 measurement positions of the example and Reference Example 1 according to the embodiment of the present invention.

DESCRIPTION OF EMBODIMENT

[0014] Prior to the description of an embodiment of the present invention, the
20 problem in a hydroponic cultivation method of the related art will be described. In the hydroponic cultivation method of PTL 3, the cultivation procedures of the early period and the late period are changed. Therefore, in vegetables cultivated using this method, there is a possibility that the contents of potassium and the contents of sodium in leaves of the central portion (inner
25 leaves), leaves of the middle portion (middle leaves), and leaves on the outside (outer leaves) may vary.

[0015] Hereinafter, an embodiment of the present invention will be described

with reference to the accompanying drawings. FIG. 1 is a diagram showing respective cultivation periods in a hydroponic cultivation method according to an embodiment of the present invention. Low-potassium vegetables of the present embodiment can be cultivated by performing hydroponic cultivation during the periods shown in FIG. 1. Vegetables of the present embodiment indicate leaf vegetables such as lettuce, salad vegetable, celtuce, Japanese mustard spinach, and cabbage. FIG. 2 is a view showing a relationship among inner leaves 10, middle leaves 20, and outer leaves 30 of lettuce as an example of a vegetable according to the present embodiment. Thereinafter, the method of hydroponically cultivating low-potassium vegetables according to the present embodiment will be described with reference to FIG. 1.

[0016] First, cultivation periods in the hydroponic cultivation method according to the present embodiment will be described. In the hydroponic cultivation method according to the present embodiment, first cultivation period Le, second cultivation period Lm, and third cultivation period Ll are set in an entire cultivation period L showing the entire cultivation period of low-potassium vegetables. That is, entire cultivation period L is divided into first cultivation period Le, second cultivation period Lm following first cultivation period Le, and third cultivation period Ll following second cultivation period Lm according to the kind of vegetable (leaf vegetable).

[0017] Entire cultivation period L is a period from time A of sowing to time E of harvest. The time length of entire cultivation period L is almost determined according to the kind of vegetable to be cultivated and can be set in advance according to the kind of vegetable. Meanwhile, it is understood that the length of entire cultivation period L is less affected by the kind of fertilizer to be used. Therefore, it is possible to set first cultivation period Le, second cultivation period Lm, and third cultivation period Ll in advance according to

the kind of vegetable.

[0018] First cultivation period Le is a period from time A of sowing to time C of switching a fertilizer. It is preferable that first cultivation period Le is formed of seedling period Le1 and normal cultivation period Le2. That is, it is preferable that seedling period Le1 and normal cultivation period Le2 following seedling period Le1 are set as first cultivation period Le. Seedling period Le1 indicates a period from germination of a seed to stabilization of growth of a seedling and also indicates a period from time A of sowing to time B of starting normal cultivation. Seedling period Le1 is typically two weeks regardless of the kind of vegetable, but can be suitably set according to an experiment or the like. Normal cultivation period Le2 is a period from time B of starting normal cultivation to time C of switching a fertilizer.

[0019] It is preferable that only seedlings which are sufficiently grown are selected during seedling period Le1 and the hydroponic cultivation of the present embodiment is performed. In this manner, low-potassium vegetables can be cultivated efficiently. Specifically, the size of each seedling (individual) of vegetables is measured at time B of starting normal cultivation (at the time of finishing seedling period Le1), only the individual seedlings grown to a predetermined size or greater are selected, the period is transitioned to normal cultivation period Le2, and individual seedlings only grown to a size less than the predetermined size are disposed.

[0020] Second cultivation period Lm is a period from time C of exchanging a fertilizer to non-fertilizer time D. Time C of exchanging a fertilizer is set as a starting time of predetermined period Lm by acquiring period Lm traced back from non-fertilizer time D, described below, through an experiment.

[0021] Third cultivation period Ll is a period from non-fertilizer time D to time E of harvest. Non-fertilizer time D is a time point of starting a period for

which any fertilizer such as potassium, nitrogen, or phosphorus is not provided. Accordingly, when third cultivation period Ll is extremely longer, there is a possibility that the vegetables wither due to physiological disorders such as potassium deficiency or calcium deficiency. For this reason, in the present
5 embodiment, third cultivation period Ll is set by performing an experiment.

