

Description

Title

REFRIGERATOR

Field

[0001]

This invention relates to a refrigerator.

Background

[0002]

As a conventional refrigerator, a refrigerator is known which is provided with an accommodation container for accommodating mainly leafy vegetables at a part inside a vegetable compartment, wherein a weak light radiation device is arranged above the accommodation container, the weak light device is a semiconductor light emitting device which emits light in a visible ray region wavelength, and the semiconductor light emitting device is a red LED which outputs a wavelength of about 660 nm (for example, see Patent Literature 1).

Citation List

Patent Literature

[0003]

[PTL 1] JP 2002-267348 A

Summary

Technical Problem

[0004]

In the conventional refrigerator shown in Patent Literature 1, however, red light is continuously radiated to vegetables and fruit such as leafy vegetables (green stuff) for twenty-four hours a day. On the other hand, plants such as green stuff perform activities such as photosynthesis in a cycle of about twenty-four hours. This cyclic activity is referred to as a circadian rhythm. In photosynthesis using solar energy, lightness and darkness of light significantly influences the circadian rhythm. Further, in the case of natural light, a wavelength of prominent light changes according to time lapse of a day. Therefore, in a state where red light with the same wavelength is continuously radiated, vegetables and fruit such as leafy vegetables (green stuff) cannot efficiently use energy of radiated light. Specifically, since, at the time of performing photosynthesis, pores of the vegetables and fruit do not sufficiently open, and carbon dioxide required for photosynthesis cannot be sufficiently taken in, efficiency of photosynthesis may deteriorate.

[0005]

This invention has been made to solve such a problem, and an object is to obtain a refrigerator capable of accelerating photosynthesis of stored vegetables and fruit such as green stuff (especially leafy vegetables) utilizing the circadian rhythm of plants and in

consideration of the state of pores of plants.

Solution to Problem

[0006]

A refrigerator according to the present invention includes: a storage compartment configured to store food; a light emitting portion capable of radiating visible light to an inside of the storage compartment; and a control portion configured to control operation of the light emitting portion to alternately repeat a visible light radiation process of causing light including visible light to be radiated from the light emitting portion and a non-radiation process of causing the light including visible light not to be radiated from the light emitting portion, the light emitting portion comprising: a first light source configured to radiate light having a first wavelength of a visible light region as a central wavelength; and a second light source configured to radiate light having a second wavelength of the visible light region different from the first wavelength as a central wavelength, the control portion configured to control, in the visible light radiation process, the light emitting portion to perform a first radiation process of causing light to be radiated from both of the first light source and the second light source and a second radiation process of causing light to be radiated only from the first light source.

Advantageous Effect of Invention

[0007]

In a refrigerator according to this invention, an advantageous effect is obtained that it is possible to accelerate photosynthesis of stored vegetables and fruit such as green stuff (especially leafy vegetables) utilizing the circadian rhythm of plants and in consideration of the state of pores of plants.

Brief Description of the Drawings

[0008]

Fig. 1 is a front view of a refrigerator relating to First Embodiment of the present invention.

Fig. 2 is a longitudinal sectional view of the refrigerator relating to First Embodiment of the present invention.

Fig. 3 is a diagram enlargedly showing a vegetable compartment portion in Fig. 2.

Fig. 4 is a diagram showing a configuration of a light emitting portion which the refrigerator relating to First Embodiment of the present invention is provided with.

Fig. 5 is a block diagram showing a configuration of a control system of the refrigerator relating to First Embodiment of the present invention.

Fig. 6 is a time chart of light radiation control of each light source which the light emitting portion of the refrigerator relating to First Embodiment of the present invention is provided with.

Fig. 7 is a flowchart showing a flow of light radiation control of the refrigerator relating to First Embodiment of the present invention.

Fig. 8 is a diagram showing an example of comparison among amounts of vitamin C in a case where cabbages are stored for three days under a plurality of light radiation conditions.

Fig. 9 is a time chart of the light radiation control of each light source which the light emitting portion of the refrigerator relating to First Embodiment of the present invention is provided with, and open/closed states of a vegetable compartment door.

Description of Embodiment

[0009]

An embodiment for practicing this invention will be described with reference to accompanying drawings. In each of the drawings, the same or corresponding portions are given the same reference numeral, and overlapping description will be appropriately simplified or omitted. The present invention is not limited to the embodiment below and can be variously modified within a range not departing from the spirit of the present invention.

[0010]

First Embodiment

Figs. 1 to 9 relate to a first embodiment of this invention. Fig. 1 is a front view of a refrigerator; Fig. 2 is a longitudinal sectional

view of the refrigerator; Fig. 3 is a diagram enlargedly showing a vegetable compartment portion in Fig. 2; Fig. 4 is a diagram showing a configuration of a light emitting portion which the refrigerator is provided with; Fig. 5 is a block diagram showing a configuration of a control system of the refrigerator; Fig. 6 is a time chart of light radiation control of each light source which the light emitting portion of the refrigerator is provided with; Fig. 7 is a flowchart showing a flow of light radiation control of the refrigerator; Fig. 8 is a diagram showing an example of comparison among amounts of vitamin C in a case where cabbages are stored for three days under a plurality of light radiation conditions; and Fig. 9 is a time chart of the light radiation control of each light source which the light emitting portion of the refrigerator is provided with, and open/closed states of a vegetable compartment door.

[0011]

In each figure, a dimensional relationship, shape and the like of each constituent member may be different from actual ones. Further, positional relationships (for example, vertical positional relationship and the like) among constituent members are, in principle, those when the refrigerator is installed in a usable state.

[0012]

(Configuration of refrigerator)

A refrigerator 1 according to the first embodiment of this invention has a heat insulating box body 90 as shown in Fig. 2. The

front of the heat insulating box body 90 is open, and storage space is formed inside. The heat insulating box body 90 has an outer box, an inner box and heat insulating material. The outer box is made of steel. The inner box is made of resin. The inner box is arranged inside the outer box. The heat insulating material is, for example, urethane foam or the like and is filled in space between the outer box and the inner box. The storage space formed inside the heat insulating box body 90 is partitioned into a plurality of storage compartments for accommodating and storing food by one or more partition members.

[0013]

As shown in Figs. 1 and 2, here, the refrigerator 1 is provided with, for example, a refrigerating compartment 100, a switching compartment 200, an ice making compartment 300, a freezing compartment 400 and a vegetable compartment 500 as the plurality of storage compartments. These storage compartments are arranged in a vertical four-stage configuration in the heat insulating box body 90.

[0014]

The refrigerating compartment 100 is arranged at the top stage of the heat insulating box body 90. The switching compartment 200 is arranged on one of the left and right sides below the refrigerating compartment 100. A cooling temperature zone of the switching compartment 200 can be switched by selecting any of a plurality of temperature zones. The plurality temperature zones which can be selected as the cooling temperature zone of the switching compartment

200 are, for example, a freezing temperature zone (for example, about -18°C), a refrigerating temperature zone (for example, about 3°C), a chilling temperature zone (for example, about 0°C), a soft freezing temperature zone (for example, about -7°C) and the like. The ice making compartment 300 is arranged laterally next to the switching compartment 200 in parallel to the switching compartment 200, that is, arranged on the other of the left and right sides below the refrigerating compartment 100.

[0015]

The freezing compartment 400 is arranged below the switching compartment 200 and the ice making compartment 300. The freezing compartment 400 is mainly for use at the time of freezingly storing a storage object for a relatively long time. The vegetable compartment 500 is arranged at the bottom stage below the freezing compartment 400. The vegetable compartment 500 is for accommodating mainly vegetables, a large-sized PET bottle with a large capacity (for example, 2L or the like) and the like.

[0016]

An opening portion formed in the front of the refrigerating compartment 100 is provided with a rotary-type refrigerating compartment door 7 for opening/closing the opening portion. Here, the refrigerating compartment door 7 is of a double swing type and is configured with a right door 7a and a left door 7b. On an outer side surface of the refrigerating compartment door 7 (for example, the left

door 7b) on the front of the refrigerator 1, an operation panel 6 is provided. The operation panel 6 is provided with an operation portion 6a and a display portion 6b. The operation portion 6a is an operation switch for setting a cooling temperature of each storage compartment and an operation mode (a defrosting mode or the like) of the refrigerator 1. The display portion 6b is a liquid crystal display for displaying various kinds of information such as the temperature of each storage compartment. Further, the operation panel 6 may be provided with a touch panel which serves as both of the operation portion 6a and the display portion 6b.

[0017]

Each of the storage compartments other than the refrigerating compartment 100 (the switching compartment 200, the ice making compartment 300, the freezing compartment 400 and the vegetable compartment 500) is opened/closed by a drawer-type door. The drawer-type door can be opened and closed in a depth direction (a front-back direction) of the refrigerator 1 by causing a frame fixedly provided on the door to slide relative to rails horizontally formed on left and right inner wall surfaces of each storage compartment.