[0022] It is preferable that the length of third cultivation period Ll is approximately 10% of entire cultivation period L. Specifically, third cultivation period Ll is preferably in a range from 5% to 10%, inclusive, of entire cultivation period L. When third cultivation period Ll is shorter than
10 5% of entire cultivation period L, an effect for reducing potassium decreases. When third cultivation period Ll is longer than 10% of entire cultivation period L, the physiological disorders tends to occur.

[0023] It is preferable that third cultivation period Ll is set to be shorter than second cultivation period Lm and second cultivation period Lm is set to be
15 shorter than first cultivation period Le. When the lengths of the periods are set in this manner, individual seedlings can be sufficiently grown and the content of potassium can be reduced.

[0024] Next, fertilizers used in the hydroponic cultivation method of the present embodiment will be described. In the hydroponic cultivation method
20 of the present embodiment, fertilizers for hydroponic cultivation, which contain different components, are used for first cultivation period Le and second cultivation period Lm. Specifically, a first fertilizer for hydroponic cultivation is used during first cultivation period Le and a second fertilizer for hydroponic cultivation is used during second cultivation period Lm. Further, water that
25 does not contain a fertilizer is used during third cultivation period Ll.

[0025] The first fertilizer for hydroponic cultivation is a fertilizer for hydroponic cultivation, which contains potassium. Specifically, the first

fertilizer is a fertilizer for hydroponic cultivation, which contains potassium, calcium, magnesium, phosphorus, and nitrogen as main components. When the first fertilizer for hydroponic cultivation is used during first cultivation period Le, vegetables normally germinate and are grown.

5 [0026] The second fertilizer for hydroponic cultivation is a fertilizer for hydroponic cultivation, which does not substantially contain potassium and contains magnesium. Specifically, the second fertilizer is a fertilizer for hydroponic cultivation, in which potassium and sodium are not substantially contained, and which contains calcium, magnesium, phosphorus, and nitrogen
10 as main components and has a pH value at the time when these main components are dissolved in water is in a range of 5 to 9. In vegetables, the absorbability of magnesium is comparable to the absorbability of potassium or sodium. In addition, magnesium greatly contributes to the growth of vegetables in the second half of cultivation of the vegetables. Therefore, when
15 the second fertilizer for hydroponic cultivation, which contains magnesium in place of potassium is used, vegetables are normally grown even in a state in which the content of potassium is decreased. Note that the expression “potassium and sodium are not substantially contained” means that blending of a negligible amount of potassium or sodium, compared to the amount of other
20 components, is acceptable at the time of preparation of a fertilizer. For example, when tap water is used to dilute a fertilizer for hydroponic cultivation, sodium contained in the tap water is to be contained in the fertilizer for hydroponic cultivation, but the amount of sodium contained in the tap water used for dilution is negligible.

25 [0027] During the third cultivation period Ll, it is preferable that vegetables are cultivated using pure water which does not contain potassium or sodium at all, but the tap water may be used for cultivation.

[0028] By using water which does not contain a fertilizer during third cultivation period L1, potassium and/or sodium contained in a vegetable are dissolved in the water so that the total content of potassium and/or sodium in the vegetable is decreased. Further, potassium and/or sodium are moved
5 (flows) from outer leaves 30 to inner leaves 10 shown in FIG. 2, and a difference in content of potassium and/or sodium among inner leaves 10, middle leaves 20, and outer leaves 30 becomes small. Inner leaves 10 are leaves positioned in the central portion of an individual vegetable. Outer leaves 30 are leaves positioned in the outermost portion of an individual vegetable. Middle leaves
10 20 are leaves provided in the middle portion (in the middle of the central portion and the outermost portion) of an individual vegetable and located in an intermediate position between inner leaves 10 and outer leaves 30.