[0018]

Further, inside the switching compartment 200 and inside the freezing compartment 400, a switching compartment accommodation case 201 and a freezing compartment accommodation case 401 capable of internally accommodating food and the like are housed in a drawable

manner, respectively. Similarly, inside the vegetable compartment 500, an upper-stage accommodation case 11 and a lower-stage accommodation case 10 capable of internally accommodating food and the like are housed in a drawable manner.

[0019]

(Cooling mechanism)

The refrigerator 1 is provided with a freezing cycle circuit which cools air to be supplied to each storage compartment. The freezing cycle circuit is configured with a compressor 2, a condenser (not shown), a throttle device (not shown), a cooler 3 and the like. The compressor 2 compresses and discharges refrigerant in the freezing cycle circuit. The condenser causes the refrigerant discharged from the compressor 2 to be condensed. The throttle device causes the refrigerant which flows out from the condenser to expand. The cooler 3 cools the air to be supplied to each storage compartment by the refrigerant expanded by the throttle device. The compressor 2 is arranged, for example, at a lower part on the back side of the refrigerator 1.

[0020]

In the refrigerator 1, an air passage 5 for supplying air cooled by the freezing cycle circuit to each storage compartment is formed. This air passage 5 is arranged mainly on the back side inside the refrigerator 1. The cooler 3 of the freezing cycle circuit is installed in this air passage 5. Further, inside the air passage 5, a blower fan 4 for sending air cooled by the cooler 3 to each storage compartment

is also installed.

[0021]

When the blower fan 4 operates, air cooled by the cooler 3 (cold air) is sent to the freezing compartment 400, the switching compartment 200, the ice making compartment 300 and the refrigerating compartment 100 through the air passage 5 to cool the insides of these storage compartment. The vegetable compartment 500 is cooled by introducing return cold air from the refrigerating compartment 100 into the vegetable compartment 500 via a return air passage for refrigerating compartment. The cold air which has cooled the vegetable compartment 500 is returned into the air passage 5 where the cooler 3 exists, through a return air passage for vegetable compartment (these return air passages are not shown). Then, the air is cooled again by the cooler 3, and the cold air is circulated inside the refrigerator 1.

[0022]

At a position on the way to each storage compartment from the air passage 5, a damper not shown is provided. Each damper opens/closes a position of the air passage 5 which communicates with each storage compartment. By changing an open/closed state of the damper, the amount of cold air to be supplied to each storage compartment can be adjusted. Further, temperature of the cold air can be adjusted by controlling operation of the compressor 2.

[0023]

The freezing cycle circuit configured with the compressor 2 and

the cooler 3, the blower fan 4, the air passage 5 and the dampers provided as described above constitute cooling means for cooling the insides of the storage compartments.

[0024]

For example, at an upper part on the back side of the refrigerator 1, a control device 8 is accommodated. The control device 8 is provided with a control circuit or the like for performing various controls required for operation of the refrigerator 1. As the control circuit which the control device 8 is provided with, for example, a circuit for controlling operations of the compressor 2 and the blower fan 4, and degrees of opening of the dampers based on temperature inside each storage compartment, information inputted to the operation panel 6 and the like is given. That is, the control device 8 controls the operation of the refrigerator 1 by controlling the cooling means and the like described before. The temperature inside each storage compartment can be detected by a thermistor (not shown) or the like installed in the storage compartment.

[0025]

(Configuration of vegetable compartment)

Fig. 3 is a cross-sectional view of the vegetable compartment 500 part which the refrigerator 1 is provided with. The vegetable compartment 500 is a storage compartment which stores food, especially vegetables. The lower-stage accommodation case 10 is supported by a frame (not shown) of a vegetable compartment door 9. On the upper side

of the lower-stage accommodation case 10, the upper-stage accommodation case 11 is placed. When the vegetable compartment door 9 is drawn out forward, the lower-stage accommodation case 10 and the upper-stage accommodation case 11 are drawn out forward being combined with the vegetable compartment door 9. When only the upper-stage accommodation case 11 is slid backward while the vegetable compartment door 9 is in the state of being drawn out, a state where only the lower-stage accommodation case 10 is drawn out is obtained. In the state where only the lower-stage accommodation case 10 is drawn out, food can be taken out from or put into the lower-stage accommodation case 10.

[0026]

Inside the vegetable compartment 500, a door opening/closing detection switch 12, a thermistor 13 and a light emitting portion 14 are provided. The door opening/closing detection switch 12 is for detecting an open/closed state of the vegetable compartment door 9. The door opening/closing detection switch 12 is provided at a position facing the vegetable compartment door 9 on an edge portion of a front opening of the vegetable compartment 500.

[0027]

To a back portion inside the vegetable compartment 500, the thermistor 13 and the light emitting portion 14 are attached. The thermistor 13 detects temperature inside the vegetable compartment 500. The light emitting portion 14 is capable of radiating visible light to the inside of the vegetable compartment 500 which is a storage

compartment. Here, an opening portion 15 is formed at a part facing the light emitting portion 14 on a back of the lower-stage accommodation case 10. The light emitting portion 14 is adapted to be capable of radiating visible light to the inside of the lower-stage accommodation case 10 through this opening portion 15. Material with a property of causing visible light radiated from the light emitting portion 14 to be transmitted may be used for at least a part corresponding to the opening portion 15 of the lower-stage accommodation case 10.

[0028]

(Configuration of light emitting portion)

Next, a configuration of the light emitting portion 14 will be further described with reference to Fig. 4. As shown in Fig. 4, the light emitting portion 14 is provided with two kinds of light sources, a first light source 16a and a second light source 16b. As described before, the light emitting portion 14 is capable of radiating visible light. Therefore, the light emitting portion 14 is provided with visible light sources which radiate visible light. The first light source 16a and the second light source 16b are the visible light sources.

[0029]

The first light source 16a radiates light having a first wavelength as a central wavelength. The second light source 16b radiates light having a second wavelength as a central wavelength. Both of the first wavelength and the second wavelength belong to a visible light region. The second wavelength, however, is different from the

first wavelength.

[0030]

Specifically, the first wavelength which is the central wavelength of the first light source 16a is between 500 nm and 700 nm including 500 nm and 700 nm, preferably between 600 nm and 700 nm including 600 nm and 700 nm. That is, light radiated from the first light source 16a is red. Specifically, for example, a red LED can be used as the first light source 16a.

[0031]

Further, the second wavelength which is the central wavelength of the second light source 16b is between 400 nm and 500 nm including 400 nm and 500 nm. That is, light radiated from the second light source 16b is blue. Specifically, for example, a blue LED can be used as the second light source 16b.

[0032]

These first light source 16a and second light source 16b are configured so that each of them can be independently turned on and turned off.

[0033]

(Control system of refrigerator)

Fig. 5 is a block diagram showing a functional configuration of a control system of the refrigerator 1. In Fig. 5, especially portions related to control of the vegetable compartment 500 are shown. The control device 8 is provided with, for example, a microcomputer and

is provided a processor (CPU: Central Processing Unit) 8a and a memory 8b. By the processor (CPU) 8a executing a program stored in the memory 8b, the control device 8 executes a process set in advance to control the refrigerator 1.

[0034]

To the control device 8, a detection signal of temperature inside the vegetable compartment 500 is inputted from the thermistor 13. Further, to the control device 8, an operation signal from the operation portion 6a of the operation panel 6 is also inputted. Furthermore, to the control device 8, a detection signal from the door opening/closing detection switch 12 is also inputted.

[0035]

Based on an inputted signal, the control device 8 executes a process of controlling operations of the compressor 2, the blower fan 4 and the like so that the inside of the vegetable compartment 500 is kept at a set temperature. Further, the control device 8 outputs a display signal to the display portion 6b of the operation panel 6.

[0036]

Furthermore, the control device 8 outputs a control signal to the light emitting portion 14 to control light-emitting operation of the light emitting portion 14 as well. As described before, the light emitting portion 14 is provided with the first light source 16a and the second light source 16b. Each of these two kinds of light sources can be independently turned on and turned off. The control device 8

can control on/off states of the first light source 16a and the second light source 16b which the light emitting portion 14 is provided with independently from each other.

[0037]

(Control of light emitting portion)

Next, description will be made on light emission operation control of the light emitting portion 14 by the control device 8 with reference to Fig. 6. The control device 8 controls operation of the light emitting portion 14 to alternately repeat a visible light radiation process of causing light including visible light to be radiated from the light emitting portion 14 and a non-radiation process of causing light including visible light not to be radiated from the light emitting portion 14. In the visible light emission process, at least one of the first light source 16a and the second light source 16b is turned on. In the non-radiation process, neither the first light source 16a nor the second light source 16b is turned on.

[0038]

The visible light radiation process is further divided into two processes. In the visible light radiation process, a first radiation process is performed first, and then a second radiation process is performed. That is, the control device 8 controls the light emitting portion 14 to perform the first radiation process and the second radiation process in the visible light radiation process. In the first radiation process, the control device 8 causes light to be radiated

from both of the first light source 16a and the second light source 16b. That is, both of red light and blue light are radiated. In the second radiation process, the control device 8 causes light to be radiated only from the first light source 16a, and the second light source 16b is turned off. That is, only red light is radiated, and blue light is not radiated.