[0029] Generally in a leaf vegetable, after a seed germinates and the cotyledons (seed leaves) are open, true leaves come out from the center
15 therebetween, the next true leaves come out from the center between the first true leaves, and this process is repeated and the vegetable is grown. Particularly in a leaf vegetable with formed head (sphere) such as lettuce or cabbage, the core grows at the center of the head, and outer leaves 30 grow from the position closest to the root on the bottom of the core. Inner leaves 10
20 are youngest leaves growing from the tip of the core. Middle leaves 20 grow from the central portion in a direction in which the core extends. Each leaf extends from the core to the outside, and middle leaves 20 can be specified by counting the number of leaves growing from the core between inner leaves 10 and outer leaves 30 when an individual headed leaf vegetable is longitudinally
25 cut. Even in leaf vegetables without formed head such as Japanese mustard spinach, outer leaves 30 grow from the position closest to the root when an individual leaf vegetable is longitudinally cut. Inner leaves 10 grow from the

center of an individual leaf vegetable. Middle leaves 20 can be specified by counting the number of leaves growing between inner leaves 10 and outer leaves 30.

[0030] Next, specific examples of the present embodiment will be described.

5 In other words, lettuce is cultivated using the hydroponic cultivation method of the present embodiment, and the results obtained by measuring the contents of potassium and sodium in inner leaves 10, middle leaves 20, and outer leaves 30, and the total contents of potassium and sodium in lettuce will be described. However, the present invention is not limited to the following example.

10 [0031] The compositions of stock solutions of the first fertilizer and the second fertilizer for hydroponic cultivation are as follows (Table 1). When these stock solutions are used for hydroponic cultivation, these solutions are used after being diluted with water.

[0032]

15 Table 1

	First fertilizer for hydroponic cultivation	Second fertilizer for hydroponic cultivation
Calcium (g/L)	46.9	0
Sodium (g/L)	0	0
Magnesium (g/L)	9.7	24.3
Calcium (g/L)	32.1	32.1
Nitrate nitrogen (g/L)	39.2	39.2
Ammonia nitrogen (g/L)	2.8	2.8
Phosphorus (g/L)	6.2	6.2
Zinc (mg/L)	50	50
Copper (mg/L)	20.1	20.1
Iron (mg/L)	3000.1	3000.1
Manganese (mg/L)	500	500
Boron (mg/L)	500	500
Molybdenum (mg/L)	20.1	20.1

[0033] In addition, the same kind of lettuce is cultivated without providing third cultivation period L1 shown in FIG. 1, as a comparative example of the

present example. Hereinafter, this will be referred to as “Reference Example 1”. Further, the same kind of lettuce is cultivated using a typical hydroponic cultivation method. Hereinafter, this will be referred to as “Reference Example 2”. In Reference Examples 1 and 2, the contents of potassium and sodium of inner leaves, middle leaves, and outer leaves and the total content of potassium and sodium of lettuce are also measured. Based on these results, influence of a difference in fertilizer for hydroponic cultivation on the contents of potassium and sodium is investigated. Note that the following experiment results show average values obtained by performing the experiment under the same conditions three times or more. In cultivation of the present example and Reference Examples 1 and 2, the temperature of a cultivation room is controlled to be in a range of 17°C to 23°C.

[0034] In seedling period Le1 of the present example, seeds of lettuce germinate and seedlings are cultivated. Specifically, first, seeds of lettuce are immersed, for 30 minutes, in an antiseptic solution obtained by diluting a sodium hypochlorite aqueous solution at a dilution magnification of 10 times and then washed. A plurality of the seeds washed in this manner are collected and buried in a sponge-like rock sheet, and then the rock sheet is immersed in a hydroponic solution containing the first fertilizer for hydroponic cultivation. In addition, the seeds are allowed to germinate in a dark state. After germination, the germinating seeds are moved to a bright environment and allowed to be grown in a hydroponic solution containing the first fertilizer for hydroponic cultivation during remaining seedling period Le1.