[0039]

A duration time of each process is set in advance. The duration time of the first radiation process, the duration time of the second radiation process and the duration time of the non-radiation process are assumed to be ΔT_1 , ΔT_2 and ΔT_3 , respectively.

[0040]

Thus, the control device 8 controls the light emitting portion 14 to perform the first radiation process, the second radiation process and the non-radiation process in that order. Then, after the non-radiation process ends, each process is repeatedly performed again in the order described before from the visible light radiation process, that is, the first radiation process. Therefore, time ΔT required for one cycle of performing each process once in order is a sum total of ΔT_1 , ΔT_2 and ΔT_3 . Further, the duration time of the visible light radiation process is a sum total of ΔT_1 and ΔT_2 .

[0041]

The control device 8 controls the light emitting portion 14 so that the visible light radiation process and the non-radiation process

are alternately repeated in a cycle of twenty-four hours or shorter. That is, ΔT is set to be twenty-four hours or shorter. Further, the duration time ΔT_3 of the non-radiation process is set to be equal to or shorter than the duration time of the visible light radiation process. That is, the duration time ΔT_3 of the non-radiation process is set to be equal to or shorter than the sum total of the duration time ΔT_1 of the first radiation process and the duration time ΔT_2 of the second radiation process. Furthermore, the duration time ΔT_1 of the first radiation process is set to be equal to or shorter than the duration time ΔT_2 of the second radiation process. As an example of the duration time of each process satisfying the conditions as described above, ΔT_1 , ΔT_2 and ΔT_3 are specifically set to two hours, ten hours and eight hours, respectively. In this case, ΔT is twenty hours.

[0042]

Description will be made on a series of flows related to the control of the light emitting portion 14 of the vegetable compartment 500 which the refrigerator 1 configured as described above is provided with, with reference to a flowchart of Fig. 7. When the refrigerator 1 is powered on, the control device 8 causes the first light source 16a and the second light source 16b of the light emitting portion 14 to be turned on at step S101 first. At the next step S102, the control device 8 resets a value of a timer t which measures elapsed time to 0 and starts timing by the timer.

[0043]

Then, at the next step S103, the control device 8 confirms whether the elapsed time t of the timer has reached $\Delta T1$ or not. If the elapsed time t of the timer has not reached $\Delta T1$, the control device 8 repeats the confirmation at step S103 until the elapsed time t of the timer reaches $\Delta T1$. Then, when the elapsed time t of the timer reaches $\Delta T1$, the control device 8 proceeds to step S104. The above steps S101 to S103 are the first radiation process.

[0044]

At step S104, the control device 8 causes the second light source 16b of the light emitting portion 14 to be turned off. Therefore, a state where only the first light source 16a is on is obtained. At the next step S105, the control device 8 resets the value of the timer t which measures elapsed time to 0 and starts timing by the timer.

[0045]

Then, at the next step S106, the control device 8 confirms whether the elapsed time t of the timer has reached $\Delta T2$ or not. If the elapsed time t of the timer has not reached $\Delta T2$, the control device 8 repeats the confirmation at step S106 until the elapsed time t of the timer reaches $\Delta T2$. Then, when the elapsed time t of the timer reaches $\Delta T2$, the control device 8 proceeds to step S107. The above steps S104 to S106 are the second radiation process.

[0046]

At step S107, the control device 8 causes the first light source 16a of the light emitting portion 14 to be turned off. Therefore, a

state where all of the first light source 16a and the second light source 16b are off is obtained. Then, proceeding to step S108, the control device 8 resets the value of the timer t which measures elapsed time to 0 and starts timing by the timer.

[0047]

At the next step S109, the control device 8 confirms whether the elapsed time t of the timer has reached $\Delta T3$ or not. If the elapsed time t of the timer has not reached $\Delta T3$, the control device 8 repeats the confirmation at step S109 until the elapsed time t of the timer reaches $\Delta T3$. Then, when the elapsed time t of the timer reaches $\Delta T3$, the control device 8 returns to step S101 and repeatedly executes the above steps. The above steps S107 to S109 are the non-radiation process.

[0048]

(Operation by light radiation control)

Next, description will be made on operation expected by the light radiation control of the light emitting portion 14 as described above. First, a circadian rhythm of plants autonomously continues a cycle of about twenty-four hours even under a condition that time information such as a light/dark cycle of light is not given. In the case of storing vegetables and fruit such as green stuff (especially vegetables and fruit) under a dark environment in which light is not radiated, however, photosynthesis is not performed, and, therefore, an effect of storability improvement, an increase in the amount of nutrients or the like cannot be obtained. On the other hand, in the case of storing

vegetables and fruit under a light environment in which light is continuously radiated, photosynthesis is performed, but problems, such as that nutrients cannot be sufficiently generated and that photosynthesis speed or photosynthetic ability deteriorates, may be induced.

[0049]

Therefore, in the refrigerator 1 according to this invention, the light emitting portion 14 of the vegetable compartment 500 performs the visible light radiation process of radiating light including visible light to the inside of the lower-stage accommodation case 10 of the vegetable compartment 500 and the non-radiation process in which the light including visible light is not radiated, alternately repeating the processes as described before.

[0050]

Therefore, the inside of the lower-stage accommodation case 10 is switched between a light period during which visible light is radiated to obtain the light environment and a dark period during which visible light is not radiated to obtain the dark environment as time elapses. That is, inside the lower-stage accommodation case 10, an environment in which change in quantity of light in the natural world caused by the sun rising in the morning and setting in the evening is simulated is created. Therefore, it is possible to encourage plants such as vegetables and fruit put in the lower-stage accommodation case 10 to perform activities such as photosynthesis according to the circadian

rhythm.

[0051]

Here, photosynthetic reaction of plants will be described. The photosynthetic reaction can be expressed by the following expression (1).

[0052]



[0053]

In this expression (1), CO_2 , H_2O , 688kcal and $\text{C}_6\text{H}_{12}\text{O}_6$ are carbon dioxide, water, light energy and glucose, respectively.

[0054]

By the photosynthetic reaction of this expression (1), plants generate oxygen and sugar from carbon dioxide in the atmosphere and water which the plants have, using light energy. This reaction is divided in two stages. The first stage decomposes water into hydrogen and oxygen using light energy absorbed by pigments included in leaves and the like, such as chlorophyll, and stores chemical energy with the function of enzyme protein. The second stage synthesizes glucose using electrons, hydrogen ions and carbon dioxide in the atmosphere. In vegetables in which glucose has increased, its storability is improved, and vitamin C is generated from the glucose.

[0055]

In order to cause photosynthesis to be actively performed, it is necessary to make light radiated to the inside of the vegetable

compartment 500 effective for photosynthesis. An absorption spectrum of chlorophyll has two light absorption peaks in red (near 660 nm) and blue (near 450 nm), and it is known that the wavelengths are especially effective for photosynthesis. As for green (500 to 600 nm), though the rate of absorption by chlorophyll is low, light scatters inside a leaf, and frequency of encountering with chlorophyll becomes high. Therefore, absorptivity of the whole leaf becomes high.

[0056]

Further, blue light has a function of opening pores of plants. Therefore, it is possible to, by radiating light including blue at the initial stage of the light period during which light is radiated, open pores of vegetables and fruit. By continuing the light period after opening the pores of the vegetables and fruit, the vegetables and fruit can sufficiently take in carbon dioxide in the air and can efficiently perform photosynthesis. On the other hand, blue light also has a function of accelerating germination and flowering. Therefore, in the case of intending long-term storage of vegetables and fruit, it is better to shorten time to radiate blue light as much as possible.

[0057]

In the visible light radiation process of accelerating photosynthesis, the second light source 16b is turned on first to radiate light including blue in the first radiation process, and, after that, the second light source 16b is turned off to radiate light not including blue in the second radiation process. Thereby, it is possible to, after

opening pores of vegetables and fruit inside the lower-stage accommodation case 10, cause photosynthesis to be performed, and it is possible to further accelerate photosynthesis of the vegetables and fruit inside the lower-stage accommodation case 10. Further, at this time, by causing the first radiation process of radiating light including blue to be shorter than the second radiation process of radiating light not including blue, it is possible to prevent germination and flowering from being accelerated, as far as possible, and obtain a sufficient pore opening function.

[0058]

The circadian rhythm of plants has a cycle of about twenty-four hours corresponding to hours from morning till night, and then till morning again. The circadian rhythm of plants, however, has a characteristic that the phase of the rhythm changes in response to influence of ambient light. For example, when light is radiated in the dark environment to obtain the light environment, the rhythm phase shifts to the morning side. By using such a characteristic to make time for the non-radiation process shorter than that of the visible light radiation process, that is, making the dark period in which light is not radiated shorter than the light period in which light is radiated so that a light radiation cycle is equal to or shorter than twenty-four hours, it is possible to increase the rate of time during which vegetables and fruit inside the lower-stage accommodation case 10 perform photosynthesis while being stored. By increasing the rate of

the time during which vegetables and fruit perform photosynthesis while being stored, it is possible to improve efficiency of generation of nutrients of vegetables and fruit, such as sugar and vitamin C.