[0035] During normal cultivation period Le2 of the present example, well-grown seedlings are selected from the seedlings grown during seedling period Le1, and each seedling is wrapped by a sponge one by one, transplanted to a hydroponic solution using the first fertilizer for hydroponic cultivation, and

then cultivated.

[0036] During second cultivation period L_m of the present example, the seedlings are transplanted to a hydroponic solution containing the second fertilizer for hydroponic cultivation, which does not contain potassium and sodium, and then cultivated. Further, during third cultivation period L_l of the present example, the seedlings are transplanted to water which does not contain a fertilizer and then cultivated. In this manner, lettuce is harvested at time E of harvest.

[0037] In hydroponic cultivation of Reference Example 1, entire cultivation period L is divided into two periods of an initial cultivation period and a final cultivation period. The initial cultivation period of Reference Example 1 is the same as first cultivation period L_e of the hydroponic cultivation method of the present example and the final cultivation period of Reference Example 1 corresponds to a period formed by combining second cultivation period L_m and third cultivation period L_l of the hydroponic cultivation method of the present example. In Reference Example 1, lettuce is cultivated using the first fertilizer for hydroponic cultivation during the initial cultivation period and using the second fertilizer for hydroponic cultivation during the final cultivation period.

[0038] In hydroponic cultivation of Reference Example 2, lettuce is cultivated using the first fertilizer for hydroponic cultivation during the entire cultivation period.

[0039] As the contents of potassium and sodium contained in harvested lettuce of the present example, Reference Example 1, and Reference Example 2, the content of potassium per 100 g of fresh weight is measured using an atomic absorption photometer. Specifically, first, the entire fresh weight is measured immediately after the harvest of each lettuce. Thereafter, each lettuce is

divided into five measurement positions of inner leaves; a middle portion of inner leaves and middle leaves (hereinafter, referred to as “inner-middle leaves”); middle leaves; a middle portion of middle leaves and outer leaves (hereinafter, referred to as “middle-outer leaves”); and outer leaves, and the fresh weights of leaves in each measurement position are measured. The fresh weight of leaves in each measurement position and the contents of potassium and the like are not measured in a case of lettuce cultivated using a typical method, assuming that the values are uniform throughout the vegetable. Subsequently, the entire lettuce or lettuce divided for each part of leaves is dried in a drier at 80°C for 72 hours or longer and then further dried at 80°C for 48 hours, thereby obtaining a dry matter. After the obtained dry matter is ground, the ground dry matter is subjected to dry ashing at 550°C for 6 hours. Elution components are extracted from the obtained ash using a nitric acid aqueous solution at a concentration of 1 mol/L. The contents of potassium and sodium contained in the extracted solution are measured using an atomic absorption photometer. The contents of potassium and sodium per 100 g of fresh weight are respectively measured by converting the contents obtained in the above-described manner to ratios per fresh weight. The results are shown in Table 2, FIG 3A, and FIG. 3B.

[0040]

Table 2

	Unit: mg/100 g	
	Entire lettuce	
	Potassium	Sodium
Present example	80	13
Reference Example 1	178	20
Reference Example 2	470	3.3

[0041] The results obtained by measuring the contents of potassium and sodium of each entire lettuce of the present example, Reference Example 1, and

Reference Example 2 are shown in Table 2.

[0042] FIG. 3A shows the content of potassium in each measurement position of the present example and Reference Example 1. In Fig. 3A, the horizontal axis shows the measurement position and the vertical axis shows the content of potassium per 100 g of fresh weight. In the case of lettuce cultivated using the hydroponic cultivation method of Reference Example 1, it is understood that a difference in content of potassium between the inner leaves and the outer leaves is large and the content thereof drastically increase from the inner-middle leaves to the middle leaves. On the other hand, in the case of lettuce cultivated using the hydroponic cultivation method of the present example, it is understood that a difference in content of potassium between inner leaves and the outer leaves is small compared to Reference Example 1 and the content thereof gradually increases from the inner leaves to the middle-outer leaves.