[0059]

Here, description will be made on what difference will occur in the amount of nutrient (vitamin C) included in vegetables and fruit when the vegetables and fruit are stored under a plurality of different light radiation conditions as described above by giving a specific comparison example, with reference to Fig. 8. Fig. 8 is a graph comparing amounts of vitamin C after cabbages are stored for three days under a plurality of different light radiation conditions. The amounts of vitamin C are indicated by rates of change when the initial amounts of vitamin C before storage are 100. As for the light radiation conditions, light intensity is equal, and color included in radiated light and radiation time per day are changed.

[0060]

In non-radiation in which light is not radiated at all during the whole day, the amount of vitamin C after storage decreases in comparison with the initial amount (the leftmost graph in Fig. 8). In comparison, under all of conditions in which light is radiated, the amount of vitamin C after storage increases in comparison with the initial amount. When a comparison is made between conditions in which light is continuously radiated all day, the amount of increase in vitamin C after storage is larger in the case of combining red light and blue

light (the third from the left in Fig. 8) than in the case of radiating only red light (the second from the left in Fig. 8).

[0061]

Furthermore, when time during which light is not radiated, that is, the dark period is provided to perform light radiation corresponding to the circadian rhythm, a result is obtained that the amount of increase in vitamin C after storage is much larger (the rightmost graph in Fig. 8). Thus, by radiating light with an appropriate wavelength according to the circadian rhythm of vegetables and fruit, it is possible to cause photosynthesis and generation of nutrients to be efficiently performed, and it is possible to obtain an effect of storability improvement and an increase in the amount of nutrients of stored vegetables. That is, with the refrigerator 1 according to this invention, it is possible to utilize the circadian rhythm of vegetables and fruit to control activities of the vegetables and fruit such as photosynthesis by performing light radiation simulating light movement in the natural world. Thereby, it is possible to, by accelerating generation of nutrients by photosynthesis or suppressing excessive transpiration, store vegetables with a high quality.

[0062]

(Another example of control of light emitting portion)

In the control of the light emitting portion 14 described above, it is not especially mentioned which time slots of a day the visible light radiation process, the non-radiation process and the like are

to be performed in. Here, as another example of control of the light emitting portion 14, an example of performing control of the light emitting portion 14, such as for a time slot in which the non-radiation process is to be performed, according to a detection result of an open/closed state of the vegetable compartment door 9 will be described with reference to Fig. 9.

[0063]

As described before, the vegetable compartment door 9 is a door capable of opening and closing the vegetable compartment 500 which is a storage compartment. Further, the door opening/closing detection switch 12 is detection means for detecting opening and closing of this vegetable compartment door 9. The control device 8 counts the number of times of opening/closing of the vegetable compartment door 9 detected by the door opening/closing detection switch 12 per predetermined time, that is, per reference time set in advance. The reference time at this time is, for example, the duration time $\Delta T3$ of the non-radiation process. The control device 8 controls the light emitting portion 14 to perform the non-radiation process in a time slot in which the number of times the vegetable compartment door 9 is opened and closed per predetermined time is equal to or below a number of times set in advance.

[0064]

The door of the refrigerator 1 is often opened and closed before and after preparation of meals or shopping and is not opened or closed while a user is sleeping or out. Therefore, in daily life, change in

the number of times of opening and closing the door can be patterned during a day and predicted. Therefore, the control device 8 counts the number of times of opening and closing the vegetable compartment door 9, and stores a time slot in which the number of times of opening and closing the door per predetermined time is small into a storage portion or the like not shown. Then, by starting the non-radiation process in the stored time slot on the next and subsequent days or after twenty-four hours after the time slot is stored, the non-radiation process can be performed in the time slot in which the number of times of opening and closing is small.

[0065]

When the vegetable compartment door 9 is opened and closed during the non-radiation process, there is a possibility that the phase of the circadian rhythm of stored vegetables and fruit changes because of influence of light outside the refrigerator 1. Therefore, by performing the non-radiation process in a time slot in which the number of times of opening and closing the vegetable compartment door 9 is small, it is possible to secure the dark period in which light is not radiated to vegetables and fruit inside the lower-stage accommodation case 10, and it is possible to efficiently perform light radiation control according to the circadian rhythm.

[0066]

It is also possible to enable the user to switch between execution of control of light radiation from the light emitting portion 14 and

termination of the control (causing the light emitting portion 14 to be continuously off) by operating the operation portion 6a of the operation panel 6 installed on the refrigerating compartment door 7. By enabling the user to select whether or not to perform control to turn on the light emitting portion 14 by the operation panel 6, it is possible to select termination to cause the light emitting portion 14 to be continuously off when not many vegetables and fruit are stored or are unused for a long time to reduce energy consumption, and it is possible to provide usability similar to that of an ordinary refrigerator.

[0067]

Further, while light radiation control is being performed, display such as "during light radiation" may be shown on the display portion 6b of the operation panel 6. Furthermore, display such as "light is on" and display such as "light is off" may be shown on the display portion 6b during the visible light radiation process (the light period) and during the non-radiation process (the dark period), respectively. Furthermore, display in which states of light inside the refrigerator (inside the vegetable compartment 500) are replaced with one day of light in the natural world may be shown on the display portion 6b. Specifically, for example, according to a process being performed in the light radiation control, display such as "morning", "daytime" and "night" may be shown on the display portion 6b during the first radiation process, the second radiation process and the non-radiation process,

respectively. By doing so, it is possible to inform the user of the state of light inside the refrigerator and improve convenience and a feeling of satisfaction. In addition, it is also possible to urge the user to pay attention not to unnecessarily open or close the door while the non-radiation process is being performed.

[0068]

The operation panel 6 is not limited to being installed on the outer side of the refrigerator 1 but may be installed inside the refrigerator (inside a storage compartment). Further, communication means may be provided for the refrigerator 1 so that an instruction may be communicated to the control device 8 of the refrigerator 1, and information about the refrigerator 1 may be received and displayed, by a mobile information terminal (a mobile phone including a smartphone, a tablet terminal or the like) via a telecommunication line or the like. That is, the mobile information terminal may be provided with one or both of the functions of the operation portion 6a and the display portion 6b of the operation panel 6.

Industrial Applicability

[0069]

This invention can be used for a refrigerator which is provided with a light emitting portion in a storage compartment for storing food and which radiates visible light to the inside of the storage compartment from the light emitting portion.

Reference Signs List

[0070]

- 1 refrigerator
- 2 compressor
- 3 cooler
- 4 blower fan
- 5 air passage
- 6 operation panel
- 7 refrigerating compartment door
 - 7a right door
 - 7b left door
- 8 control device
 - 8a CPU/
 - 8b memory
- 9 vegetable compartment door
- 10 lower-stage accommodation case
- 11 upper-stage accommodation case
- 12 opening/closing detection switch
- 13 thermistor
- 14 light emitting portion
- 15 opening portion
- 16a first light source
- 16b second light source
- 90 heat insulating box body

100 refrigerating compartment
200 switching compartment
300 ice making compartment
400 freezing compartment
500 vegetable compartment
201 switching compartment accommodation case
401 freezing compartment accommodation case

Claims

[Claim 1]

A refrigerator comprising:

a storage compartment configured to store food;

a light emitting portion capable of radiating visible light to an inside of the storage compartment; and

a control portion configured to control operation of the light emitting portion to alternately repeat a visible light radiation process of causing light including visible light to be radiated from the light emitting portion and a non-radiation process of causing the light including visible light not to be radiated from the light emitting portion;

the light emitting portion comprising:

a first light source configured to radiate light having a first wavelength of a visible light region as a central wavelength; and

a second light source configured to radiate light having a second wavelength of the visible light region different from the first wavelength as a central wavelength;

the first wavelength being between 500 nm and 700 nm including 500 nm and 700 nm,

the second wavelength being between 400 nm and 500 nm including 400 nm and 500 nm,

the control portion configured to control, in the visible light radiation process, the light emitting portion to perform a first

radiation process of causing light to be radiated from both of the first light source and the second light source first and then a second radiation process of causing light to be radiated only from the first light source, and to end the visible light radiation process after the first radiation process and the second radiation process are performed.

[Claim 2]

The refrigerator according to claim 1, wherein the control portion controls the light emitting portion so that the visible light radiation process and the non-radiation process are alternately repeated in a cycle of twenty-four hours or shorter.

[Claim 3]

The refrigerator according to claim 1 or 2, wherein duration time of the non-radiation process is equal to or shorter than a total sum of duration time of the first radiation process and duration time of the second radiation process.

[Claim 4]

The refrigerator according to any one of claims 1 to 3, wherein the duration time of the first radiation process is equal to or shorter than the duration time of the second radiation process.

[Claim 5]

The refrigerator according to any one of claims 1 to 4, further comprising:

a door capable of opening and closing the storage compartment;
and

detection means configured to detect opening and closing of the door; wherein

the control portion controls the light emitting portion to perform the non-radiation process in a time slot in which the number of times of opening and closing of the door detected by the detection means per predetermined reference time is equal to or smaller than a predetermined number of times.