[0043] Specifically, in the lettuce cultivated using the hydroponic cultivation method of the present example, a difference in content of potassium between inner leaves and middle leaves is smaller than that between middle leaves and outer leaves. In contrast, in the lettuce cultivated using the hydroponic cultivation method of Reference Example 1, a difference in content of potassium between inner leaves and middle leaves is larger than that between middle leaves and outer leaves. In addition, a difference in content of potassium between inner leaves and outer leaves of the lettuce of the present example is smaller than a difference in content of potassium between inner leaves and outer leaves of the lettuce of Reference Example 1.

[0044] FIG. 3B shows the content of sodium in each measurement position of the present example and Reference Example 1. In FIG. 3B, the horizontal axis shows the measurement position and the vertical axis shows the content of

sodium per 100 g of fresh weight. A difference in content of sodium between inner leaves and outer leaves is not significant between two cultivation methods. However, in all measurement positions, the content of sodium of the lettuce of the present example is smaller than that of Reference Example 1.

5 Moreover, a difference in content of sodium between inner leaves and outer leaves of the lettuce of the present example is slightly smaller than that of Reference Example 1.

[0045] As is apparent in Table 2, FIG. 3A, and FIG. 3B, when lettuce is cultivated using the hydroponic cultivation method of the present embodiment,

10 the contents of potassium and sodium in the entire lettuce and in each portion thereof are smaller than those of lettuce cultivated using a hydroponic cultivation method of the related art and a difference in contents of potassium and sodium of each leaf of the lettuce are smaller than those of lettuce cultivated using a hydroponic cultivation method of the related art.

15 [0046] In the present example, Reference Example 1, and Reference Example 2, all fertilizers for hydroponic cultivation being used do not contain sodium, and sodium is not intentionally added to the hydroponic solution as well. Nevertheless, sodium is detected from leaves of the cultivated lettuces. It is considered that sodium is detected due to tap water used for dilution of

20 fertilizers for hydroponic cultivation. In other words, it is considered that sodium is detected because a sodium hypochlorite aqueous solution (NaClO) for disinfection, which is added to tap water, is absorbed by lettuce.

INDUSTRIAL APPLICABILITY

25 [0047] Since the contents of potassium and sodium are small in the low-potassium vegetable of the present invention, it is possible to provide vegetables which can be safely taken by renal disease patients.

REFERENCE SIGNS LIST

5	[0048]	10	inner leaves
		20	middle leaves
		30	outer leaves

CLAIMS

1. A method for hydroponically cultivating a low-potassium vegetable, comprising:

dividing a total cultivation period from sowing to harvest into a first cultivation period, a second cultivation period following the first cultivation period, and a third cultivation period following the second cultivation period according to a kind of a vegetable;

cultivating the vegetable using a first hydroponic cultivation fertilizer containing potassium in the first cultivation period;

cultivating the vegetable using a second hydroponic cultivation fertilizer that does not substantially contain potassium and contains magnesium in the second cultivation period; and

cultivating the vegetable using water that does not contain a fertilizer in the third cultivation period.

2. The method for hydroponically cultivating a low-potassium vegetable according to claim 1,

wherein the third cultivation period is set to be shorter than the second cultivation period, and

the second cultivation period is set to be shorter than the first cultivation period.

3. The method for hydroponically cultivating a low-potassium vegetable according to claim 1 or 2,

wherein the third cultivation period is set to be in a range of 5% to 10%, inclusive, of the total cultivation period.

4. The method for hydroponically cultivating a low-potassium vegetable according to any one of claims 1 to 3,

wherein the first cultivation period is divided into a seedling period and a normal cultivation period following the seedling period, and

the size of the vegetable is measured when the seedling period is finished and only vegetable grown to have a predetermined size or greater is selected and cultivated for the normal cultivation period.

5. A low-potassium vegetable comprising:
an inner leaf positioned in a central portion;
an outer leaf positioned in an outermost portion; and
a middle leaf located in of an intermediate position between the inner leaf and the outer leaf,
wherein a difference in content of potassium between the inner leaf and the middle leaf is smaller than a difference in content of potassium between the middle leaf and the outer leaf.